Ministry of Water Resources

Ministry of Environmental Protection

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No.1 Document Strategic Knowledge Exchange - An EU Perspective and Overview

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Table of Contents

List of Appendices

Summary

The Strategic Knowledge Exchange (SKE) study between the EU China River Basin Management Programme (RBMP) and the Development Research Centre (DRC) of the Ministry of Water Resources (MWR) has enabled key concepts of integrated river basin management developed for the EU Water Framework Directive to be made available to water strategy policy makers within the MWR. The emphasis has been on joint development and knowledge exchange to derive and enhance a common understanding of water management issues. Shared ownership of this documents and the RBMP Technical Reports it builds on has been an important aim.

The study developed from a comparative analysis of the EU Water Framework Directive (EU WFD) and the China 2011 No.1 Document on Accelerating Water Conservancy Reform and Development (No.1 Document). The two initiatives were agreed and brought into force 10 years apart and reflect the differences in development and societal expectations of their time in Europe and China. In many respects the two documents are remarkably similar in their ambition and scale. Both documents signal significant improvements in water management and resource protection in their geographic areas. They pose significant technical and institutional challenges, which must be overcome to achieve successful implementation. Europe has invested significantly to develop methods to implement the EU WFD and the lessons learned may assist in the implementation of the No.1 Document.

The SKE study focuses on three priority areas of water security agreed with DRC, Flood Security, Water Resource (Supply) Security and Water Ecology Security. Intensive meetings and exchanges of information between European and Chinese experts led to the development of short Strategic Analysis Papers for each security area. These identify key messages from Europe that may assist in the implementation of the No.1 Document. They provide potential approaches that could enhance water security significantly and optimise implementation of the No.1 Document, if they are developed and adapted for China.

The following key messages have emerged relating to the three water security work areas and the cross cutting economics.

Flood Security

The key message is that to increase flood security a revision of the flood standards, accompanied by a broadening of the scope from hazard to proportionate risk management, would bring the maximum benefit. Following this strategy would allow a modernisation of approach and significantly improved flood protection.

In Europe similar approaches have allowed informed decision making, optimisation of expenditure and enhanced protection from flooding. Decisions need to include assessments of vulnerability in terms of socio-economic hazards and risks, exposure and resilience to provide a more integrated approach, using a mix of structural, non-structural and managerial measures.

Enhancing flood security requires a long term vision and should be integrally linked to spatial planning for urban and regional development in both developing and developed areas.

Water Supply Security

The key message for water resource supply security is that a change to a proactive risk management approach to water resource planning should be adopted, rather than the more reactive approach that is currently followed. In addition, drought management responses should be based on robust and up-to-date knowledge of the status of available water resources, so that any reductions in water allocations for the duration of the drought are proportionate and recognise the relative priorities of each sector.

Ecological Security

In ecological security the recommendation is for China to introduce an integrated water resources impact permit enforcing the "Three Red Lines" policy (SC, 2012) on reducing water use through fair allocation of abstraction quotas between users, increasing water use efficiency and reducing the impact of pollution loads on rivers and lakes. The technical steps for the implementation of the Three Red Lines will require detailed development to build a robust regulatory framework. A secondary recommendation is to set up a central level authority to oversee the new permitting procedure thus separating policy enforcement from local priorities that may jeopardise sustainable economic growth for all users.

Economic and Financial Assessment

Cutting across the three securities is an assessment of the economic and financial instruments that China could adopt to optimise the three securities. These focus on the use of economic assessment tools and improving water demand management. An impact assessment framework supporting strategic decision making should include the use of the appropriate economic assessment tools. Demand management by administrative tools should be supplemented by strengthening of differential water tariffs within and between sectors. In agriculture, the largest water user, demand management should involve a strengthening of volumetric charging systems, but closely consider the regional differences as well as the potential social and economic effects of higher water prices. For all types of water resource infrastructure, a financing strategy could be developed as a core element of implementation of the three securities.

The Strategic Analysis Papers are developed from Technical Reports on each security area, supplemented by cross cutting studies, providing economic analysis to support decision making and to optimise the effectiveness of implementation. The Technical Reports for each security area are linked and published separately along with the supporting economic methodologies. A joint reference library has also been developed storing the EU and Chinese technical papers used in the study.

Future development and research topics have been identified that will build on this study in the future. The China Europe Water Platform will provide one of the vehicles for future co-operation developing methods to enhance water security in China.

1 Introduction

1.1 No.1 Document and the EU WFD

The China 2011 No.1 Document "Accelerating Water Conservancy Reform and Development" (No.1 Document) and the EU Water Framework Directive (EU WFD) both represent significant changes to the pace of water resources protection, the scale of infrastructure investment and the importance both societies place on water security, now and in the future. The EU WFD has been described as the most ambitious environmental directive to be agreed by the EU and has brought significant changes to the way water is managed across Europe. Similarly the China No.1 Document is regarded as the most important water policy document produced by China since the 2002 Water Law and reflects a significant change of emphasis and urgency in addressing China's water issues. The two initiatives were agreed and brought into force almost ten years apart and consequently reflect the global, political and societal pressures of their time in each region. Both are sanctioned at the highest level and take an essential long term perspective on the management of water.

The EU Water Framework Directive (2000/60/EC, 22 December 2000) is a directive of the European Parliament and of the European Council, establishing a framework for community action in the field of water policy. It is legally binding for all EU Member States and sets a timetable for action, including transposition into each Member State law by 2003.

The China 2011 No.1 Water Document, published 31 December 2010, in force 1 January 2011, is a formal decision of the Central Committee of the Communist Party of China (CPC) and the State Council on accelerating the water conservancy reform and development.

There are considerable synergies between the two approaches and opportunities exist for Europe and China to work together to jointly overcome the significant challenges posed in managing and protecting water as an essential and scarce natural resource.

1.2 Principal Drivers for Change

China and Europe both face significant challenges in water management. The starting points and scale may vary, but the common pressures of a changing climate and a growing population, combined with increased urbanisation and in China also continued industrialisation must be overcome. Both China and Europe have stated the wish to move towards more sustainable management of water and the need to make significant changes to achieve this.

Food production continues to be a central theme for water resource management in China, as about 68% of available water is currently used for irrigation. This is currently less important in Europe, although climate change will bring additional pressure, especially in southern Europe, where irrigation is more critical to rural economies.

In Europe the EU WFD, as updated by the EU Water Blueprint in 2012, the EU Groundwater Directive in 2006, the EU Floods Directive in 2007 and other supporting environmental directives provide mechanisms to make the necessary improvements. In China, the No.1 Document, signals a significant change of pace and commits significant investment over the next ten years.

For China and Europe, doing nothing to increase water security is not an option. However a number of themes emerge from discussions between the Chinese and European experts involved in this study. The scale of the challenge will need phased implementation with the highest priority water security initiatives undertaken first.

Integrated river basin management has been identified as the overall approach to water management in both regions, but several aspects require coordination with administrative entities for effective implementation.

Economic appraisals can assist in prioritisation and in determining the most efficient and effective options, in financial and economic terms. There will be increased emphasis on scenario analysis and planning, based on best available evidence. Risk based approaches, adaptive engineering and innovative solutions will be important. Overall a long term approach to water planning will be critical, closely linked to strategic urban and rural development planning.

1.3 Risk Based Approach

Risk management is a proactive approach focused on the design of measures that will be put in place in advance of extreme events to prevent or mitigate the level of risk exposure and, hence, the vulnerability to impacts. The traditional approach in Europe in the previous century and still predominant in China, was to be reactive, taking a disaster mitigation approach to extreme events, rather than a more proactive approach.

The terminology of ‘risk management’ and ‘risk based approaches’ is being used increasingly frequent for water security strategies developed worldwide as well as for this study. The terminology should be clarified to increase understanding and to stimulate the uptake and further development of these techniques. Extreme events in water security context include the risk of flooding, drought, and pollution.

The concept of risk management in water planning is based on the following:

- the knowledge that extreme events will recur
- that the severity of the event cannot be predicted in advance
- that preparation and planning is necessary to mitigate the range of possible impacts
- that mitigation is an ongoing process involving structural and non-structural measures
- that all water users have a responsibility to manage water as efficiently as possible.

Risk management in water planning seeks to build resilience in water infrastructure through structural and non-structural measures in an ongoing process. It requires the development of a clear understanding of what type of extreme event might be expected to happen in the future and take account of what has happened in the past. The likelihood of extreme events has to be considered alongside the estimated impact on people, the economy and the environment. It helps to identify weaknesses in water infrastructure and opportunities for managing impacts by addressing the risk factors.

Risk management relies on strong evidence to assess the likelihood of extreme events that could jeopardise water security, together with the potential impact and losses to society and the environment. This is achieved by using the best quality information available using predictive models to forecast and estimate, where extreme events could occur and by reviewing accounts of past events.

These risk based approaches continue to develop in Europe and China and aim to allow the best technical estimations of probability and impact to be assessed. They are based on modelled and statistical appraisals of available information. They should allow decision makers to prioritise and gain maximum water security for known expenditure and timescale.

In a changing climate, and as uncertainty increases, these risk based approaches become more important. As climate change adaptation measures are developed, the assumptions will be critical in designing flexible responses and infrastructure solutions. However, these risk based assumptions are only part of the decision making process. Broader political, social and economic considerations are equally important for the final decisions to be taken by well informed politicians.

1.4 Integrated River Basin Management

Integrated river basin management (IRBM) is at the intellectual heart of the EU and Chinese approaches to water management, however, the maturity of approach and extent of application differ.

Isolated measures to improve water security cannot be successful without taking account of what happens upstream and downstream. Integrated river basin management adopts a holistic approach to protecting the whole body of water, its source, tributaries, its main rivers, lakes and groundwaters, through a coordinated strategy involving all the interested parties in decision-making. The river basin approach is acknowledged in Europe as the best way to manage water.

In 2000, the European Union took a groundbreaking step when it adopted the Water Framework Directive (WFD). The WFD introduced a new legislative approach to managing and protecting water, based not on national or political boundaries, but on river basins as natural geographical and hydrological formations. These are known as River Basin Districts. IRBM needs clear coordination and collaboration between administrative authorities and stakeholders within the river basin.

In China IRBM is applied through river basin water resources commissions, for instance the Changjiang Water Resources Commission and the Yellow River Conservancy Commission, but hampered by provincial authorities having significant authority over tributaries and limited representation in the commissions. The No.1 Document signals a significant reform in approach and acknowledges the need to include the tributaries in future priorities.

Organisationally there are administrative divides between the Ministry of Water Resources and between the Provinces and other ministries with their own mandates on specific parts of water resources protection and development. Coordination does take place and operational teams do work together, but often within still complex institutional settings. The EU WFD introduced the concept of a single competent authority to take overall responsibility for river basins to overcome these issues.

1.5 Strategic Knowledge Exchange Study

1.5.1 Background

The Development Research Centre (DRC) of the Ministry of Water Resources (MWR) and the EU China River Basin Management Programme (RBMP) agreed to carry out a joint analysis of water management policies in China and in the EU focusing on the No.1 Document and the EU WFD.

An initial formulation phase of work took place from September to December 2011 in the form of a comparative analysis of the EU WFD and the No.1 Document leading to a communication with EU Member States participating in the EU Water Initiative. This allowed a greater understanding of the two initiatives and developed a strong working relationship between the DRC and the RBMP. Further dialogue outlined the work proposed to inform the development of policy and strategy for the implementation of the No.1 Document. The timeframe for the analysis was January to June 2012.

This knowledge exchange phase served to:

- Enhance knowledge transfer between the EU and China on key elements of water policy and strategy
- Contribute towards effective implementation of the No.1 Document on the basis of absorbing the relevant advanced ideas and experience of the WFD
- Develop and mentor Chinese experts engaged in the joint development work
- Outline future exchanges on water sector policy development and implementation, and provide structured research proposals to be considered and taken forward under the China Europe Water Platform after closure of the RBMP.

The study was implemented as a series of focused work areas on different elements of water security. It has been undertaken by a joint team of Chinese experts identified by DRC and EU experts identified by the RBMP.

This Final Report provides a targeted analysis of the knowledge exchange needed to deliver recommendations to MWR on policies, strategies and programmes to inform the implementation of the No.1 Document. It focuses on work areas that MWR have indicated as a priority, and where the EU water policies and directives are deemed relevant to China. It provides structured suggestions on future exchanges under the China Europe Water Platform.

1.5.2 Key Issues

The study is based on the key principles for water management in China outlined in the opening statement of the No.1 Document:

"Water is essential for life, production and ecology"

In EU context "production" is best translated as "supporting all aspects of beneficial uses of water".

MWR translates this into a set of six securities to be achieved by future water resources development and management in China:

1 Flood control security
2 Water supply security
3 Food security
4 Economic security
5 Ecological security
6 National security.

These securities may be seen to reflect the overall national policy of *"putting people first"* as stated by General Secretary Hu Jintao at the 17th National Congress of the Communist Party of China in October 2007:

"Scientific Outlook on Development
takes development as its essence
and puts people first as its core"[1]

After careful analysis and consultation it was agreed that EU experience could be best applied within the work areas of:

- Flood risk security
- Water supply security, including water financing
- Ecological security.

To make these themes operational two cross-cutting themes were also selected to be addressed:

- Governance and institutional development
- Water resources economics

This study structure is graphically illustrated in Figure 1.

[1] Yang Daqing. Tasks for a scientific view on development. China Daily, 05 November 2007.

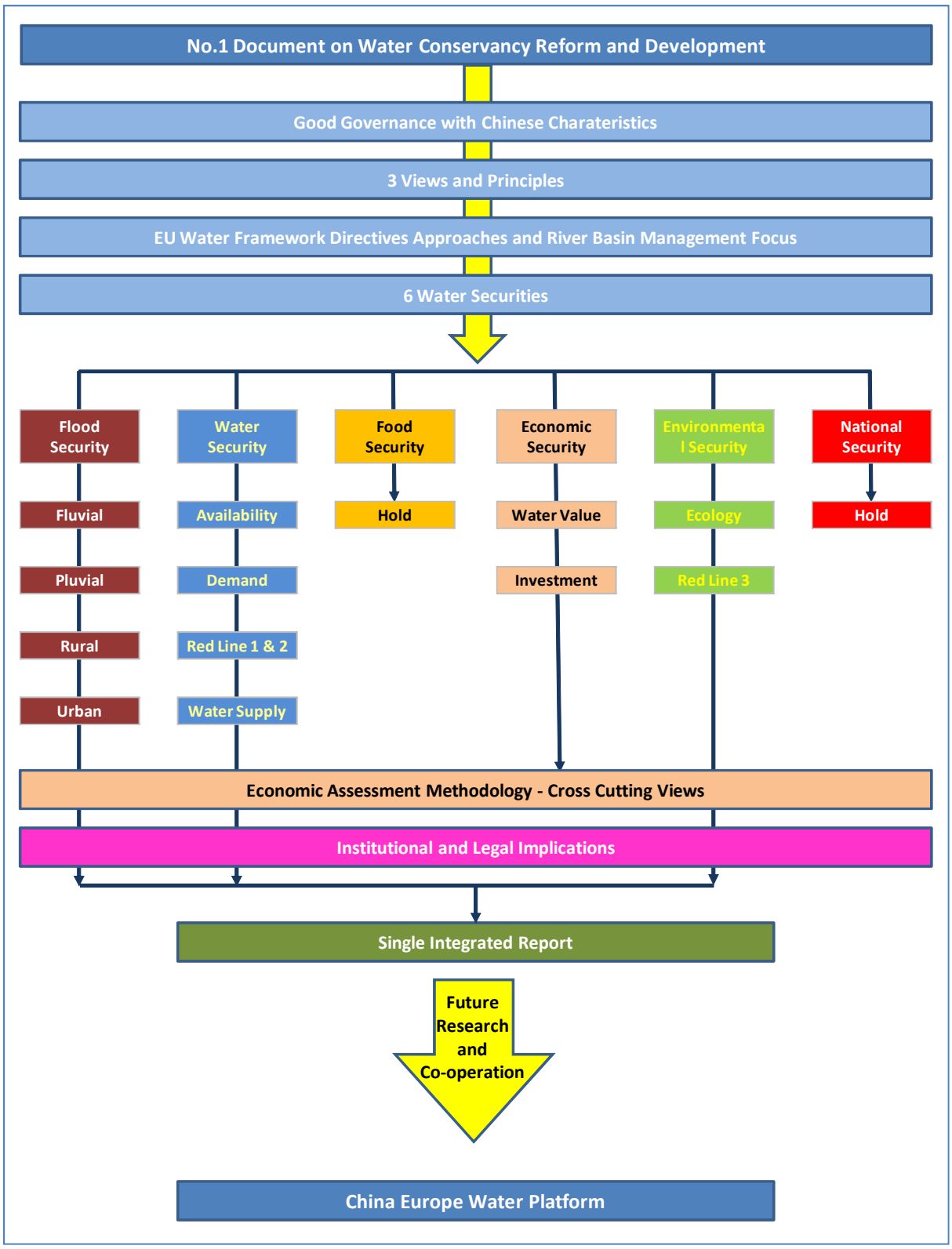

Figure 1 Study structure

1.5.3 Scope of Study

The scope of the SKE study has been carefully defined following discussions to develop an understanding of strategy and policy making processes in China. In reality these processes are

remarkably similar to those in Europe and Figure 2 defines the extent of the study within the overall process. It illustrates that the European contribution is confined to developing technical and strategic thinking.

One of the main outcomes is the development of approaches to water security in partnership between DRC and RBMP experts. Many of the outcomes are intangible, but give key individuals access to the current information from Europe and China and to critically evaluate its possible application. The process of developing short strategy or 'think piece' papers to explore options is also an important outcome.

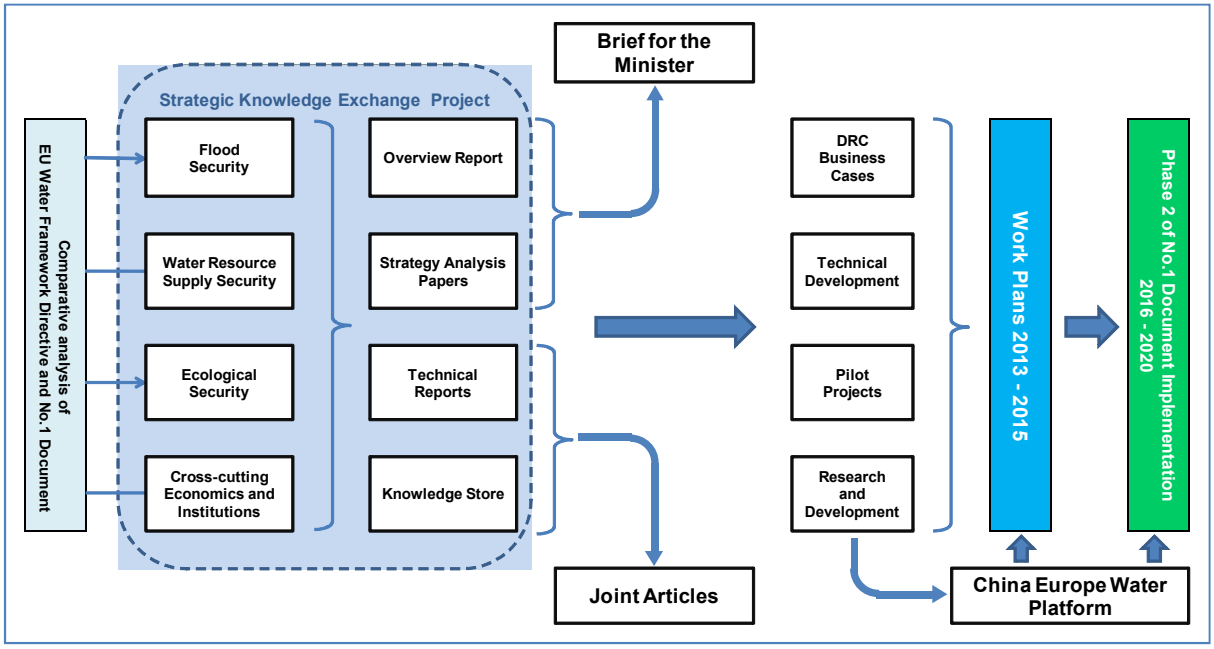

Figure 2 Scope of the Strategic Knowledge Exchange Study

1.5.4 Working Method

The working methods were innovative and experimental. The short and intensive programme jointly developed by DRC and RBMP to exchange knowledge, focussed on the three water security work areas and supporting economic analysis. The approach which evolved was unconventional and sits outside the normal environmental and engineering consultancy sphere. The outcome is a series of high level strategic analysis papers, supported by a strong technical base. In addition, all involved have learnt important lessons that will be of significance to future work in China and Europe.

A strong partnership of Chinese and European technical co-ordinators was put in place to oversee and facilitate. European experts were placed in the DRC office for ten day periods to allow intensive interaction and joint development and exchange. This allowed one to one working and joint development of themes. For each water security area a Chinese and European specialist were paired. Economists were also engaged to ensure this cross cutting theme was fully integrated.

Language was the main barrier, with none of the Europeans able to converse in Chinese. The Chinese experts had a good working knowledge of English, and interpreters assisted when needed. Short

intensive sessions allowed the discussion of technical issues and daily work programmes to be developed. This usually entailed researching the theme using European and Chinese literature, writing up a joint position and then validating in Chinese and English. Workshops held at DRC allowed a wider audience to participate and allowed a broader exchange of information and ideas.

In this way a block of information was assembled into the Technical Reports for each water security area. These became the core working documents and are published as separate RMPB Technical Reports, which are listed in Appendix 2 and available from the RBMP Knowledge Centre (www.euchinarivers.org) or the China Europe Water Platform Document Repository (www.cewp.org). Key reference documents used in the study are listed in Appendix 2 and available from DRC.

Figure 3 shows the makeup of the reports in diagrammatic form.

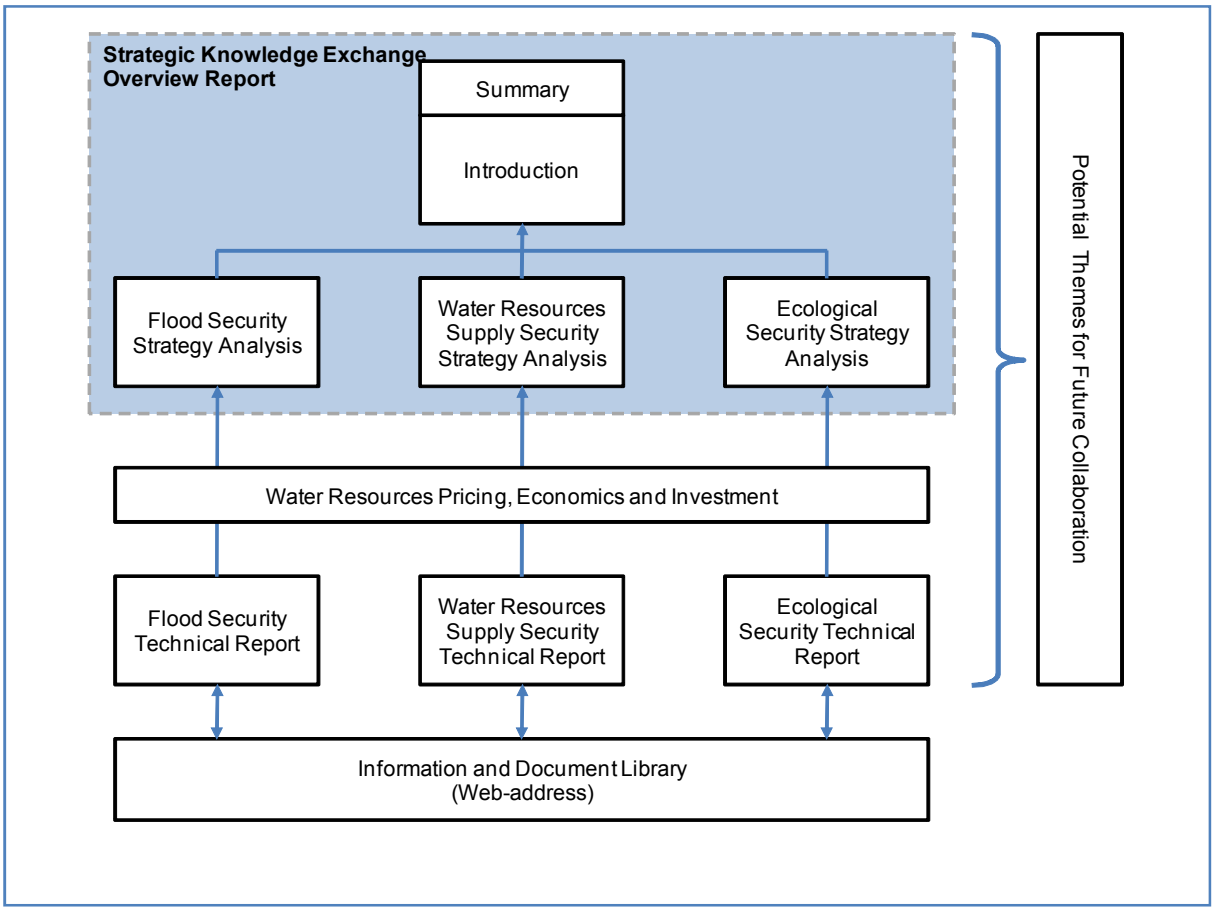

Figure 3 Reporting Structure and Format

All the European and Chinese reference papers have been placed in an information store for future reference. From the Technical Reports a series of short strategy analysis papers were developed as a precursor to ministerial/senior briefings that will be undertaken by DRC at the end of this process.

In this way the strategic knowledge exchange developed a common position and understanding. The process in itself was a learning experience for all. Developing the short strategic analysis papers was difficult for many, but an important discipline in strategy development. It is also hoped that all involved will be more competent in their field, see the broader perspectives and contexts and have the confidence to approach difficult issues with an open mind.

The following three sections include the strategic analysis papers developed jointly between European and Chinese experts. They are short papers that allow the key messages and supporting strategic approaches to be read quickly and easily.

2 Strategy Analysis for Flood Security

This strategy analysis has been derived from short intensive cooperation by flood risk management experts and strategists from Europe and the DRC. It has allowed expertise from the EU to be applied to some of the flood security issues faced by China that will be addressed by the implementation of the No.1 Document and other policy documents. The strategy analysis summarises the emerging issues into a brief format suitable to promote discussion on future water policy, development and research. The aim is to ultimately increase flood security in China in response to a changing climate, a growing population and increasing urbanisation.

2.1 Key Messages

Flood management has always been a priority in China's water management, as it is in some EU member states like France, the Netherlands, UK and central European nations like Hungary and Romania.

Based on comparisons between the EU and Chinese approaches a number of themes emerge that may increase flood security in China and allow the optimum benefit to be gained from the implementation of the No.1 Document.

The key message is that **to increase flood security a revision of the flood standards accompanied by a broadening of the scope from hazard to proportionate risk management would bring the maximum benefit**. Following this strategy would enable a modernisation of approach and significantly improved protection for a modern and quickly developing China.

In Europe similar approaches have allowed informed decision making, optimisation of expenditure and enhanced protection from flooding. Work will be needed to adapt these concepts and to build on the excellent work on flood risk management already in place in China. Recently Europe has seen a broadening of the scope of flood control and protection from the mostly infrastructural approach favoured by engineers towards engineers towards complementary non-infrastructure management measures. Decisions need to include assessments of vulnerability in terms of socio-economic hazards and risks, exposure and resilience to provide a more integrated approach, bringing a mix of structural, non-structural and managerial measures.

Enhancing flood security requires a long term vision and should be integrally linked to spatial planning for urban and regional development in both developing and developed areas. Flood risk management is a fundamental element of development planning and should be incorporated in the design of infrastructure projects at an early stage, taking into account the social and economic development

opportunities increased flood protection can bring. Modelling can test future development scenarios and identify options that could optimise decisions on the phased implementation of the No.1 Document. Infrastructure development can be prioritised to meet approved or agreed standards, suitable for modern China.

2.2 EU Floods Directive

Both China and Europe aim at reducing the adverse consequences for human health, the environment, cultural heritage and economic activity associated with floods. To facilitate this, a management framework for the assessment and management of flood risks is required.

The European Union has put this in place through the development and adoption of the EU Floods Directive[2] which takes a risk based approach. This requires the EU Member States to develop three essential work areas. These are 1) flood risk assessments to identify flood prone areas, 2) flood mapping comprising flood hazard maps and 3) flood risk maps. These items provide the necessary basis on which informed decision making can take place on the third subject: the flood risk management plans.

Flood risk assessments are based on readily available information and studies on long term hydro-meteorological developments, in particular impacts of climate change on the recurrence of floods. The assessments include maps of river basins and descriptions of past floods and their impact.

Flood hazard maps and flood risk maps will be produced for river basins at an appropriate scale. These maps will indicate flood probability and return period, flood extent, flood water level and water velocity. They will indicate the number of inhabitants potentially affected, an assessment of loss of economic assets, and an assessment of other potential adverse consequences of future floods.

Flood risk management plans should take into account all relevant aspects such as costs and benefits, flood extent and flood discharge routes and areas, which have the potential to retain flood water, such as natural floodplains. Environmental objectives, soil and water management, nature conservation, spatial planning land use and navigation and port infrastructure are also considered in the plans.

Stakeholder engagement is an integral part of integrated river basin management in Europe and is a mandatory requirement under the Directives. All assessments, maps and plans should be made available to the public.

2.3 Integrated River Basin Management

A key lesson from Europe is the continued development and application of Integrated River Basin Management. The No.1 Document signals the need to shift focus of flood control from the mainstreams to tributaries and sub-catchments. Flood control engineering in one place may bring security but may also enhance flood risks downstream. The need for Integrated River Basin Management is further strengthened by the shift from heightening dikes to giving more space to the river through widening the river bed or creation of retention areas upstream.

[2] EU, Directive on the assessment and management of flood risks" (Directive 2007/60/EC)

In the EU the development of river basin management plans under the Water Framework Directive, and of flood risk management plans under the Flood Directive, are both elements of integrated river basin management. The two processes should use the potential for synergies and benefits taking into account the Water Framework Directive objective to achieve good ecological and chemical status, and ensuring efficient and wise use of resources.

Both directives require the appointment of competent authorities in order to ensure clear lines of responsibility for implementation and reporting. EU Member States must coordinate their flood risk management practices in shared river basins, including neighbouring non-member states, and shall in solidarity not undertake measures that would increase the flood risk in neighbouring countries.

In China there is a long history of establishing a specific competent authority to deal with flooding. For the Yellow River this was set up two thousand years ago, a comparable authority for the Yangtze River was established in 1925 and since the 1970s, competent authorities to harness the other five major rivers have been established. These approaches are useful in building relationships between provinces and across international river boundaries. Integrated river basin management is only possible when taking the stakeholder approach seriously. In China progress on stakeholder engagement has been made in the past ten years after the adoption of the principle “putting people first” and a scientific outlook on development.

2.4 Triple Layer Safety Approach

Modelling approaches are not confined to structural engineering, and integrated approaches to flood security emerge as the most effective way of reducing flood risk. Europe is further developing the ‘Triple Layer Safety’ approach proposed in the Netherlands.

The ‘Triple Layer Safety’ approach IS a new element of flood management. It is the systematic combination of three layers comprising 1) “prevention”, followed by two layers to minimize potential adverse consequences through 2) “protection” provided by local measures and smart spatial planning, and 3) “preparedness”, which relates to crisis management, evacuation and temporary flood protection measures, for instance enhancement of early warning systems and providing instructions to the public on what to do in the event of flooding.

Prevention will, as always, be the most important layer. Importantly, standards for flood prone areas will be renewed, looking to flood risks rather than flood probabilities.

The effective use of the second layer, especially through spatial planning, is limited by the extent to which development of new areas for housing and other activities are needed. In China these possibilities are large since it is expected that in the coming 20-30 years around 300 million people will move from the countryside to the cities, this being 20-25% of the total Chinese population. Pressure for development of land with good transportation potential will continue to be intense, particularly around cities and along the coast and rivers. In the short term, it will be financially attractive to allow industrial or residential development in floodplains or areas suited for flood retention. In the long run, however, it is much cheaper, both financially and socially, to avoid settlement in flood prone areas as much as possible. Examples are mentioned in DRC (2012).

Alternatively, it can be very efficient in economic, social and environmental terms to make more space for water. Such a broadening of the approach for flood risk management will result in the need for better cooperation, both horizontally (between ministries and departments) and vertically (between the various administrative layers: national, provincial, municipal, district, county, etc.). It strengthens the arguments for the stakeholder approach and integrated river basin management.

In general, the potential benefits of the "preparedness" layer are small in comparison to the benefits of an efficient level of protection in the first layer, because it only mitigates the consequences of a flood. Even if the total population of a flooded area could have been evacuated, the material losses will be large. Therefore, measures in the third layer may never be used as an argument to lower the protection level beneath the level indicated by efficient standards.

However, as long as the suggested enhanced standards are not adopted, and/or flood defences are not in compliance with the standards, the more urgent and effective the non-structural and managerial measures in the third layer can and must be.

2.5 Making space for water – Creating Room for the River

Strong dikes are only one way of protection. Lowering water levels in the main rivers under extreme conditions by enlarging the discharge profile or increasing the upstream water storage can be an effective alternative.

Protection from floods by repeatedly increasing the heights of dikes has its limitations both from a technical and a spatial planning perspective. This is especially true for urban areas, where dikes are built close to the river's edge to create more space for urban development. Heightening dikes will require more land or special construction techniques. In addition the flood risk is increased in case of dike failure, as the damage caused by the devastating power released by the higher river water levels.

Increasing the stream profile by widening the river bed or the space between dikes is not yet common, but already widely practiced in the Netherlands in the "Room for the River Program". This is achieved even with the Netherlands being one of the most densely populated countries in the world. A small scale variant of this is to reconnect rivers to their flood plains and allow seasonal flooding wherever possible in order to harvest the benefits of floods. These solutions can be achieved, if flood risk management becomes a core element of spatial planning together with the creation of urban development opportunities.

Making space for rivers is also ongoing in China, especially after the large floods on the Yangtze River in 1998 (CPCCC, 1998). The first major retention basin was built on the Jinjiang sector of the Yangtze River already in 1952 as supplement to the natural storage provided by the Dongting Lake upstream from Wuhan and the Poyang Lake upstream of Nanjing. Also the Yellow River has a major retention basin along its lower reaches. In Europe small retention basins can be found along the Rhine River in Germany and the Seine and Loire Rivers in France.

The concept of making space for water will become even more important in China as flood control shifts from structural to integrated options with more emphasis on the tributaries, as flagged in the No.1 Document. In many cases these tributaries pass through cities and towns. This will bring major

challenges and opportunities. In these situations it will be even more important to link urban development with flood risk management through appropriate spatial planning with a long term view. In addition, use of innovative approaches, alternative technical solutions and soft engineering will be essential. Use of socio-economic cost benefit analysis, with a long term perspective in mind, will be needed to identify the most cost effective options.

2.6 Economic Assessment Models

Dedicated modelling methods for economic assessment of flood risk, using the information just described, have been adopted to optimise and enhance flood security in the Netherlands. These models focus on expected loss (flood risk), not only the probability of flooding. This cost benefit approach to calculate efficient protection standards is described in RBMP Technical Report 072 Efficient Safety Standards for Ring-Dike Areas. In the long run, the derived standards are assessed as the most efficient ones, taking all costs of infrastructure improvements and all benefits of reduced flood hazard into account, irrespective whether these costs and benefits are financial or non-financial.

The fundamental recommendation is that recurrence intervals of efficient standards for flood risk management should be proportional to the potential loss by flooding. When the potential loss becomes larger, then the recurrence interval should be increased by the same factor. The national standards for flood control in China established in 1994 may have been the right standards for 1994, but they would certainly not be the right safety standards for 2012. It is possible to illustrate this statement with some statistical figures. Between 1994 and 2011 real GDP has grown by a factor of 5.3. All other things being equal, the recurrence intervals given in the 1994 standards should by 2011 have been increased by factors ranging between 3 for low density rural areas to 9 for big cities. Also on average, the losses by flooding in China are a relatively high percentage of GDP (DRC, 2012). This also indicates that the standards are too low compared to current wealth at risk. As in the Netherlands, the standards are outdated and need revision.

Moreover, it has to be taken into account that an industrial society is less resilient to flooding than a rural society. The flooding in Thailand in 2011 is a recent example. The flood water was not excessively deep, but completely incapacitated a large part of Thailand's industry for many months, and in some cases for more than a year. The linkages between industrial facilities all around the world are critically important and a breakdown in one location seriously affects other locations up and downstream in the production chain. In "Current Situations and Challenges of the System on Flood Control in China" (DRC, 2012) the same type of remarks are made, also referring to the increasing vulnerability of cities and the steady increase in the amount of losses per flood.

The approach proposed in RBMP Technical Report 072 "Efficient Safety Standards for Ring-Dike Areas" provides a very different perspective to the flood safety standards currently in use in China, which have been in place since 1994. Since then the vulnerable assets in China have increased considerably and therefore the standards are in urgent need of review. This is further emphasised by the increasing risks from a changing climate, the increasing population and the continued migration into cities. An adaptation of this methodology would bring great benefits and would provide an opportunity to review flood security standards in a progressive way.

2.7 Flood Engineering Project Appraisal

Through the No.1 Document, China is committed to significant expenditure on improving flood security and budgets have been increased. A large number of engineering projects will be brought forward for funding and construction. It will be important to assess the cost effectiveness of these engineering projects against a set of agreed national criteria and thus allow a ranking in order of priority.

The cost benefit approach outlined above can also be used for project prioritisation and optimisation of projects included in the No.1 Document implementation. Before projects are given the go-ahead they should clearly meet the required and agreed levels of protection. These should meet a set of recalculated efficient protection standards or show clearly how these could be achieved in a phased way. Adaptive water management scenarios and flexible engineering solutions can help to deal with the uncertainties of climate change. In this way the requirements of the No.1 Document can be achieved in the most cost effective way.

UK has an agreed system of approval for national flood risk programmes and projects to achieve the standards and levels of protection agreed by government. The Environment Agency lists and prioritises according to agreed principles and the Minister is invited to make a decision based on available budget.

Such a procedure will ensure that the most effective schemes go forward and the outcomes of the No.1 Document are realised. A development of the proposed financial modelling approaches would allow objective project appraisal to be undertaken and assessed against a broader flood risk management approach.

Setting flood protection levels in terms of probability of flooding or in financial terms within the national budget will, eventually, always be a political decision to be taken within the context of the entirety of priorities set by the government, this being Chinese or European.

3 Strategy Analysis for Water Resource Security

The Strategic Analysis for Water Resource (Supply) Security outlined in this chapter has been developed to provide a structured approach to deliver the challenging requirements of the No.1 Document and its “Three Red Lines”. The chapter draws together water resource planning experience from both China and from the EU to set out a strategic approach to how these challenges can be met.

For many centuries management of water has been a recurring priority for successive Chinese administrations. This has been achieved through policy and administrative instruments such as water drawing permits and water allocations, combined with the construction of infrastructure at all scales from the river basin to irrigation districts. The No.1 Document introduces a possible break with this tradition by specifying the introduction of differential water prices and demand management tools.

3.1 Key Messages

For water resource supply security, **a change to a proactive risk management approach to water resource planning should be adopted**, rather than the more reactive approach that is currently followed. In addition, drought management responses should be based on robust and up-to-date knowledge of the status of available water resources, so that any reductions in water allocations for the duration of the drought are proportionate and recognise the relative priorities of each sector.

The general trend in international strategic water resource planning has been to move towards more risk management approaches, recognising increasing fluctuations in hydrological conditions, rather than a more reactive approach based on historical data and dealing with the issues when they occur. The concept of drought risk management is based on the knowledge that drought will recur, that its characteristics will vary in time, space and scale from droughts previously experienced, and that preparation for managing droughts is based on robust and up-to-date knowledge of the status of available water resources and future demands (both in the short and long-term), and that administrative mechanisms are available to implement the necessary actions.

The principles behind this strategy are:

- To move from a reactive to a pro-active approach to water management in those years with drier than average conditions. This will reduce risk and hence vulnerability to drier than average conditions

- To develop an effective knowledge base of robust hydrological, hydro-geological and meteorological data, combined with analytical tools to support strategic planning and when necessary drought management responses

- To provide clear targets of water use efficiency against which the performance of the major water users can be monitored and addressed

- A competent authority will be identified to initiate the necessary administrative and regulatory changes, to monitor performance against water drawing right conditions and targets, and to take disciplinary action where necessary and warranted.

- Moving from the current position of separate technical studies into a coherent and integrated water resources planning strategy that can be delivered in practice to meet the requirements of the No.1 Document requires a combination of further technical analysis building on existing work combined with institutional and other administrative changes. At present there are different agencies at national, river basin, and provincial level with responsibilities and interests in the water resources sector. Each has a very different sphere of responsibility and capability to influence decision making. MWR for example has the leading role in water planning, particularly for surface waters, whereas the management of groundwater also falls under the Ministry of Land and Resources.

The following chapters set out possible approaches to water resource planning that could be followed in China to help delivery of the water supply security objectives of the No.1 Document in a timely and effective manner. These approaches are drawn from European experience in delivering the requirements of the WFD. Priorities for action are identified, together with possible pilot projects to test and ground truth the proposed approaches drawn from European experience, so that these can be adapted to be appropriate for circumstances in China.

3.2 EU Water Framework Directive

The Water Framework Directive (WFD) brings together earlier, piecemeal water legislation both at EU level and from across the EU Member States. It provides the framework that enables integrated and co-ordinated management of all waters through:

- management of water on a river basin scale, requiring the management of land as it affects water and water dependent habitats)

- a combined approach for the control of pollution, setting emissions limit values and water quality objectives

- the development of ecological objectives

- a risk based approach to protection and restoration of aquatic environments

- an adequate contribution of the different water users, particularly industry, households and agriculture, to the recovery of the costs of water services

- encouraging active involvement of all interested parties in water management.

Each of the EU Member States has approached implementation of the WFD from a different starting point, both in terms of pre-existing regulatory and administrative arrangements, the structure and ownership of water utilities, and the scientific and technical background of the organisations with interests in surface water, groundwater and water management. The individual approaches taken have been informed by a Common Implementation Strategy (EC, 2000), which through a series of pilot studies and other investigations over time has developed a series of agreed scientifically based methodologies for analysis and interpretation. These methodologies continue to evolve, drawing on the experience of the first round of River Basin Management Planning.

It is envisaged that a similar programme of research and development, tested in a number of pilot studies will be required to ensure a co-ordinated and cost-effective approach to implementation of the No.1 Document.

3.3 Situation in China

There is an extensive body of technical and planning work related to water resources available in China through MWR, DRC and the academic sector, and also internationally through the European Union, World Bank, Asian Development Bank, UK Department for International Development, and other funding agencies. This work provides a solid foundation for the new approach to planning for water resource security that is required to meet the objectives of the No.1 Document.

In terms of water resource security, these objectives are enshrined in the first two of the Three Red Lines, namely:

- The first red line sets **water quantity** objectives in rivers, lakes and groundwater. It requires the "total quantity control of water abstraction" namely less than 635 billion m^3 in 2015 and 670 billion m^3 by 2020

- The second red line sets objectives for **water use efficiency**. This will require strict water demand management by strengthening of existing administrative instruments such as stricter water use quotas in combination with differential water pricing for high water consumption industries and the service industry.

- The third red line sets objectives for **water quality** by demands on reduction of pollution loads within the assimilation capacity of Water Functional Zones (WFZ) of rivers and lakes.

The recurring theme from the range of reports on China's water resources (ADB, 2012), is the change in emphasis from supply-side options to address an increasing imbalance between available supplies and forecast demands towards demand-side options requiring much more effective use of water to be achieved through targeted water use efficiencies and differential pricing.

The literature reviews undertaken as part of the SKE have highlighted the opportunity for more transparent assessment of the water resources available not only under average, but also under more extreme conditions. The reviews have also identified the need to assess and quantify uncertainty in calculations of water resource availability so that the risk to supply security is better understood. This would facilitate a more robust approach to water allocations, and decisions about restrictions on water

use in allocations at times of drought. Such water resource assessments are also needed for setting discharge standards and environmental flow objectives, so the strategic approach to water resource security set out in this paper needs to be viewed in the context of the approach set out in the chapter on Water Ecological Security.

3.4 Balancing Water Resources, Supply and Demand

The key elements that are required before a risk-based approach to water resource security (i.e. drought) can be successfully implemented are:

- Evaluation of current water resource availability, including both surface water and groundwater, and its variability in both space and time
- Evaluation of current water demands including water use efficiency and wastage
- Forecasts of future demands and sensitivity to different water use efficiency assumptions
- Real-time monitoring of water resources
- Water allocations that take account of the relative priorities of each sector

3.4.1 Assessment of Water Resource Availability

The fundamental requirement for any water resource plan is a robust assessment of the water resources that are available to sustain economic and social well-being once the environmental requirements for rivers and lakes have been met. This is embedded in the Chinese characterisation of a “Healthy River” as a water body which is able to satisfy human demands while safeguarding the water ecology.

Whilst assessments for a whole river basin can provide useful macro-level statistics, such averages can hide smaller areas, which in China can be far upstream, which are characterized by very high water insecurity due to dependence on rainfall. Choosing the appropriate spatial unit for analysis, interpretation and dissemination of the outputs is an urgent initial priority. Under the EU WFD River Basin Districts are the main units for management of River Basins. It may be that the Water Function Zone used for the Strategic Analysis Paper on Water Ecology Security is also the appropriate spatial scale for the analysis of Water Resources Security.

Assessments of water resource availability using historically observed data are required for both surface water and groundwater sources under:

- Annual, wet season and dry season under average conditions
- Annual, wet season and dry season under dry season conditions with a return period of say 1 in 10 years
- Long-term variations of groundwater levels which respond slowly to climatic variations and changes in abstraction.

The potential impact of climate change on these assessments also needs to be quantified.

Surface water

Current hydrological analysis used to determine water resource availability in China use standard hydrological analysis of historical data to assess the water available at different probabilities. In contrast, it appears that water allocations are based on average conditions and will therefore tend to be too high for about half the time when hydrological conditions are drier than the "average" year. In such circumstances, that may not be classed as "drought", some form of rationing and/or cutting back on water allocations may be required to prevent unsustainable levels of abstraction.

The hydrological analyses also appear to be based on a relatively short period of observed flow data – for example the average statistics quoted in the 2011 China Water Statistical Yearbook (Table 1-3) are calculated for the period 1956 to 1979. Note that the 2nd National Integrated Water Resources Plan used data for the period from 1956 to 2000, however the statistics in the yearbook do not appear to have been updated accordingly.

Future work on surface water availability to underpin delivery of the first two red lines of the No.1 Document should therefore comprise:

- Providing water resource availability assessments for a number of different design conditions (for example based on the 1 in 10 year annual average flow, annual wet season flow and annual dry season flow), not just the average condition to be used for water allocation analyses
- Water resource availability assessments for different spatial areas within each river basin (some consolidation to achieve consistency between water resource zones and other zones used for water planning would be useful)
- Assessment of the vulnerability of these assessments to climate change
- Incorporation of results into a water resource GIS database in which other water and environmental indices can be incorporated.

Groundwater

Many reports highlight that groundwater resources (especially in Northern China) are becoming severely depleted as shown by a decline in groundwater levels and poorer water quality. It appears that groundwater abstraction often exceeds recharge rates, and in some areas it is non-renewable fossil groundwater that is being abstracted.

Various academic papers (Appendix 1 and Appendix 2) suggest that China's groundwater resources are the subject of continuing technical and academic research, but the interpretation of the results and their integration into strategic water resource planning is not apparent.

Groundwater reacts slowly to inter-annual changes in rainfall and recharge and is therefore a valuable strategic resource available to balance demands in years of water shortage or even drought, but it follows that these periods of heavy abstraction must be followed by periods with low abstraction to enable recovery of the groundwater levels.

Future work on groundwater to underpin delivery of the first two of the Three Red Lines should therefore comprise:

- Confirmation of the spatial extent and boundaries of the main aquifer units, both those being actively recharged and those with no current recharge
- Identify areas with shallow aquifers that coincide with actual or potential flood detention basins that could serve the dual purpose of groundwater recharge basins
- Estimates of annual average recharge to the main aquifer units, under a range of rainfall conditions, for example average, 1 in 10 years, etc.
- Estimates of annual average recharge under different future climates
- Areas with physical characteristics amenable for groundwater recharge schemes
- Development of GIS application to hold time-series and spatial data on groundwater levels, groundwater quality, and overall abstraction.

3.4.2 Water Requirements

Demand forecasts are required by different organisations for a range of policy, strategic and operational purposes. The end use of the forecast will determine the spatial scale of the analysis, the number of different categories of demand (for example domestic, industrial, service, etc.) and the time horizon over which the forecast is calculated.

For the development of the Water Resources Security Strategy estimates of current and future water demands, including the returns to the water environment for non-consumptive uses, are needed for the following main categories of use:

- Public water supply; both urban and rural
- Environmental flows to be maintained downstream of points of abstraction
- Irrigated agriculture, both large-scale (predominately through diversion of surface water) and for small-scale local schemes often supplied from groundwater
- Direct abstractions for industry, not supplied from public water supplies
- Hydropower
- Navigation.

The high-level demand forecast model appropriate for strategic water resource planning needs to be able to take account of different assumptions about socio-economic growth, unit water consumption (for example per capita consumption and consumption per unit of industrial output), cropped areas and water efficiency targets. Estimates of the actual consumptive use, and hence of the volumes returned to the water environment through wastewater treatment plants and/or direct discharge are also required.

The models also need to be based on agreed spatial scales (for example Water Function Zones) which can then be aggregated to give forecasts at Provincial and River Basin scale. Further details of the required functionality of such a model are given in the Technical Report. Such models have been developed and applied to assess urban infrastructure investments under the EU WFD, while a river basin water allocation model currently is being developed for the Aral Sea and its tributaries.

The requirements for environmental flows are discussed elsewhere and the requirements for navigation and hydropower fall outside the scope of this strategy analysis.

3.4.3 Planning Water Resource Allocations

The approach to planning of water resource allocations is one of the main aspects of water resource planning, where there are significant differences between current practices in the EU and in China.

As noted in Section 3.2 the approach in Europe has evolved in the different Member States over many years and is now enshrined in the WFD. The WFD requires that abstractions should only be permitted at the level that does not cause the water body to fail the appropriate classification. A database of flow at the selected assessment points (typically the downstream point of each river basin) is created to represent the naturalised flows (that is flows unaffected by abstractions and/or discharges upstream. Such a database typically comprises historic data and also data to take account of future uncertainties such as the impact of climate change.

The environmental flow requirements at each assessment point are then calculated in a separate exercise. In order to protect the water environment during drier than average years, estimates of the flow required to maintain target environmental conditions are required. The volume of water available for abstraction is then the difference between the total water resources available and the environmental flow. This is then compared against the total volume of the existing abstraction permits (in China called “water-drawing permits”) and the volumes taken in recent years (called “recent actual”). If the aggregated permits exceed the water available for abstraction, this indicates that measures are required to reduce the total licensed quantity.

The current approach in China is to assign water allocations on the basis of average water resources availability. This means that half the time, there is insufficient water available to meet all the allocations in full, so that some degree of rationing will be required.

Water allocations should therefore be made on the basis of the water resources available with a return period of 1 in 10 years.

3.4.4 Economic Analysis

In the past, water resource planning has tended to rely on the construction of new infrastructure to meet increasing demands. Building supply-side infrastructure to meet unconstrained demands is no longer considered to be sustainable. In recognition of this move to supplement supply-side measures with demand-side measures, the No.1 Document sets out certain high-level targets for water use efficiency, and introduces the option of differential water pricing within and between sectors. This will require setting priorities for water use, with environmental requirements and urban water supply given the

highest priority, followed by the industrial and agricultural sectors, with essential industries given higher priority and each sector ranked according to the economic value of water within the sector.

In order to set appropriate priorities, a different approach to economic analysis, water pricing and allocations is required to provide a robust basis for planning as well as for operational responses to drought conditions as and when they do occur. The approach comprises:

- An increased use of appropriate economic assessment tools that can improve the decisions to be taken, since they provide a more complete picture of the existing and projected situation and possible consequences of action
- A more coherent approach to water pricing that considers financing, incentives and also the price elasticities of water demand at the sectoral and regional scales.

Economics is a cross-cutting theme with links across the Three Red Lines of the No.1 Document, so the appropriate use of economic assessments to evaluate and compare alternative strategic options is important for all three. For water resource security, demand management is crucial and the use of water pricing should be considered as one of the key elements of water demand management.

3.4.5 Uncertainties and Risks

Drought and floods are natural occurrences; the magnitude of both types of these extreme events can be mitigated to some extent by risk management, which includes elements of forecasting and pro-active responses to events as they develop. Whilst pro-active flood management now is the norm in China, water resource management in years with less than average rainfall and particularly under drought conditions is much more reactive. This type of response to events is no longer tenable especially given the recent shift in balance between rural and urban populations which will continue.

This means that the impacts of drought no longer have a disproportional impact on rural areas which are more reliant on local water resources and rain-fed agriculture, but will have greater impact on national food security. The increasing scarcity of water resources is leading to increased competition for supplies. At present, water allocations appear to be based on average conditions; the hydrological conditions experienced in China mean that the aggregate total allocation will be greater than the available supplies.

So there is increasing pressure for the development and implementation of robust and transparent water allocation processes that are based not only on “normal” hydrological conditions, but on a hierarchy from just drier than average conditions to extreme drought. Such variability will be enhanced by the impacts of climate change.

3.5 Priority for Action

As noted in other documents, the No.1 Document and the EU Water Framework Directive have much in common though being characterised by important differences in the administrative and legal context of China, the EU as a whole, and each of its Member States. One important common element is that the changes required to deliver the objectives of the No.1 Document on the one hand and the WFD on the other will take time to implement consistently across all river basins.

Experience suggests that a stepwise approach can be very effective to allow the technical methodologies to be properly developed, tested and where necessary refined in pilot studies, before they are rolled-out on a countrywide basis. Most innovations in the water sector in China are based on this approach, for instance the DFID supported Water Resources Demand Management Assistance Project and the on-going MWR pilot on introduction of bio-monitoring. For other studies appropriate approaches will need to be developed from scratch, drawing on existing Chinese and EU experience and best practice.

1st Phase: Urgent Initial Improvement during 12th FYP (2012-2015)

The focus of this phase will be to integrate the water resource availability, demand forecast and water allocation activities currently being undertaken by different government, provincial and other agencies. This will require:

- Updated assessments of water resource availability using consistent approaches across all China, covering both surface and groundwater systems
- Assessing the risk to long-term water resource availability under different future climate changes
- Compilation of high-level demand forecasts for the key sectors with clearly defined assumptions on water use efficiencies
- Development and pilot testing of economic assessment tools
- Development of water charging schemes and incentives for efficient water drawing permits
- Assessment of the absolute costs and benefits of achieving water use efficiencies
- New water allocations based on the water resources available in the 1 in 10 dry year
- Integrate water resource security strategy with other strategic aims
- Design of a decision support tool to inform water allocations, drought responses and disaster responses
- Design of pilot projects to be implemented during Phase 2 to develop and test the operational response to drought.

In addition to these quantitative elements of water planning, the risk to drinking water supplies needs to be addressed through the country-wide adoption of Water Safety Plans.

2nd Phase: Medium Term Improvements during the 13th FYP (2016-2020)

Building on the outputs from Phase 1:

- Implement the water allocation and drought management decision support system in pilot river basins or catchments
- Implement new charging scheme for water drawing permits across China

- Monitor effectiveness of intervention options
- Update intervention options as required in the light of experience from the Pilot Studies.

3rd Phase: Fulfilment of the No.1 Objectives during the 14th and 15th FYP 2021- 2030

Review the strategy for Water Resource Security in the context of the other technical strategies, refine where necessary and develop new programme for monitoring and regulation:

- Update and refine where necessary underlying water resource assessments
- Test observed water body status against targets to identify quantity and/or quality measures to achieve compliance
- Review and update where necessary water use efficiency targets.

4 Strategy Analysis for Ecological Security

The No.1 Document and the "Three Red Lines" water resources policy objectives defined by MWR is a formidable and unique water resources challenge unprecedented in the world. The EU on the other hand has accumulated an unmatched wealth of good policy practices aiming at controlling water use and pollution discharge and securing a high level of water resources protection across the union. The objective of this Strategy Analysis of Water Ecology Security is to provide MWR decision makers with an insight into the rationale for policy action desirable to successfully implement the Three Red Lines defined in the No.1 Document based on EU experience with good policy practices.

4.1 Key Messages

Based on an assessment of the current Chinese practices for water resources protection and water ecology security and a comparison with EU and EU Member State policy experience in the field, the success of the Three Red Lines policy under MWR is expected critically to hinge on the capacity of the Chinese government at all levels (central, provincial & local) to thoroughly and effectively monitor and enforce the policy.

Currently the Chinese regulations for permitting of water abstraction as well as wastewater discharge into water bodies do not enable adequate monitoring for compliance and enforcement. The required permits are not integrated (quantity, efficiency and quality) and more critically, the permits are too simply worded and do not cover in adequate unambiguous detail and precision the obligations of the permit holder with regard to Emission Limit Values (ELV), mixing zones, Best Available Technologies (BAT) requirements, monitoring and inspection, reporting requirements, sources and data to be reported, specific changes in operating conditions, which would require a reassessment of the permit, penalties to be incurred in case of breach of permit, and more.

In the EU an integrated water permit will be written by experienced inspectors who in very great detail and unambiguous precision will specify the obligations of the permit holder. It is this attention to detail and the unambiguous precision in the written permit drafted by an experienced inspector, which makes all the difference, when it comes to compliance inspection and enforcement procedures.

The key message is that to enable effective compliance and monitoring of the achievement of the Three Red Lines policy, a new water resources regulatory process, having at its core **a new integrated "Water Resources Impact Permit" for water users and pollution dischargers, and merging the three dimensions of the Three Red Lines (water quantity, water use efficiency, water quality), is an absolute necessity**.

- **1 operator**
  Every operator, or enterprise, using significant quantities of water or causing significant discharge of wastewater into receiving waters is allocated “Three Red Lines Targets” for quantity, use efficiency and quality.

- **1 permit**
  Every operator allocated Three Red Lines Targets is subject to a new “Water Resources Impact Permit” process controlled at the central level allowing for unambiguous and strictest reporting, monitoring and enforcement as required by the No.1 Document.

- **1 competent authority**
  Every operating site allocated Three Red Lines Targets is subject to mandatory periodic inspections coordinated by a single competent authority in charge of water resources protection to control compliance with the requirements of the Water Resources Impact Permit.

The new permit is an integrated permit in the sense that it merges targets for: 1) water abstraction, 2) water use efficiency and 3) wastewater discharge.

The permit should 1) describe the conditions under water users or polluting operators, or enterprises, are allowed to operate, 2) define practically enforceable conditions for water abstraction and wastewater discharge limit values reflecting the environmental quality and pollution prevention objectives, and 3) document unambiguously and precisely pollution control and prevention measures as well as monitoring and reporting obligations of the operator with timetables that can be monitored and enforced by local authority.

The new permit should balance fairly and effectively, the reward (incentive for the use of new innovative water efficient technologies) and the punishment (administrative and judicial enforcement through civil and criminal pursuits for offenders).

In the EU such integrated permit instruments were introduced in the 1990”s. These were accompanied by strong and fair enforcement mechanisms that effectively remove the economic benefit of non-compliance. **These permits have been the most important policy tool to effectively reduce the pollution of water bodies and start a positive circle of water ecology protection and improvement in the EU.**

4.2 Operators Subject to Permitting

Operators subject to the Water Resources Impact Permit would be limited to large industrial plants handling major quantities of water, pollutants and/or hazardous substances. In an initial phase this could be applied to the largest operators responsible for 40% of the water abstracted within in a Water Functional Zone (WFZ) or the generation of 40% of the untreated wastewater discharges into a WFZ. In a second phase, the coverage could be extended to the operators responsible for around 70% of the water abstraction or pollution discharges. The remaining lower tier (smaller) polluters, who would amount to 30% of water abstraction or generated pollution, could be exempt from the need for the new permit, but be subject to a mandatory “notification” of their operation to the competent authority to ensure they are included in the water resources impact system for regular monitoring.

Operators subject to the Water Resources Impact Permit process would be clearly specified by sector, or by the production quantity that would trigger permit requirement, in an annex to the policy. Operators would be given clear time windows to register with the competent authority, to apply for the permit and to implement the requirements of the permit.

The production sites covered would include all large plants consuming a significant quantity of water and/or discharging wastewater into a water body including:

- Energy industry
- Mining and mineral processing
- Production and processing of metals
- Chemical industry
- Other large production industries such as pulp and paper, slaughter houses, dairies, big livestock farms, major food processing and brewery industries
- Municipal water, wastewater and solid waste management facilities.

Operators handling hazardous substances would be subject to additional requirements within the same new integrated permit system to reduce risks of pollution hazards. Operators subject to these added requirements would be defined precisely in other annexes of the policy through the specification of thresholds that may be handled, either for generic hazardous substances in line with international classification (explosive, oxidizing, flammable, toxic, dangerous, etc.) or for particularly toxic or dangerous substances.

The competent authority shall issue clear guidelines on the categories of water users required to complete the permit process each year and the thresholds in terms of water use volume and discharge flow and load. Operators requiring the new permit would have to notify the regulating competent authority to ensure the authority has a complete list of operators without the inspectors having to search for them. Failure to notify would result in sanctions and eventually closure of the operation.

Rather than directly abstracting or discharging water to the environment themselves, many water users may take their water supply from a water company and / or discharge wastewater to a municipal sewer system and wastewater treatment plant. In such cases the user is still required to prepare a permit to demonstrate water saving, best practice in pollution prevention and compliance with the discharge standards to the sewer system, agreed with the water treatment company. However some sections of the permit would be devolved to the water company and incorporated in their overall permit requirements.

4.3 Scope of the Water Resources Impact Permit

The Water Resources Impact Permit may be issued as a new “state level” permit to operate, that with time could replace existing provincial or local level permits.

To acquire a permit, an operator will have to submit to the regulating competent authority an "application" providing extensive information on abstraction of water, processes involving water and discharge of wastewater. The competent authority would check the application validity and assess to what extent the information submitted is complete. Issues of commercial confidentiality would be considered and respected when justified, but complete information would have to be submitted by the operator so a thorough and complete permit can be assessed and issued.

Part of the information required in a permit application would be a water resources impact study, which should document:

1 The extent of the potential impact, including geographical area and size of the affected population

2 Any effects on specifically protected areas, species or other assets of particular significance

3 The provincial trans-boundary nature of the impact

4 The magnitude and complexity of the impact

5 The probability of the impact

6 The duration, frequency and reversibility of the impact.

Operators handling hazardous substances would be requested to submit additional information concerning the risk and potential impact of an accident, such as safety measures, a safety plan and an emergency response plan, worked out by independent experts certified by the relevant competent authority.

The permit issued by the competent authority would require the cooperation of a group of experienced permit writers well versed in inspection and enforcement covering the Three Red Lines Targets (water quantity, water use efficiency and water quality). Through the extensive use of check-lists, guidance documentation and negotiation between experts working for the competent authority and the applicant, agreement would be reached on upgrading or replacement of technologies that would be implemented by the applicant operator over specified time period to ensure impact reduction targets are met at clearly specified deadlines. These necessary changes and their timing would be written into the permit.

The new permit document would be a substantial document specifying in detail:

- The receiver of the permit (operator production site)
- The scope of the permit (all water handling processes at the production site)
- Clearly defined and specified list of obligation of the permit holder in terms of water abstraction quantity, water use efficiency, wastewater treatment and discharge
- Full analysis of water resources availability, impact of abstraction on water resources sustainability and compliance with water allocation quotas.

- Water use limits appropriate to the type of industry and volume of production representing best practice in water use efficiency.
- Emission limit values to be fixed for every relevant pollutant and considered as best practice for the relevant process and production
- Expected receiving water quality and specified mixing zone, location of receiving water functional zone monitoring point, assimilation capacity of receiving water, with assumptions used in its calculation (flow, velocity, decay coefficient, temperature, etc.)
- The flows and loads in the discharge and receiving waters to be used as the basis of calculation of impact and likely compliance with receiving water quality at the downstream control point
- Full water resources impact assessment using river water quality modelling systems to verify the calculations and assess the impact in relation to other abstractions and discharges in the area
- Statistical means of assessing compliance or failure with abstraction, discharge and WFZ standards for flow volume and quality
- Efficient technologies to be progressively introduced and the timing of their introduction
- List of requirements to be implemented by the operator as well as by the authority responsible for monitoring and reporting
- Special and detailed obligations concerning all important inspection procedures especially regarding continuous and discontinuous measurements
- Rights of access for regulatory inspectors to access the production site and take samples without advance notice
- Temporal limitation of the permit
- Costs of inspection
- Penalties to be incurred in case of breaching the permit conditions
- Requirements and plans for monitoring and reporting water use and discharge flow and load.

If the above considerations indicate that operations will impact water resources negatively, although meeting best practice production standards, then tighter requirements for water use efficiency and pollution load discharge may need to be negotiated to satisfy the objectives of the Water Functional Zone within an agreed timetable.

The permit would be reviewed and updated each time the operator changes processes or increases process capacity, within specified limits defined and documented in the permit.

4.4 Competent Authority

To ensure the water resources impact permit satisfies the objective of compliance with the Three Red Lines Targets, the permit should be coordinated and supervised by a single competent authority at the national level.

Depending on the size and potential impact of the production site requiring the new permit, the permitting could be handled by a local representative office of the central level competent authority.

The main functions of the competent authority would include the following:

- Issue the policy and publish nationwide the request for relevant operators to notify the competent authority
- Process the notification received by the operators and ensure validity
- Submit application forms to notifying operators with deadline for submitting their application for the Water Resources Impact Permit
- Check completeness of application received
- Coordinate the participation of other special authorities and experts in the permit assessment process to cover the Three Red Lines Targets (water quantity, efficiency and quality)
- Coordinate the consultation and participation of the public in relation to the review of the water resources impact study and the Environmental Impact Assessment (EIA)
- Evaluate whether the preconditions to issue a permit are fulfilled
- Determine and coordinate the obligations to be fixed in the written permit
- Coordinate monitoring, inspection and enforcement.

In many developed countries this type of permit would be managed by the water directorate of the environmental agency or ministry. China is an exceptional case. Due to the historic importance of water quantity in China, but also the severe water quality problems facing China, the competent authority can be either MWR or MEP, or both decided on a case by case basis.

4.5 Phased Introduction of the permit

The establishment of a new national “Water Resources Impact Permit” at the scale and depth necessary for the No.1 Document successfully to achieve the targets of the Three Red Lines, will take time to develop in China. Important hurdles need to be overcome, including the qualification and experience of the professionals writing the permits, the establishment of dedicated representatives of the central level competent authority in the provinces and agreement on the penalties to be incurred by permits violators and legal enforcement rules to ensure swift processing.

Consequently a phased approach allowing the regulatory framework progressively to converge to an optimal and efficient status compatible with the three targets of the red lines is desirable.

Building on EU experience, it is recommended that the implementation of the No.1 Document starts first by addressing the largest and most heavy polluters in each WFZ. At that time, the capacity of MWR and other relevant authorities to issue a formal permit will not be available. It is therefore suggested that during the first phase of the implementation, the requirements imposed on the largest water abstractors or polluters within each WFZ are embedded in a formal "proto-permit" that allows strict enforcement without having the character of a fully fledged permit. This will enable testing of the practical permitting procedure and the progressive build up of the expertise and capacity by relevant authorities across the country to handle the fully fledged permit procedures required in a second phase without overloading the capacity of authorities and the operators.

The proposed implementation plan foresees three phases.

1st Phase: Urgent Initial Improvement during 12th Five Year Plan (FYP)(2012-2015)
The focus of this phase will be to significantly reduce large water abstraction and wastewater discharge at point sources by targeting a first tier of large operators representing the highest Three Red Lines improvement potential. The target is to achieve an overall cumulative improvement in the WFZs of at least 30% for each of the Three Red Lines.

During this phase the targeted companies will be selected by the competent authority based on WFZ water abstraction and pollution load scenarios, allowing identification of the highest improvement opportunities through regulation of a minimal number of operating sites in each WFZ.

During this phase the targeted operators will be asked, based on the documentation in the Water Resources Impact Permit, to agree on a "protocol" for Three Red Lines improvement allowing unambiguous and efficient monitoring, reporting and enforcement that subsequently will be negotiated between the operator and the competent authority. The development of these protocols, which will have character of "proto-permits", will allow the competent authorities to test the practical permitting process and procedures and prepare for the launch of formal permits in the second phase. The first phase will also contribute to build the capacity and expertise of competent authorities for permit coordination, writing and issuance and of clarifying rules and procedures for related compliance monitoring, inspection and enforcement.

2nd Phase: Establishment of the Water Resources Impact Permit during the 13th FYP (2016-2020)
In the second phase the attention will be turned to the second tier of the most significant abstraction and discharge point sources to harness the bulk (around 70%) of the excessive water abstraction, especially those depleting groundwater levels, and the pollution loads reaching water bodies. The Water Resources Impact Permit will be officially launched in a staged approach for each WFZ, addressing successive groups of operators starting always with those having the highest potential for reduction of water abstraction or pollution discharge, and those with the highest risk of accident hazards. During this period non-point sources will also start to be targeted through improved agricultural practices.

Finally during this phase the Water Functional Zones will be supplemented or replaced by "water ecological zones", which will be identified and documented based on the ecology, morphology and hydrodynamics of the river and the degree of artificial modification incurred so far. For these zones an

assessment of main pressures and impacts using as basis the WFZ scenarios, but now adapted to the newly defined ecological zones, will be developed and documented as basis for defining “good ecological status” objectives for all river bodies to be implemented in the third phase.

3rd Phase: Fulfilment of the No.1 Objectives during the 14th and 15th FYP 2021- 2030

At the beginning of the third phase, river ecological flows and water quality are expected to have been significantly improved to levels compatible with the establishment of genuine “good ecological status”. In addition the competent authority will, at that stage, have acquired experience and expertise in handling and coordinating an efficient and enforceable water resources impact permitting tool with enforcement capability. This will open the door for the fine tuning of pollution prevention and control in water bodies for any individual operator handling chemical substance considered a priority hazardous substance and deserving attention for reduction as part of the Environmental Quality Standard (EQS) improvement process. This third phase will then focus on incrementally improving and restoring the ecology of the water bodies using instruments and tools similar to the ones defined and applied in the WFD in the EU.

4.6 Inspections, Incentives and Penalties

Inspections are the most important element of enforcement and compliance efforts. Under the new permit, stronger and more thorough inspections would need to be deployed to all permit holding sites. Inspection should be conducted by government inspectors, or by independent agencies hired by and reporting back to the responsible enforcement agency. There are a number of different types of inspection activity that need to be deployed for effective compliance monitoring and enforcement of the Water Resources Impact Permit.

Among others the following inspection types may be considered:

- *Walk-through inspection*
  A walk-through inspection provides a quick survey of general issues, e.g. control equipment and working practices. This type of inspections helps to determine whether more extensive inspection is needed. These inspections can be announced or can also be unexpected.

- *Compliance evaluation inspection*
  Compliance inspection involves an intensive examination of a particular technological process or a whole facility, but does not include sampling. It would consider records, interview staff, review self-monitoring data, examine control equipment, etc.

- *Sampling inspection*
- Sampling inspection includes the visual and record examination described above, but also includes collecting and analysing physical samples. This is the most resource intensive type of inspection.

Criteria to decide on frequency and type of inspection would include:

- The potential hazard of the production to water bodies

- The complexity of the inspection needed to evaluate compliance
- The history of the operator in relation to compliance
- The availability of self-monitoring information
- Specific inspections resulting from accidents or requests from the local population.

Inspection of a production site should systematically lead to an inspection report specifying:

1 Does the operator have an accurate permit?
2 Is the correct water consumption and pollution release monitoring equipment installed?
3 Is all monitoring equipment properly maintained and accurately operated?
4 Are all records properly maintained?
5 Does the plant comply with all emission limits and other operating conditions?
6 Is the plant implementing agreed upgrading requirements?
7 Does the management plans include compliance requirements?
8 Are there any signs of deliberate falsification of records, equipment, etc?

Incentives under the new permit are essentially the access to innovative and efficient technologies that allow an operator to lower its water consumption, minimize pollution release and improve productivity, quality and efficiency, leading to lower cost and higher profitability. Through the integrated nature of the permitting process, regulatory experts can assist the operator to obtain access to best available technology adapted to its specific process and production situation.

The penalty system for the enforcement of the Water Resources Impact Permits needs to be effective, proportionate and deterrent. Effectiveness means that penalties are sufficiently serious to ensure a high level of compliance with the policy and achieving the desired objective. Proportionality implies that penalties adequately reflect the seriousness of the violation and do not go beyond what is necessary to achieve the desired objective. Effectiveness requires that penalties have a deterrent effect on the offender, who should be discouraged from repeating the offence and on other potential offenders to commit a similar offence.

Penalties should include a broad “toolkit” of civil sanctions for regulators to promote and enforce regulatory compliance. This may include fines or other financial sanctions, which should be sufficiently high to deter and combat non-compliance (current penalties are too low and ineffective) and the strengthening of statutory notices to work alongside criminal law rules for worse and repeating offenders.

4.7 Human Resources Requirement

Professionals involved in the permitting process and follow-up inspections under the new integrated permit will require extensive qualification and training to be able to deal with the large diversity of processes used by operators and the complexity of dealing with an integrated permit.

Entry level requirement should be high, preferably four years university degree or equivalent. Inspectors and permit writers will need extensive initial training up to 1 year including formal courses

self-learning and practical experience gained on-the-job under supervision by senior staff. Regulatory permitting and inspector staff should be subject to periodic professional evaluation of performance by superiors and be eligible for continuing professional development training to keep abreast of changes in technology, legislation, standards and management systems. Due to the great diversity of operator processes, the inspectors may need specialised training and knowledge of the range of production technologies involved. Finally the inspectorates should be equipped with professional quality management systems offering transparent mechanisms for assessing efficiency of procedures including training.

The number of production sites managed by inspectors should also be limited to allow thorough inspection. A number of sites between 30 and 100 per inspector depending on the nature and complexity of the production allowing for annual or quarterly inspection depending on the breadth of permit requirement.

Appendix 1

Appendix 1 RBMP Technical Reports on the SKE Study

Number	Title
T-072	Flood Risk Economic Assessment - Efficient Safety Standards for Ring-Dike Areas
T-073	No.1 Document Flood Security Analysis
T-074	No.1 Document Flood Security Strategy Analysis
T-075	No.1 Document Water Resource Supply Security
T-076	Water Resource Supply Security Strategy Analysis
T-077	No.1 Document Water Ecology Security Analysis
T-078	No.1 Document Water Ecology Security Strategy Analysis
T-079	Economic approaches in water management
T-080	Legal and Institutional Analysis for the No.1 Document
T-081	No.1 Document Strategic Knowledge Exchange – An EU Perspective and Overview
T-090	Potential Development and Research arising from No.1 Document Strategic Knowledge Exchange

Appendix 2

Appendix 2 Key References used in the SKE Study

All reference materials are available in the SDC Knowledge Repository.

ADB, 2008. Water Rights and Water Allocation – Issues and Challenges for the Region. Asian Development Bank.

ADB, 2012. Drying Up – What to do about droughts in the People's Republic of China. Asian Development Bank.

Barbier, E. B, M. Acreman and D. Knowler, 1997. Economic Valuation of Wetlands a Guide for Policy Makers and Planners, Ramsar Convention Bureau; IUCN-The World Conservation Union.

Berbel, J., J. Calatrava and A. Garrido, 2007. Water Pricing and Irrigation: A Review of the European Experience.

Bogaert, S. et al., 2012: The role of water pricing and water allocation in agriculture in delivering sustainable water use in Europe – Report to the European Commission.

Brouwer, Roy, 2005 (ed). Cost-benefit analysis and water resources management, Cheltenham, Elgar, 2005, 404 p.

CPCCC & SC, 1998. Opinions on post great-flood reconstruction, harnessing the rivers and lakes, and water infrastructure construction (ZF[1998]15),

CPCCC & SC, 2011. Accelerating Water Conservancy Reform and Development. CPC Central Committee and the State Council, Decision No. 1, 2011.

DRC, 2008. Management System on Water Abstraction Permit in China. Internal Memo, Furen Jiang, MWR Development Research Centre.

DRC, 2012a. Cooperation MWR-MEP in the Management of the WFZs. Internal Memo, MWR Development Research Centre.

DRC, 2012b. Current Situation of China Water Permitting, Internal Memo, MWR Development Research Centre DRC, 2012

DRC, 2012c. Current Situations and Challenges of the System on Flood Control in China. Internal Memo, MWR Development Research Centre.

EC, 1996, Industrial Pollution Prevention and Control Directive, 1996/61/EC. European Commission.

EC, 2000: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive). European Commission.

EC, 2003. Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Guidance Document No.1: Economics and the Environment – The Implementation Challenge of the Water Framework Directive. Working Group 2.6 WATECO.

EC, 2007. Directive on the assessment and management of flood risks", Directive 2007/60/EC. European Commission.

EC, 2009a. Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Guidance Document No. 20: Guidance document on exemptions to the environmental objectives. European Commission.

EC, 2009.b Impact assessment guidelines, SEC (2009) 92. European Commission.

EC, 2010e. Industrial Emissions Directive 2010/75/EC. European Commission (Replacing IPPC Directive).

Eijgenraam, C.J.J., 2007. From optimal to practical safety standards for ring-dike areas; "Water Science and Technology", volume 56, issue 4, pp. 113-124, (Journal of the International Water Association).

ENTEC, 2006: Valuing Our Natural Environment. DEFRA, UK.

ENTEC, 2010: Managing scarce water resources – Implementing the pricing policies of the WFD. Final Report. London. Report for the European Commission - DG Environment.

European Environment Agency, 2005: Market-based instruments for environmental policy in Europe. EEA Technical Report No 8/2005. Copenhagen.

European Environment Agency, 2009: Water resources across Europe — confronting water scarcity and drought. EEA Report No 2/2009. Copenhagen.

Government of China, 2002. Water Law

MEP, 2003. Management Measures for Collection Standard of Pollutant Discharge Fee. Ministry of Environmental Protection (SEPA).

MEP, 2009. China's Environmental Regulatory Framework: An overview on environmental governance. Ministry of Environmental Protection of China.

MWR, 2006. Management Regulations on Water Drawing and Licensing and Collection of Water Resource Fee. Ministry of Water Resources.

MWR, 2007. Hydrology Regulation of the People's Republic of China. Ministry of Water Resources.

MWR, 2011. China Water Statistical Yearbook 2011 (for 2010). Ministry of Water Resources, P.R. China.

NBRC, 2011. China Statistical Yearbook 2011 (for 2010). National Bureau of Statistics of China, P.R. China.

NDRC, 1998. Management Measures for Urban Water Pricing, National Development and Reform Commission.

SC, 1994. Standard for Flood Control. State Council, People's Republic of China.

SC, 2012. Opinions of the State Council on Practicing the Most Stringent Water Resources Management System. 2012 No. 3 Document. State Council, People's Republic of China.

WB, 2009. Environmental Flows in Water Resources Policies, Plans and Projects. Rafik Hirji and Richard Davis for the World Bank.