Ministry of Water Resources

Ministry of Environmental Protection

EU – China
River Basin Management Programme

Technical Report 077

No.1 Document Water Ecology Security Analysis

Philippe Bergeron (TOR 455) et al.

July 2012

EU-CHINA

Document Information:

Document No:	TR-077
Date of Draft:	25 May 2012
Date of Issue	31 July 2012
Author:	Philippe Bergeron Liu Hongxian Xia Peng
Checked by:	Lars Skov Andersen
Approved by:	Lars Skov Andersen

Table of Contents

List of Appendices

1 Main dimensions of water ecology security

Water Ecology Security in China is of particular importance considering the huge water resources challenges faced by the country.

China faces 4 main water resources challenges:

1 Shortage of water in the Northern and North-Western regions causing at times acute water scarcity in large urban areas such as Beijing, Tianjin, Shenyang and more

2 Excess of water in the South often leading to flooding

3 Polluted water all over China due to limited pollution control and large discharges of inadequately treated wastewater from from human settlements, industry and agriculture

4 Muddy water due to inadequate control of soil erosion in upstream catchments of most river basins.

All these four challenges dramatically affect the ecology of the water bodies in the country and therefore impact on the national ecology security. Climate change is expected to exacerbate the difficulties with more extreme rainfall events mostly between June to September, which see 60%~80% of the total annual rainfall. This leads to a growing mismatch between water availability and water demand especially in the North and the coastal areas, where the engines of economic development are located.

In the frame of this study, water ecology security in China can be rationalised into six dimensions which include:

1 Pollution prevention and control

2 Maintenance of environmental flow

3 Maintenance of groundwater levels

4 Restoring and sustaining river morphology and ecology

5 Watershed management with soil and water conservation

6 Wetland protection.

1.1 Pollution prevention and control

Pollution prevention and control may be the most critical issue because water pollution from human settlements, industry and agriculture impact negatively and may destroy the ecology of water bodies, some times in irreversible ways. *In the presence of severe water pollution no meaningful water ecology revival or restoration can succeed.*

Pollution sources comprise “point sources” where harmful substances are emitted directly into a body of water and “non-point source” when pollutants reach the water body through surface or sub-surface flows.

The most important pollution sources in China include:

- Sewage from human settlements
  Sewage from human settlements may be discharged into water bodies untreated, poorly treated or at the occasion of overflow of under-capacity sewer or sewage treatment systems. Sewage often includes personal-care products and household cleaning products such as laundry detergent, bleach, or fabric softener; window cleaner, dusting spray, or stain remover; hair dye, shampoo, conditioner, etc. Similarly when we take medications, we eventually excrete the drugs like antibiotics in altered or unaltered form, sending the compounds into the waterways.

- Chemical and Industrial Processes
  Chemical and industrial processes generate a wide variety of inorganic or organic wastewater, which if untreated before discharge into receiving waters make dramatic contributions to pollution and often are toxic to ecological life and biota in the water.

- Fertilizers & Nutrient Pollution
  Fertilizers and nutrients contribute nitrates, phosphates and similar nutrients into water bodies. Deposition of atmospheric nitrogen (from nitrogen oxides and ammonia) also causes nutrient-type water pollution.

- Pesticides
  Pesticides that are applied to farm fields and roadsides and that run off into local streams and rivers or drain down into groundwater contaminating fresh water resources.

- Mining
  Mining produces wastes that release heavy metals and other pollutants that previously were locked away in the earth. Rainwater leaches these compounds out of the exposed earth, resulting in "acid mine drainage" and heavy metal pollution. This also includes huge pools of mining waste "slurry" often stored behind containment dams that can leak or burst.

- Sediment
  Soil erosion takes place when forests are "clear felled". When the root systems that previously held soil in place die sediment is free to run off into nearby streams, rivers, and lakes and can seriously affect fish and other aquatic life. Poor farming practices that leave soil exposed to the elements also contribute to sediment pollution in water.

- Air pollution
  Air pollution can contribute substantially to water pollution. Pollutants like mercury, sulphur dioxide, nitric oxides, and ammonia deposit out of the air and then cause problems like mercury contamination in fish, acidification of lakes, and eutrophication. Most of the air pollution that affects water comes from coal-fired power plants and the tailpipes of our vehicles, though some also comes from industrial emissions.

- Heat
  Heat may also be a water pollutant. It causes increasing water temperatures which may result in changes to the aquatic ecosystems with the deaths of many aquatic organisms. These increases in temperature are most often caused by discharges of cooling water by factories and power plants.

The threats emanating from excessive pollution of water bodies are multiple. Besides the obvious impact of polluted water on the capacity to treat raw water for human drinking water consumption, polluted water harms the biota. Toxic industrial spills can kill plant and animal life directly as well as leach to the groundwater table. Organic pollution from sewage or other organic matter can alter the nutrient levels in a body of water, causing bacteria or algae to multiply. This in turn can alter the oxygen content of the water and kill plants and animals. Water pollution can also alter the pH of water, making it more acidic or more alkaline. Many species of plants thrive only in certain conditions, and a large shift in pH can kill them or stunt their growth. In some cases, subtle sources of pollution might not kill off large plants, but might affect micro-organisms and shift the natural balance over time. Pollution in water harms not only plant growth, but also causes plants to absorb dangerous chemicals from the water and pass them on to animals that rely on them for survival. Both the plants and animals may then pass these pollutants on to humans who consume them.

Direct effects of water pollution on plants are multiple. Acidic water may impact on foliage, bark and hurt the fine root hairs of many plants. Polluted ground water may also wash the essential nutrients that plants need out of the soil. Water pollution may make the soil acidic and negatively affect the solubility of nutrient ions, such as iron, magnesium, potassium and calcium. Without these nutrients, plants become more susceptible to drought, fungal infections and insects Water pollution can also disrupt photosynthesis in aquatic plants.

Pollution prevention and control aims at avoiding discharge of pollutants into water bodies and in that way strengthen water ecology security. Important strategy elements include:

- Permitting the discharge of any pollution into receiving water to better control it

- Defining emission limit value (ELV) for the discharge of pollutants into rivers from human settlement, industry and agriculture

- Defining environmental quality standards in receiving water and water biota compatible to a thriving natural ecological life

- Prevent spills and accidents involving hazardous substances and limit the damage when they occur though emergency preparedness

- Eliminate or restrict use of products or processes that cause water pollution
- Promote a life-cycle approach to industrial production sites forcing operators to return sites to their original state when the activity is closed
- Encourage the use of clean process technology which avoids or minimises the need for discharge of wastewater into water bodies
- Promote recovery, recycling and reuse policies that avoid the release of pollutants into receiving waters
- Impose pollution charges to dischargers of pollution into water bodies with charges preferably corresponding to the economic cost of the discharge
- Establish environmental liability and compensation regulatory requirements for polluters forcing them to reassess their water use policies
- Provide market based incentives to good performers.

1.2 Maintenance of environmental flow

Environmental flows can be described as 'the quality, quantity, and temporal variation of water flows required to maintain the components, functions, processes, and resilience of aquatic ecosystems which provide goods and services to people. The flows of many rivers in China are being increasingly modified, when water is stored for hydropower or withdrawn massively for agriculture and urban use and some times transported over very large distances like in the 3 South to North Transfer Canals and not returned to the river through drainage or groundwater flows. Thus the flow of many rivers in China is being reduced or seasonally altered changing the size and frequency of floods, the length and severity of droughts, adversely affecting ecosystems.

The provision of environmental flows, including volumes and timings, help to maintain downstream aquatic ecosystems and provide services to dependent communities. Environmental flows have been recognised as a crucial necessity in developed countries for more than two decades to provide services such as:

- clean drinking water
- groundwater recharge
- food sources such as fish and invertebrates
- opportunities for harvesting, grazing, and cropping on riverine corridors and floodplains
- biodiversity conservation (including protection of natural habitats, protected areas, and national parks)
- flood protection
- navigation routes
- removal of pollution through bio-assimilative and biogeochemical processes
- recreational opportunities
- cultural and aesthetic benefits.

Assigning water between environmental flows and consumptive and non-consumptive purposes is a sensitive task requiring social and not only technical consideration. To achieve equitable, sustainable and broadly accepted results, decisions should be informed by scientific information and analysis. The causes of changes in river flow can also be broader than just the abstraction or storage of water and the regulation of flow by infrastructure. Upstream land-use changes due to forestry, agriculture, and urbanisation can also significantly affect flows. The impacts of environmental flow consideration can extend beyond rivers to groundwater, estuaries, and even coastal areas.

Important strategy elements to secure environmental flows in rivers include among others:

- Clarify and strengthen the legal standing of environmental water allocations
- Recognize environmental flows in water resources policies and legislation
- Include environmental water provisions in basin water resources planning
- Develop studies to demonstrate the benefits from environmental water allocation
- Define guidance methodologies for setting environmental objectives in basin plans
- Specify clear requirements for stakeholder involvement in the decision making mechanisms
- Appoint an independent authority to audit implementation.

1.3 Maintenance of groundwater levels

Groundwater plays a crucial role in complex natural systems by:

1 providing base flow to rivers

2 supporting aquatic ecosystems as well as riparian and terrestrial vegetation

3 maintaining a geochemical balance

4 preventing earth subsidence.

In many parts of China groundwater is overexploited (groundwater abstraction in the Hai River basin is estimated by the World Bank to be about 50 percent greater than the sustainable yield) and is also subject to chemical pollution in urban and industrial areas.

Development of groundwater resources is rarely a question of finding and using new resources, but rather introducing policies enabling the sustainable use of groundwater that has already been discovered. Prevention of depletion and damage to the groundwater reserve has high priority in sustainable abstraction and use. The risk of over-use must be taken seriously, and appropriate management plans for each borehole or well field must be formulated and proper authorisation and licensing of abstraction should thoroughly be applied.

To assist in minimizing abstraction-induced stress on groundwater, the following strategy elements can be deployed:

- Policies and strategies to use groundwater only in instances where comparison with surface water resources shows it to be economically and environmentally superior, for instance as a strategic reserve to be used only during periods of surface water shortages or outright drought
- Strong permitting and enforcement of water abstraction and pollution control
- Water demand management by introducing various incentives for heavy users to save water and to reduce total consumption
- Innovative technical solutions to reduce loss and leakage and improve the usefulness of the same volume of water
- Cost covering tariffs, to put water in line with other commodities by charging the full costs of production and distribution and encouraging consumers to find ways to reduce water consumption
- Education and involvement of all stakeholders in decision-making, especially at local level through water user associations
- Aquifer classification to provide a framework for implementing differentiated protection
- Groundwater reserve determinations to allow for the role of groundwater in sustaining aquatic ecosystems to be understood and promoted within the context of a balance between use and protection
- Land-use zoning that restricts potentially polluting activities in areas with important or sensitive aquifer systems
- Establishment of intensive groundwater monitoring programmes to track trends in pollution and excessive abstraction
- Promote relevant and applied groundwater-related research, so that practicing hydro-geologists have both knowledge and the appropriate tools to manage the groundwater resources in an integrated manner.

1.4 Restore and sustain river morphology and ecology

Existing, relatively intact ecosystems in the aquatic environment are the keystone for conserving biodiversity, and providing the biota and other natural materials needed for water ecology security. When the ecology of water bodies is impaired, the prevention of further degradation should be the primary objective. Restoration of aquatic ecosystem is often a complementary activity to be combined with protection and preservation of river eco-systems.

In addition to pollution, many aquatic resources in need of restoration have problems that originate from harmful alteration of the river channel form or other physical characteristics, which in turn may have led to problems such as habitat degradation, changes in flow regimes, and siltation. Stream channelization,

ditching in wetlands, disconnection from adjacent ecosystems, and shoreline modifications are examples of structural alterations that may need to be addressed. Restoring as far as possible the original site morphology and other physical attributes is essential to improve water quality and bring back native biota.

The restoration of the ecology of a river should as far as possible re-establish the ecological integrity of degraded aquatic ecosystems. Ecological integrity refers to the condition of an ecosystem - particularly the structure, composition and natural processes of its biotic communities and physical environment. An ecosystem with integrity is a resilient and self-sustaining natural system able to accommodate stress and change. Its key ecosystem processes, such as nutrient cycles, succession, water levels and flow patterns, and the dynamics of sediment erosion and deposition, are functioning properly within the natural range of variability. Restoration strives for the greatest progress toward ecological integrity achievable within the current limits of the watershed, by using designs that favour the natural processes and communities that have sustained native ecosystems through time.

To assist in restoring and sustaining river ecology and morphology the following strategy elements may be considered:

- Identify the root cause of degradation that may include the cumulative effects of numerous impacts upstream and upslope as well as downstream modification such as dams and channelization
- Develop clear achievable and measurable goals
- Focus on feasibility taking into account scientific, hydrological, financial, social and other considerations
- Design for self-sustainability by minimising the need for continuous maintenance of the site, such as supplying artificial sources of water, vegetation management, or frequent repair of damage done by high water events. This also involves favouring ecological integrity, as an ecosystem in good condition is more likely to have the ability to adapt to changes
- Restore native species and avoid non-native species that may out-compete native species because they are expert colonisers of disturbed areas and lack natural controls
- Favour natural fixes and bioengineering techniques that combine live plants with dead plants or inorganic materials, to produce living, functioning systems that prevent erosion, control sediment and other pollutants, and provide wildlife habitats
- Provide adaptive management that monitor changes to help determine whether additional actions or adjustments are needed and adapt where changes are necessary.

1.5 Watershed management with soil and water conservation

The terms watershed, catchment, drainage area and river basin are all used to describe a land surface from which water flows downhill to a specified point on a watercourse, lake or the sea. It is determined by topographical features, which include a surrounding boundary or perimeter known as a drainage divide, beyond which water flows away into another catchment or catchments.

Integrated watershed or river basin management has become recognised internationally as an important holistic approach to natural resources management and the protection of rivers and their ecology. Key elements of watershed management include good practices in sound and integrated land-use planning together with the adoption of appropriate land-use practices for land and water resources management and protection acknowledging the close linkages between land and water. Other important elements include the management system, financial resources, institutional and legal frameworks as well as community participation.

Benefits of watershed management include:

- reduction in the rate of sedimentation in major dams, rivers and harbours
- reduction of the rate run-off and damaging floods
- conservation of soil fertility and the maintenance and improvement of agricultural productivity
- maintenance and improvement of water quality
- reduction in soil salinity and acidity
- protection of wildlife habitats
- increased public awareness of the inter-relationships within watersheds and identification of land capability
- maintenance and improvement of tree and vegetation cover.

Watershed degradation observed in China include1) ecosystem alteration, including changes to vegetative cover and composition and the introduction of plant and animal pests leading to deforestation, land clearing, weed invasion, introduction of animal pests, loss of wetlands, 2) soil erosion and deposition, including processes which remove and transport soil and deposit it elsewhere leading to water erosion, wind erosion, siltation and sedimentation, mass movement of soil, coastal erosion, and 3) soil degradation, involving the alteration of soil properties *in situ,* which leads to soil salinity, degradation of soil structure, soil fertility decline, soil acidification, waterlogging and soil pollution.

The following strategy elements can be considered to support integrated watershed management:

- Coordinating policies and programme with clearly defined responsibilities for each tier of government

- Establishing a comprehensive and strongly coordinated legal and administrative system which addresses planning, environmental protection and resource management in an integrated fashion

- Developing a land and resource management system based on watershed or river basin units and utilising standardised regional planning policies and processes

- Identifying and rehabilitating natural resources degradation

- Providing for stable, productive and high quality eco-systems

- Promoting community participation

- Managing surface water resources in a way that sustains catchment yields and maintains the supply of appropriate and equitable quantities of water to all legitimate water users
- Managing surface water resources in a way that maintains and where appropriate improves water quality
- Ensuring that river flows are of adequate quantity and quality to maintain aquatic and wetland habitats and ecosystems and ensure the quality of the riverine environment
- Coordinating the use and protection of surface water resources in conjunction with groundwater resources
- Maintaining the productivity of groundwater resources to ensure the long-term sustainability of both the quantity and the quality of these resources
- Ensuring that the needs of environmental systems dependent upon groundwater resources are met
- Integrating groundwater management with the wider environmental and resource management framework.

1.6 Wetland protection

Wetlands are unique ecosystems that often occur at the edge of aquatic (water, fresh to salty) or terrestrial (upland) systems. They may be wet year-round, wet during certain seasons, or wet during part of the day. They generally include swamps, marshes, bogs, as well as tidal marshes, prairie potholes, sea grass beds, forested wetlands, and seasonally ponded sites.

Although wetland types are diverse, they all possess several ecological characteristics that distinguish them from upland or other aquatic ecosystems. Specifically, wetlands are characterised by unique hydrologic, soil (substrate), and biotic conditions. The hydrological regime, is typically the *primary factor* driving the other ecological elements of the system. A site has a wetland hydrology, when it is wet enough to produce soils that can support hydrophytic vegetation.

Important benefits of wetlands include:

- healthy fisheries
- support for birds and other wildlife
- high biological productivity
- biodiversity protection
- erosion control
- flood damage reduction
- good water quality
- aesthetic and recreation.

A primary goal of wetland protection is to preserve and restore wetland benefits by re-establishing natural ecological processes. Wetland protection may therefore involve 1) a restoration of a degraded

wetland or former wetland to a pre-existing condition or as close to that condition as is possible, 2) the conversion of a non-wetland to a wetland, or 3) an enhancement of a wetland by increasing one or more of the functions performed by an existing wetland beyond what currently or previously existed in the wetland.

The following strategies can be considered to support wetland protection:

- Strengthen legislation, policies, agreement and compliance on wetlands protection
- Increase public awareness and commitment to protecting wetlands
- Improve wetland science, data and monitoring
- Secure and protect existing wetlands
- Create, reclaim, rehabilitate and manage wetlands
- Improve coordination between wetland conservation partners

2 Priority for action

Considering the high pollution still affecting many water bodies (rivers and lakes) in China, pollution prevention and control is certainly the dimension that needs the most urgent attention and action. Human, industrial or agricultural water pollution can destroy the ecology of water bodies. Experience in the EU has shown that the reduction and elimination of water pollution in water bodies often can be reversible. With the help of massive investment programmes in wastewater treatment plants for human settlements, industry and agriculture the ecological degradation of receiving waters can be reversed. Efficient water pollution control and prevention can lay the necessary foundation upon which ecological restoration and revival of water bodies biota, fauna and flora can be developed.

It is important to notice that inaction not anymore is an acceptable option. Due to accelerating economic growth, inaction would inevitably lead to excessive water consumption especially with regard to the second red line that concerns water efficiency per unit of wealth generated. The new regulatory regime to be established should therefore be flexible and allow the periodic revision and tightening of water ecology security improvement targets.

2.1 Differences between the WFD and the No.1 Document

One major difference between the WFD (2000/60/EC) in the EU and the No.1 Document on Water Resources in China is indeed the status of water body pollution at the time the new policy is being promoted and launched. The WFD in the EU was launched in the year 2000, around 25 years after the first of major river clean-up programmes in Europe which started with the river Rhine in the early 1970s when the city of Rotterdam no longer could the Rhine water for drinking water supply purposes.

In China the No.1 Document is being launched at a time when the pollution of water bodies across the country is still frighteningly high and mostly well above what is required to allow a smooth ecological recovery of water ecosystems.

A second difference is that the implementation of the WFD is strongly supported by a number of EU pollution control and prevention policies. The WFD stresses the combined approaches of Emission Limit Values (ELV) for pollution emission and Environmental Quality Standards (EQS) that heavily rely on a whole set of other regulatory instruments for implementation, permitting and enforcement. These supporting policies include among others the Drinking Water Directive (DWD 98/83/EC), the Urban Wastewater Treatment Directive (UWWTD 91/271/EEC), the Industrial Pollution Prevention and Control Directive (IPPCD 2008/1/EC), now reformed as Industrial Emission Directive (IED 2010/75/EC), the Control of Major Accident Hazards Directive (COMAHD 96/82/EC), the Aarhus Convention on Access to Information (2003/4/EC), Public Participation (2003/35/EC), the

Environmental Liability Directive (ELD 2004/35/EC), the Environmental Impact Assessment Directive (EIAD 97/11/EC) and the Strategic Environmental Assessment Directive (SEAD 2001/42/EC).

All these policies are well established, understood and enforced throughout the EU with competent authorities able to rely on numerous years of successful experience of pollution control, prevention and enforcement. Many requirements under these directives find their way into the requirements and conditionalities (notification, monitoring, reporting, inspection) that are part of the integrated permit that any operator which produces significant pollution (around 50.000 sites in the EU) needs to have and comply with to operate.

In China efficient water pollution control and prevention is still in its infancy and may be hampered by pollution control regulation which is ambiguous and difficult to enforce due to a weak permitting process and overburdened pollution control inspectorates with limited enforcement power.

In the EU a “permit” to abstract water or discharge pollution goes well beyond the mitigation measures included in the EIA. To get a permit to operate an operator needs to prepare and submit an EIA. This document is one of several studies and reports that an operator has to submit in its application for a permit to a coordinating competent authority. The resulting permit is a bulky document written by experienced inspectors, who know exactly what requirement and details need to be written for the permit to be practically enforceable. If the operator is dealing with hazardous substances, the permit will include a number of additional requirements to ensure the risk of accident is strongly minimised. The permit serves as guiding document for the inspectorate to perform routine or extraordinary inspection and report on compliance.

In China, in spite of the many authorisations needed to operate, no document clearly sets out the whole range of compliance requirements needed to monitor and enforce the conditions of the authorisation. In addition it is suspected that many operators especially State and Province Operated Enterprises do not really operate with a permit, report poorly on their permit and are not sanctioned in any way by inspectors when they violate their permits.

A third difference maybe the differentiated regulatory framework prevailing in the 27 Member States. There is a difference between Directives and Regulations. EU Directives are framework requirements issued by the European Commission upon approval by the European Council, that need to be transposed at the national level and allow for some degree of flexibility on the transposition arrangement to take into account the differentiated national regulatory framework. These differentiated implementing arrangements allow for testing on the ground of implementation arrangements by the various member states that can help identify better regulatory approaches. By comparison EU Regulations like the REACH Regulation (2006/1907/EC) have to be transposed at the national level without change of a single word. Thus there is far less space for regional innovation with respect to these.

China with its centralised regulatory framework may not have the possibility to test implementation arrangements of central regulation. The national regulation should be well thought through from the outset, leaving fewer margins for adaptation and interpretation at the provincial level for superior and nationally coherent results.

2.2 Other differences between EU and China

In terms of water resources and their uses, China and the EU are markedly different as well.

In China the overall availability of water is markedly lower than in the EU. While in the EU the average availability of fresh water is about 4,000 m^3/capita/year, in China this is only around 2200 m^3/capita/year, one third of the world average of about 7,300 m^3/ capita/year, however, it may be noticed that countries like Denmark, Germany .

A country is considered water "stressed" if the availability of water is below 1,700 m^3/capita/year and water "scarce", if the availability of water is below 1,000 m^3/capita/year.

Taken at the country level the water availability in China is not very different and in fact higher than a number of EU countries including Belgium, Denmark, Germany and the UK (Table 1).

Table 1 Water availability in 15 EU member states (Unit: 1000 m^3/capita/year)

EU	1995	2025
Austria	11.2	10.9
Belgium	*1.2*[b]	*1.2*
Denmark	2.5	2.4
Finland	22.1	21.3
France	3.4	3.3
Germany	2.1	2.1
Greece	5.6	5.8
Ireland	14.1	13.4
Italy	2.9	3.2
Luxembourg	12.3	10.7
Netherlands	5.8	5.6
Portugal	7.1	7.4
Spain	2.8	3.0
Sweden	20.5	18.9
United Kingdom	*1.2*	*1.2*

The difficulty in China and difference in China is that this availability is affected by a relatively extreme temporal distribution, with the bulk of the rainfall occurring between June and September, while it is mostly even the whole year in Northern Europe. Geographically both China and the EU sees large regional differences.

Another significant difference is the pace of economic development in China which has been growing at over 10% per year over the past 20 years. This is causing a rapid increase of the demand for water for population, industry and agriculture, so far with little attention to the efficiency of water use. In Europe, which mostly has mature economies, the pace of economic growth is more subdued and usually stays in the lower single digit. The impact of water demand is negligible and in fact declining due to the high price of water generated by the need for water utilities to cover the full cost of operation and increasingly also new investment.

2.3 Lessons learned

In the light of the differences highlighted above the following statements are possible.

- *The WFD philosophy of establishing good ecological status needed for ecological security in water bodies can today only be a longer term vision for China.*

  Pollution in rivers and lakes is far too high to enable the application of tools documented in the WFD to promote practically good ecological status. Currently the Water Functional Zones (WFZs) are constrained to calculate the total pollution load reduction according to the Total Water Pollutant Discharge Amount Control Policy (TWPDAC Policy) based on hypothetically achieved ambient water quality standard instead of the real pollution situation in the river, presumably because pollution is too high. This makes it difficult, if not impossible, to identify meaningful priority chemicals for which real concentrations in water, sediment or biota could be credibly limited.

- *The WFZ concept currently applied in major rivers to lower total pollution release to different river segments is partially incompatible with the WFD approaches.*

  The purpose of the WFZs is to lower excessive pollution levels to less environmentally impacting loads. Practical pollution reduction targets to be achieved under the WFZ pollution load allocation scheme are still high and well beyond what one would call “good ecological status” as prescribed by the WFD and the EQS directives.

  On the other hand, the WFZ concept and the scenario modelling tools developed around them are well suited to address the immediate need to reduce the pollution load into water bodies significantly. The scenarios can help identify point sources of pollution which contribute the largest load to the WFZ and at lowest possible cost can achieve the highest pollution load reduction for the river segment. The WFZ models developed can conveniently use real pollution levels coming from the upstream reaches (instead of hypothetical good quality standards) as starting point and using assimilative capacity rules for the water body it can identify point sources where a pollution load reduction would yield acceptable downstream water quality standards.

- To succeed the No.1 Document needs to demonstrate fast and credibly that it can make a difference by achieving significant pollution load reductions during the 12th Five Year Plan (FYP).

  Pollution reduction of water bodies has been on the agenda of the GoC for many years. Since the 11th FYP, which prescribed quantitative water pollution targets per province, significant macro level progress has started to appear. At the local level, however, results seems to be rather patchy and only mildly convincing, not least because of the increasing complexity of the pollution load discharged into the rivers.

  With the No.1 Document endorsed in 2010 and launched in 2011 by the highest political instance of the country (Central Committee of CPC) and the “Three Red Lines” policy endorsed and commented by the highest level of government (State Council) in 2012, the credibility of the government in matters related to efficient quantitative and qualitative water resources management is at stake. Prompt, decisive, positive results within the 12th FYP are needed to

validate the usefulness of the No.1 Document policy and strengthen the longer term perspective towards Chinese ecological security.

- *Implementation of the No.1 Document and Three Red Lines is expected to face significant bottlenecks.*

  Based on past experience in China, two bottlenecks in particular are expected to appear in the implementation of the No.1 Document. The first one may be linked to the downscaling of the pollution load allocation and the agreements that need to be reached on pollution load reduction targets at the local level. The second one will be the enforcement of the agreed pollution load reduction targets imposed upon operators.

  Addressing the first bottleneck may require public and stakeholder consultation and participation in the decision of pollution load reduction at the local level that may be beyond the capacity of the current competent authorities. Complete inventories of discharge points are barely known, real pollution load releases into the river by operators are unknown or inaccurate and may not be made publicly available and the development of pollution impact studies considering individual point source mixing zones won't be available for several years. The absence of scientific underpinning of pollution impact of specific discharge points is expected to lead to infighting among operators as to who should bear the costs of the pollution reduction load demanded at the macro level by the WFZ. Decisions may be fought over in the court postponing opportunity for swift action and results.

  The second bottleneck is linked to the poor historical performance of water pollution control in general in China. Due to the absence of strong permitting practices for polluting operators, inspectors and enforcers of either water abstraction limits or pollution load discharges are poorly capable to enforce authorised requirements. In as much as permits are handled by provincial or lower level administrations, which often have a vested interest in maximising the output and profit of an operator instead of protecting the environment, permits limit are neither respected nor enforced thoroughly by the local or provincial competent authority.

2.4 Recommended priorities

Based on the above assessment it seems that efficient pollution control for different socio-economic sectors (human settlement, industry, agriculture, energy) using water and discharging wastewater as well as from accident hazards shall be the starting point for ecological security to be developed and ensured throughout the country.

Efficient pollution control means the strictest enforcement as mentioned in the No.1 Document. Strictest enforcement may best be enabled in China with the help of a new, innovative and national "Water Resources Impact Permit" that integrates water quantity, water use efficiency and water quality as prescribed in the No.1 Document and the Three Red Lines.

An example of how the two bottlenecks can be overcome successfully in the early phase of a water ecology restoration of a river can be found in the practical approach taken by Germany, when it had to address the dramatic pollution of the Elbe River after reunification in 1991.

In a three phases programme spanning 18 years, the German Government convincingly succeeded in transforming the Elbe River from a “sewer like” status to a clean river status with restored water ecology (Appendix 1- Appendix 3).

According to the three phase approach adopted in the Elbe River, the first phase was an “urgent restoration” programme needed to significantly reduce the pollution level in the river to a pollution load compatible with practical self-induced ecological restoration. Ecological restoration could then practically follow in the subsequent phases based on simple ecologically embedded water quality objectives such as 1) using Elbe River as drinking water supply requiring only simple technical means (sand and gravel filters) or 2) using Elbe River water for agricultural purposes and 3) eventually dredged river sediments can be used as fertilizers for agricultural soils.

It is worth to note that the restoration of the Elbe River was supported and coordinated by a newly created International Commission for the Protection of the Elbe River (ICPER) established in 1990. The ICPER proactive role was to focus the attention of the stakeholders mostly from Germany, Czech Republic and Poland, which had very different interests in the river in order to 1) address common challenges and leave aside sources of contention, 2) promote useful information exchange on accurate water quality needed for action plan programming, and 3) focus on a coherent and harmonised implementation plan endorsed by all parties.

The Common Implementation Strategy (CIS) framework of the ICPER was supported by five full time technical working groups, including 1) ecological status, 2) reporting, 3) floods, 4) groundwater and 5) chemical status that used and partially co-developed and co-authored the guidance documents adopted by the EU for the implementation of the WFD.

2.5 Drawbacks of the Chinese permitting system

To compare the strengths and weaknesses of the Chinese water permitting system with European practices illustrated by the French permitting system (Appendix 4), two regulations are worth analysing:

1 The water abstraction permit applied by Water Resources Bureaus (WRB) to operators in accordance with the administrative licensing decree of the State Council Nr. 460 from 2006

2 The implementing regulation HSZ 2006 Article 17 regulating the administration of the discharge of wastewater into the Yellow River issued by the Yellow River Conservancy Commission based on the MWR regulation on the “Supervision and Management of Emission Discharge into Rivers”.

The Yellow River Conservancy Commission (YRCC) in accordance with the regulation HSZ (2006) No.17 already regulates the discharge of pollution into the river. The regulation was enacted due to the chronic low flow of the Yellow River and the need for one competent authority to administer the flow regime of the river as well as the total pollution load discharge into it. Water quality monitoring according to the Article 17 is entrusted to the water quality competent authority.

Quote: ”The pollutant discharging units shall entrust the water quality monitoring units with national meteorological accreditation qualifications to carry out the monitoring for no less than three times within 3 months after the test run of the drainage outlet to rivers and submit the monitoring data to the Yellow

River Water Resources Protection Bureau (YRWRPB) within the fourth month. The YRWRPB requires the pollutant discharging units to rectify within the specified time, if the drainage outlet to rivers does not meet the setting requirements after verification and make a decision revoking consent of settings, if the rectification does not meet the requirements."

This example demonstrates that in critical circumstances, it is well possible for the Chinese government to entrust the responsibility to coordinate water quality and quantity management in a river to a single competent authority in this case YRCC through the MWR.

The similarities and differences between the documentation requested when applying for a permit and the documentation to be contained in the permit in the EU and China are illustrated in Table 2, taking the French permitting system as example for EU (Appendix 4).

Table 2 Content of permit application documents and permits in the EU and China

EU IPPC/ IE Directive	**Regulation 460 (2006) Water Abstraction Permit**	**Regulation HSZ No.17 (2006) Wastewater Discharge Permit (Yellow River)**
Permit Application Documentation		
• the installation and its activities • the raw and auxiliary materials, other substances and the energy used in or generated by the installation • the sources of emissions from the installation • the conditions of the site of the installation • the nature and quantities of foreseeable emissions from the installation into each medium as well as identification of significant effects of the emissions on the environment • the proposed technology and other techniques for preventing or, where this not possible reducing emissions from the installation • where necessary, measures for the prevention and recovery of waste generated by the installation	• Application: the name and address of applicant or application organisation; reasons for the application ; starting time and duration of water abstraction; purposes, quantity of water withdraw, water consumption of each month during the year; water source and water abstraction point; water abstraction method, measurement method and water-saving measures; discharge outlet and treatment measures for major pollutants in discharging water and sewage; other matters prescribed by the water conservancy administrative department under the State Council; • Relevant explanations about interests relationship with a third party; • Relevant public record materials should be provided if	(I) Application for settings of the drainage outlet to rivers; (II) Basis documents of construction project, mainly referring to the documents approved by relevant administrative agencies for the construction project; (III) Argumentation report of settings of the drainage outlet to rivers, which may be replaced by the brief analysis of the impact of settings of the drainage outlet to rivers on the water functional zones upon agreement if the settings of the drainage outlet to rivers have little impact on water functional zones; (IV) Other relevant documents that shall be submitted, mainly referring to the documents that the examining authorities require the pollutant discharging units to provide for the review of the drainage outlet to rivers in addition

EU IPPC/ IE Directive	Regulation 460 (2006) Water Abstraction Permit	Regulation HSZ No.17 (2006) Wastewater Discharge Permit (Yellow River)
• further measures planned to comply with the general principles of the basic obligations of the operator as provided for in Article 3 • measures planned to monitor emissions into the environment.	an application belongs to project of public record; • Report of technical basis : construction projects are required to submit water resources assessment report, including source for water abstraction , water use rationality and the impact on ecology and environment; • Other materials prescribed by the water administration department of the State Council.	to the materials in the former three items, mainly including the commitment letter of a third interested person.
Water Permit Content		
• Member States shall ensure that the permit includes all measures necessary for compliance with the requirements of Articles 3 and 10 for the granting of permits in order to achieve a high level of protection for the environment as a whole by means of protection of the air, water and land. • The permit shall include emission limit values for pollutants, in particular, those listed in Annex III, likely to be emitted from the installation concerned in significant quantities, having regard to their nature and their potential to transfer pollution from one medium to another (water, air and land). If necessary, the permit shall include appropriate requirements ensuring	• The name of water abstraction organization or individual • Water abstraction duration: the validity period of water permit is generally five years and no more than 10 years • Water abstraction quantity and purposes • type of water source • Water abstraction and discharge site discharge method and quantity.	(I) Registration form of the drainage outlet to rivers (II) Environmental impact statement (table) or other forms of water environmental impact analysis reports (III) The documents in which the people's government or the competent department of environmental protection approves the pollutant discharge (IV) A brief description of the main pollution chain and the operation of pollutant discharging facilities, process and water pollution control facilities.

EU IPPC/ IE Directive	Regulation 460 (2006) Water Abstraction Permit	Regulation HSZ No.17 (2006) Wastewater Discharge Permit (Yellow River)
protection of the soil and ground water and measures concerning the management of waste generated by the installation. • Where appropriate, limit values may be supplemented or replaced by equivalent parameters or technical measures. • The permit shall contain suitable release monitoring requirements, specifying measurement methodology and frequency, evaluation procedure and an obligation to supply the competent authority with data required for checking compliance with the permit. • The permit shall contain measures relating to conditions other than normal operating conditions. Thus, where there is a risk that the environment may be affected, appropriate provision shall be made for start-up, leaks malfunctions, momentary stoppages and definitive cessation of operations. • Member States may prescribe certain requirements for certain categories of installations in general binding rules instead of including them in individual permit conditions, provided that an integrated approach and an equivalent high level of environmental protection as a whole are ensured.		

The main differences between the permits in Europe and China are:

1 The Chinese permit is not integrated. Abstraction and discharge are handled with different permits even if they concern one operating site.

2 The application form and documentation requested for assessment is not clearly specified in the regulation thus giving the applicant room for manoeuvre concerning the documentation submitted. In Europe the documentation to be submitted is extremely detailed and evaluation of permit will not start until the complete documentation is submitted. The applicant will be notified by the competent authority that the documentation is considered complete.

3 The Chinese permit is equally too simply worded and does not seem to list in adequate detail and precision the obligations of the permit holder with regard to Emission Limit Values (ELV), mixing zone extent, BAT requirements, monitoring and inspection, reporting requirement, sources and data to be reported, specific operation condition changes which would require a reassessment of the permit, penalties to be incurred in case of breach of permit, etc.

In the Chinese regulation it is also unclear which operating sites or units are subject to a permitting process. This is creating some ambiguity. In the EU regulation the administrative units requiring a permit according to the law are clearly defined in a positive and exhaustive list stating industrial sectors as well processing quantity thresholds for those sectors. Failing to notify the competent operation of an operation or change of operation subject to a permit, can incur very severe penalties often leading to a closure of the plant.

In the EU the integrated permit will be written by experienced inspectors who specify in very great details and unambiguous precision what are the obligations of the permit holder. It is this attention to details and precision in the written permit drafted by an experienced inspector, who knows the traps and difficulties of inspection, which makes all the difference when it comes to compliance inspection and enforcement procedures. An EU integrated permit is a very bulky document, very different from the mitigation measures of the EIA report.

Another significant difference is the integration of the trans-boundary dimension in the permitting process. According to the Article 17 of the EU IPPC Directive an operating site, which is expected to impact the environment in a trans-boundary context, must inform all potentially affected parties beyond the unit direct jurisdiction and these may raise an opinion on the proposed permit during the consultation process preceding the issuance of the permit.

Quote: "Where a Member State is aware that the operation of an installation is likely to have significant negative effects on the environment of another Member State, or where a Member State likely to be significantly affected so requests, the Member State in whose territory the application for a permit pursuant to Article 4 or Article 12 (2) was submitted shall forward the information provided pursuant to Article 6 to the other Member State at the same time as it makes it available to its own nationals. Such information shall serve as a basis for any consultations necessary in the framework of the bilateral relations between the two Member States on a reciprocal and equivalent basis."

Inspection, penalties and incentives are other differences between the Chinese and EU permitting system that are dealt with in Chapter 6.

3 Possible strategy – an integrated water resources impact permit

The proposed strategy below is aimed at effectively addressing the priority area of pollution control and prevention identified as the essential precursor of water ecology security targeted by MWR under the No.1 Document.

The strategy intends to create a new, innovative and national level “Water Resources Impact Permit” that will be indispensible for implementation of the Three Red Lines.

The proposed new permit is expected to cover in one permit the Three Red Lines targets (water quantity, water efficiency, water quality). As such it is partially integrated and can benefit from the experience of a number of features of the EU IPPC permit.

Based on the EU experience (Appendix 4) the new permit policy could be formulated along the following 3 mutually reinforcing principles.

1 operator

Every operator using water and causing significant abstraction and/or discharge into a receiving water (also beyond WFZ major rivers boundaries) is allocated “Three Red Lines Targets” (quantity, use efficiency, quality).

1 permit

Every operator allocated “Three Red Lines Targets” is subject to a new permitting process leading to a “Water Resources Impact Permit” issued at the state level, but implemented at the provincial level with oversight from the central level allowing strictest reporting, monitoring and enforcement as required by the No.1 Document.

1 competent authority

Every operator allocated Three Red Lines Targets or operating under a Water Resources Impact Permit is subject to mandatory periodic inspections coordinated by a single competent authority to control compliance with the requirements of the Water Resources Impact Permit.

The following paragraphs summarise the main aspects of the proposed permitting policy.

3.1 Operators subjected to the permitting process

Operators subjected to the Water Resources Impact Permit would be limited to large plants handling major quantities of pollutants and/or hazardous substances. In an initial phase this could include the largest operators responsible for abstraction of 40% of the water within in a WFZ or generation of 40% of the untreated wastewater discharges released into a WFZ. In a second phase, the coverage could be extended to the operators responsible for 70% or 80% of the abstraction or pollution loads. Smaller remaining operators would remain excluded as they would account for less than 30% of the abstracted water or generated pollution.

Operators subjected to the Water Resources Impact Permit process would be specified in detail and documented in an annex to the policy document and could include all plants consuming significant quantities of water including:

- Energy industry
- Mining and mineral processing
- Metal production and processing
- Chemical industry
- Other industries such as pulp and paper, slaughter houses, dairies, big farms**, etc.**
- Municipal wastewater and solid waste management facilities

Operators handling hazardous substances would be defined precisely in other annexes of the policy document through the specification of minimal quantities of either generic hazardous substances in line with international classification (explosive, oxidising, flammable, toxic, dangerous etc.) as well as particularly toxic or dangerous substances that would require a permit for their use.

Operators falling under the categories of operation requiring a permit would have to notify the regulating competent authority within a defined period to ensure the authority has a complete list of operators without having to chase them. Failure to notify could mean prohibition to operate.

The new permit would not be an additional permit. It would rather consolidate all the existing authorisations and permits linked to water abstraction and wastewater discharge of operators into a new single integrated permit that would replace existing ones after it has been issued. The new single integrated permit would provide the tools necessary for forceful inspections and for unambiguous compliance control and enforcement.

3.2 Scope of the Water Resources Impact Permit

The Water Resources Impact Permit would be issued as a new state level permit 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 about abstraction of water, processes involving water and discharge of

wastewater. The competent authority will check the validity of the application and to which 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:

- The extent of the potential impact (including geographical area and size of the affected population
- Any effects on specifically protected areas, species or other assets of particular significance
- Any trans-boundary impact between administrative areas
- The magnitude and complexity of the impact
- The probability of the impact
- The duration, frequency and reversibility of the impact.

Operators handling hazardous substances would be requested to submit additional information linked to the risk of accident such as safety measures, a safety plan and an emergency response plan worked out by independent experts and 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 criteria (water quantity, efficiency and 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 change or upgrade of technologies that should be implemented by the applicant to ensure emission reduction targets are met at certain deadlines. These necessary changes and their timing would be written down in the permit.

The permit document would end up being a substantial document specifying in detail:

- The receiver of the permit (permit holder)
- The scope of the permit (all water handling processes of the permit holder)
- Clearly defined and specified list of obligations of the permit holder in terms of water abstraction quantity, water use efficiency and amount and quality of treated wastewater discharge
- Emission limit values to be fixed to every relevant pollutant and how it will be monitored and reported
- Expected receiving water quality and specified mixing zone, location of receiving water functional zone monitoring point, carrying capacity of receiving water, with assumptions used in its calculation (flow, velocity, decay coefficient, temperature, etc)

- The quantity and pollution loads in the wastewater discharge and receiving waters to be used as the basis of calculation of impact and likely compliance with receiving water quality and the downstream control point

- Full water resources impact calculation that will most likely utilise river water quality modelling systems to resolve the calculations and put the impact into the context of other abstractions and discharges in the area. Extensive guidance and training on the application of these models will be required.

- Statistical means of assessing compliance or failure with abstraction, discharge and WFZ standards for flow volume and quality

- Efficient technologies to be introduced progressively and the timing of their introduction

- List of requirements executable by the operator as well as by the inspection authority for monitoring and reporting

- Special and detailed obligations concerning all important inspection procedures especially regarding discontinuous measurements and continuous measurement

- Rights of access for regulatory inspectors to access the operator site and take samples without advance notice

- Temporal limitation of the permit

- Cost sharing of inspections

- Penalties to be incurred in case of breaching the permits conditions.

Details about regulatory procedures applied in the UK and some EU countries are reflected in the RBMP Technical Report 069 on Regulation for Water Quality Management - Handbook on EU Principles and Practice.

The permit would need to be reviewed and updated each time the operator changes processes or increases production capacity as defined and documented in the permit.

It is understood that in China in the case of nuclear installations, because of the residual risks involved, it is the Chinese Ministry of Interior which is signing of the permit to operate a nuclear plant. Similarly in France (Appendix 4) it is the “Prefect” or the representative of the central government in the regions and provinces, who officially is signing of the environmental permit while the experts of the competent authority prepare the underlying technical documents.

Perhaps a similar approach of central government oversight could be explored and applied in the case of the Water Resources Impact Permit given the critical importance of the Three Red Lines for future economic development of China and the fact that the highest political and governmental institutions of the country have issued and endorsed the No.1 Document.

The Ministry of Environmental Protection (MEP) took the first steps towards permitting 5 years ago. Following a decision of the State Council, six Regional Environmental Supervision Centers (RESCs) were established to enable MEP to be directly represented in the provinces to oversee the Provincial EPBs inspections activities. Each RESC covers 3 - 5 provinces or provincial level municipalities. MEP RESCs are located in Beijing, Shenyang, Nanjing, Xian, Chengdu and Guangzhou.

3.3 Functions of the Competent Authority

To ensure the Water Resources Impact Permit satisfies its objective of enforcing the Three Red Lines Targets, the permit should be coordinated and supervised by a single competent authority at the national level.

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

- Issue the policy and publish nationwide the request for relevant operators to notify the local representative of the competent authority
- Process the notification received by the operators and ensure validity
- Submit to notifying operators application forms with the deadline for submitting an application for a 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' elements (water quantity, efficiency and quality)
- Coordinate the consultation and participation of the public in relation to the water resources or environmental impact review
- Evaluate whether the preconditions to issue a permit are fulfilled
- Determine and coordinate the obligations to be fixed in the written permit
- Coordinate monitoring and inspection.

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. Even if there were no pollution in the rivers, China would still face a water resources challenge due to the serious water scarcity in the northern part of the country and around the major growth areas in the country.

4 Proposed three phase implementation strategy

The establishment of a new national Water Resources Impact Permit at the scale and depth necessary to make the No.1 Document successful and achieve the targets of the Three Red Lines, will take time to develop in China. Consequently a phased approach allowing the regulatory framework to progressively converge to an optimal and efficient status compatible with the three targets of the red lines is desirable.

Building on the Elbe River restoration highlighted earlier (Appendix 1 – Appendix 3), it is recommended that the implementation of the No.1 Document starts soonest and first addresses the largest water users and most heavy water polluters in each WFZ. At the start, the capacity of MWR and other relevant authorities to issue a formal permit will not be available. It is therefore recommended that during the first phase of implementation the requirements imposed on the largest operators of each WFZ to achieve the Three Red Lines Targets is embedded in a protocol or proto-permit that later can be formalised to enable strict enforcement. This will allow the progressive build up of the expertise and capacity by relevant authorities across the country to handle the fully fledged procedures required in a second phase to operate smoothly the issuance of Water Resources Impact Permits without overloading the capacity or interrupting the production of the operators who will need the new permit.

The proposed implementation plan foresees three phases:

1st Phase: Urgent initial improvement during 12th FYP (2012-2015)

2nd Phase: Establishment of the Water Resources Impact Permit process during the 13th FYP (2016-2020)

3rd Phase: Fulfilment of the No.1 Document objectives during the 14th and 15th FYP (2021- 2030)

4.1 1st Phase: Urgent initial improvement during 12th FYP (2012-2015)

The focus of this phase will be significantly to reduce large water abstraction and wastewater discharge at point sources by targeting a first tiers of largest operators representing the abstractors and emitters with highest potential to achieve the Three Red Lines. The target will be to achieve an overall cumulated improvement of 30%-40% at the macro level in terms of greater efficiency of water use and pollution reduction in the WFZs. Actual water usage during the FYP period may not be reduced significantly due to the demand for continues socio-economic development, which will call for additional water usage for domestic as well as industrial purposes. As a whole, the quantity of water use should show a trend toward a stabilisation of total usage compatible with the overall quantitative targets of the No.1 Document to be achieved by higher water use efficiency in agriculture.

During this phase the targeted companies will be selected by the competent authority based on WFZ pollution load scenarios enabling identification of the highest pollution load reduction opportunities in each WFZ.

Operators within the sectors identified as most water demanding or most polluting with production capacity above defined thresholds would be requested to "notify" the competent authority of their existence and their key production and processes capacity. This information will be then analysed by the managers of the WFZs using modelling tools and scenarios to identify the largest abstractors or polluters to be targeted for rapid pollution load reduction under this 1st phase.

During this phase finally targeted companies will be then asked based on a Water Resources Impact Permit application, to agree on a "protocol" for Three Red Lines improvement allowing efficient and unambiguous monitoring, reporting and enforcement that will be negotiated between operating operators and competent authority. The development of these protocols, which will represent proto-permits, will allow the competent authorities to test and prepare the development and launch of formal permits starting with the second phase and build the capacity of competent authorities for permit development coordination, issuance and related compliance monitoring, inspection and enforcement.

4.2 2nd Phase: Establishment of the Water Resources Impact Permit process during the 13th FYP (2016-2020)

In the second phase the attention will be turned to the second tier of most significant abstraction and discharge points sources to target the bulk of the pollution (up to 80%) reaching water bodies or excessive abstraction depleting groundwater levels. The Water Resources Impact Permit will be officially launched in a staged approach for each WFZ and successive groups of operators starting always with the most polluting and those with the highest risk of accident hazards in each WFZ. During this phase non-point sources will also be targeted through improved agricultural practices.

Finally during the second phase "ecological zones" will be identified and documented based on the morphology 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 these newly defined ecological zones, will be developed and documented as basis for defining "good ecological status" objectives for all rivers and lakes to be implemented in the third phase.

As the water pollution will become less severe, this phase will also be important for start of the ecological restoration works. That is then the time when the experience and expertise accumulated in the EU about the implementation of the WFD will start to become useful. See chapter 6 presenting several aspects of promoting good ecology in water and water ecology restoration in water bodies.

4.3 3rd Phase: Fulfilment of the No.1 Document objectives during the 14th and 15th FYP (2021- 2030)

At the beginning of the 3rd phase, the pollution load in rivers is expected to have been significantly reduced to levels compatible with achievement of genuine "good ecological status". In addition MWR will, at that stage, be equipped with an efficient and enforceable water resources impact permitting tool and legal enforcement capability. This will open the door for the fine tuning of water abstraction as well

as pollution control and prevention in water bodies for any individual chemical substance considered a priority substance and deserving attention for reduction as part of the EQS improvement process. This third phase may 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.

5 Proposed three phase strategy outline for other dimensions of Water Ecology Security

The following tables (Table 3, Table 4 and Table 5) briefly document and summarise how other dimensions of water ecology security could be advanced as part of the three phases highlighted in the preceding paragraphs.

Table 3 Urgent initial improvement during the 12th FYP period (2012-2015)

Pollution Prevention & Control	**Maintenance of Ecological Flow**	**Maintenance of Groundwater Levels**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
Develop scenarios in the WFZ to identify largest impacting operators that can achieve significant improvement by addressing a minimal numbers of operators	Clarify and strengthen the legal standing of environmental water allocations	Test a strong permitting and enforcement of water abstraction and pollution control of groundwater for heavy abstractors	Develop studies to delineate ecological zones in all river basins with an assessment of pressures and impacts from upstream and upslope as well as downstream modification such as dams and channelization	Coordinate policies and programme with clearly defined responsibilities for each tier of government	Increase public awareness and commitment to protect wetlands
Select priority list of operators or sites to be targeted during the initial phase	Recognise environmental flows in water resources policies and legislation	Add or strengthen groundwater protection as a responsibility of the WFZ management authority		Develop studies to identify the most important trends in natural resources degradation	Improve wetland science, data and monitoring

Pollution Prevention & Control	**Maintenance of Ecological Flow**	**Maintenance of Groundwater Levels**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
Develop operator specific water resources impact reducing protocols with agreement on series of measures, implementation periods and improvement targets		Increase the water abstraction charge to provide incentive to save		Establishing a comprehensive and strongly coordinated legal and administrative system which addresses planning, environmental protection and resource management in an integrated fashion	Strengthen legislation, policies, agreement and compliance on wetlands protection
Use the process to develop the above protocols to develop permitting process and procedures for the new permit.		Establish water demand management by heavy users to reduce total consumption by introducing incentives to save water		Develop guidelines to provide for stable, productive and high quality eco-systems	
Build capacity and train permitting staff and inspectors teams		Establish intensive groundwater monitoring programmes to identify and track trends in pollution and excessive abstraction		Develop a land and resource management system based on watershed or river basin units and utilising standardised regional planning policies and processes	

Pollution Prevention & Control	**Maintenance of Ecological Flow**	**Maintenance of Groundwater Levels**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
		Develop studies to understand and document the role of groundwater reserve for sustaining terrestrial and aquatic ecosystems			

Table 4 2nd Phase: Establishment of Water Resources Impact Permit during the 13th FYP (2016-2020)

Pollution Prevention & Control	**Maintenance of the Ecological Flow**	**Maintenance of Groundwater Level**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
Transpose the protocols developed under 1st phase into new formal permits for the first tier operators	Include environmental water provisions in basin water resources planning	Introduce a strong permitting and enforcement of water abstraction and pollution control of groundwater for heavy abstractors	Develop feasibility studies for ecology restoration taking into account scientific, hydrological, financial, social and other considerations	Ensure that all river basin management plans address the sustainable use, protection and management of the source areas of rivers	Ensure that river flows are adequate to maintain wetland habitats and ecosystems and the quality of the riverine environment
Extend progressively the permitting requirement to a second tier group of operators and sites (by sector as well as by size of operation)	Develop studies to demonstrate the benefits from environmental water allocation	Develop systematic studies to classify aquifers to provide a framework for implementing differentiated protection	Implement pilot projects designed to be self-sustaining and minimising the need for continuous maintenance of the site.	Improve coordination between watershed management and conservation partners	Create, reclaim, rehabilitate and manage wetlands

Pollution Prevention & Control	**Maintenance of the Ecological Flow**	**Maintenance of Groundwater Level**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
Issue a regulation requesting any operator or site abstracting water or discharging pollution to notify the competent authority about their existence, their abstraction and discharge facilities and quantity involved	Define guidance methodologies for setting environmental objectives in river basin plans	Establish groundwater protection programme in each WFZ to stabilise ground water depletion and reverse chemical pollution	Restore native species and avoid non-native species that may out-compete natives because they are expert colonisers of disturbed areas and lack natural controls		Improve coordination between wetland conservation partners
Build management capacity and quality control procedures for permitting staff and inspector bureaus	Develop studies documenting the economic value of ecological services of water as basis for allocating a price to ecological flows	Enforce land-use zoning that restricts potentially polluting developments on important or sensitive aquifer systems	Favour natural fixes and bioengineering techniques that combine live plants with dead plants or inorganic materials, to produce living, functioning systems to prevent erosion, control sediment and other pollutants, and provide wildlife habitats		
Develop database and information base to accurately monitor pollution reduction and trends	Appoint an independent authority to audit implementation	Develop guidelines to assess when and where surface water use can be economically and environmentally	Develop adaptive management guidelines that monitor to help determine whether additional actions		

Pollution Prevention & Control	**Maintenance of the Ecological Flow**	**Maintenance of Groundwater Level**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
		superior to groundwater abstraction and vice-versa	or adjustments are needed and adapt where changes are necessary		

Table 5 3rd Phase: Fulfilment of the No.1 Document objectives during the 14th and 15th FYP (2021-2030)

Pollution Prevention & Control	**Maintenance of the Ecological Flow**	**Maintenance of Groundwater Level**	**Restore and Sustain River Morphology and Ecology**	**Watershed Management**	**Wetland Protection**
Routine monitoring and forceful enforcement of compliance with permit requirements to ensure no significant pollution is returned to the water bodies	Specify clear requirements for stakeholder involvement in the decision making mechanisms	Implement systematically groundwater protection programmes in each WFZ to stabilise ground water depletion and reverse chemical pollution	Implement programme of ecological restoration projects based on the lessons learned from pilot projects. Maximise project design for measures to be self-sustaining and minimising the need for continuous maintenance of the operator	Implement programme of watershed management in priority areas	Create, reclaim, rehabilitate and manage wetlands
		Coordinate use of surface water resources in conjunction with groundwater resources			

6 Some additional permitting issues

6.1 Inspections, incentives and penalties

Inspections are the most important element of enforcement and compliance efforts and consequently attached great importance in the EU as illustrated by France (*Appendix 3). Under the new permit, much stronger and thorough inspections would need to be deployed to all permit holding operators. Inspection should be conducted by government inspectors, or by independent parties hired by and reporting back to the responsible enforcement agency.

There are a number of different types of inspection activities that need to be deployed for effective compliance monitoring and enforcement of the Water Resources Impact Permit, including:

- *Walk-through inspection*: this provides a quick survey of a process, where an inspector checks on 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*: this 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*: this type of inspection includes the visual and recorded examination described above, as well as collecting and analysing physical samples. This is the most resource intensive type of inspection.
- *Specific inspection*: this would be carried out resulting from accidents or by request from the local population.

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

- The potential hazard of the site to water bodies
- The complexity of the inspection needed to evaluate compliance
- The history of the site in relation to compliance
- The availability of self-monitoring information

Inspection of a site should 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 permit records properly maintained?

5 Does the operator comply with all emission limits and other operating conditions?

6 Is the operator implementing agreed upgrading requirements?

7 Does the opertor's 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, minimise 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 with access to best available technology adapted to its specific process and production situation.

The penalty system for the enforcement of the Water Resources Impact Permit needs to be effective, proportionate and dissuasive. Effectiveness means that penalties are capable of ensuring 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. Dissuasiveness requires that penalties have a deterrent effect on the offender, who should be discouraged from repeating the offence and on the other potential offenders to commit the said offence.

Penalties should include a broad "toolkit" of civil sanctions for regulators to promote and enforce regulatory compliance. This may include administrative monetary sanctions and the strengthening of statutory notices to work alongside criminal law for worse and repeating offenders to combat non-compliance.

6.2 Human resources requirements

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

Entry level requirement should be high, preferably 4 years university degree. Inspectors and permit writers also 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, inspectors may need specialisation also to spread knowledge in organisation. Finally the inspectorates should be equipped with professional quality management system offering transparent mechanism for assessing efficiency of procedures including training.

The number of operators managed by inspectors should also be limited to allow thorough inspection. A number of operators between 30 and 100 per inspector depending on the nature and complexity of the sites allowing monthly or quarterly inspection depending on the breadth of permit requirement may be considered appropriate (Appendix 3).

6.3 Importance of "Notification" by operators

It is understood that MWR with the help of local Water Resources Bureaus has initiated an extensive survey aiming at getting an inventory of points with discharge into water bodies. While the effort is important, it may not reach the ultimate goal of facilitating effectively pollution control. The surveyors doing the inventory may miss some discharge points, which are below water level and partially hidden. Some discharge from small creeks, which are very polluted, may not be identified as discharge points. Most critically the operators may not be made responsible for failure to report or document a discharge when the work has been made by the authorities placing the burden of proof with the authority.

A more robust approach would be to include in the new permit regulation, the obligation for operators, sites or owners of discharge points to "notify" the competent authority within a fixed period upon entry into force of the regulation. Failure to notify the competent water authority thoroughly under the new regulation, would be then an infringement of regulation and trigger the risk of penalties. If the penalty applied to wrong doers is stiff enough to be a deterrent, the competent authority would rapidly be able to gather a rather accurate picture of the pollution discharge into water bodies. Operators who fail to notify thoroughly would take the risk of facing an ever increasing penalty linked to the length of the period during which a discharge point is kept not notified as per the regulation requirement.

A similar approach could be taken for water abstraction from surface and groundwater.

The "notification" could be requested from all operators above defined sectoral thresholds even below the levels for which a permit would be required. This would allow the competent authority to collect a rather complete picture of all abstractions and discharges into water bodies. Such documentation would be useful to monitor and fine tune the permit system to reach out to an overwhelming proportion (maybe 80 %) of the overall abstraction and pollution discharge to ensure, over time, adequate water ecology security in water bodies.

7 Promoting good ecology in water bodies

This chapter brings together a summary of good practices related to the promotion, development and maintenance of good ecology in water bodies.

The first set summarises EU and UK guidance on how to reference and define good ecological status of water bodies. The second set provides guidance on how to develop an ecological health check of a water body. The third set documents briefly how to define an adequate ecological/ environmental flow in a river. The fourth set documents good practices steps for restoring good ecological status in an deteriorated water body.

The EU has spent the past ten years developing and adapting methods for monitoring and protection of water ecology for the EU WFD. These have been summarised and published in Chinese as RBMP Technical Report 061 Ecological and Biological Monitoring - European Water Framework Directive Guidance and Methods[1], which is a useful reference work on this subject.

7.1 EU Guidance Documents to reference good ecological status of water bodies

The EU WFD introduces ecological objectives at the heart of water resource protection. These are designed to protect and where necessary restore the structure and function of aquatic ecosystems, and thereby safeguard the sustainable use of water resources. The effectiveness of our water management strategies will be assessed on ecological outcomes, based on these objectives.

The EU Common Implementation Strategy (CIS) Guidance Document No. 13[2] Overall Approach to the Classification of Ecological Status and Ecological Potential – Classification (2005) outlines the role of the general physio-chemical quality elements in ecological classification, as well as the general guidance on the assessment of ecological status and potential leading to the overall ecological classification of water bodies for the purposes of the WFD.

The key overview document for the UK on Surface Water Classification is the UK Technical Advisory Group Paper (UK TAG), 2007[3] Recommendations on Surface Water Classification Schemes for the Purposes of the Water Framework Directive.

---

1 The handbook, in Chinese and English, is available at www.euchinarivers.org and www.cewp.org

2 EU Common Implementation Strategy (CIS) guidance Document No. 13 Overall Approach to the Classification of Ecological Status and Ecological Potential – Classification (2005)

3 UK Technical Advisory Group, 2008, UK River Assessment Methods. Benthic Invertebrate Fauna, River Invertebrate Classification Tool.

Both documents give an in depth view of this subject and the technical capability needed to be developed before this can be made operational in China.

7.2 Ecological health check of water bodies

In order to achieve this, a clear view of the current status of aquatic ecosystems is required, including a view on the pressures and risks impacting in each catchment. This requires comprehensive and risk based ecological monitoring programmes. The baseline information on these elements is known as characterisation.

Associated with the monitoring information is the development and adoption of methodologies for ecological monitoring and assessment, or classification schemes. These classification schemes are fundamental to the assessment of compliance against objectives and are the primary driver for water management and improvement. Accurate and reproducible assessment against objectives becomes a critical issue as this drives investment and management actions to protect and improve water resources.

The EU WFD timetable requires the establishment of monitoring programmes for surface waters by the end of 2006. The EU Common Implementation Strategy (CIS) Guidance Document 7[4] focuses on the monitoring requirements of the EU WFD and 'aims to guide experts and stakeholders in the design and implementation of the monitoring networks and programmes required to meet the requirements of the WFD for all categories of waters.'

The Ministry of Water Resources in China is undertaking a series of pilot studies on Indicators, Standards and Methods for River and Lake Health Assessment[5]. This utilises similar methodologies to the EU WFD and has drawn information from Australian, US and European knowledge and has adapted this to the Chinese situation. The principles will be the same in any water environment, but significant primary work is needed to provide enough monitoring information to give a statistically robust assessments and classification methodologies. The work is progressing well but will need considerable support and new skills before it can be consolidated into a routine assessment methodology. This study should assist in the development of these important Chinese River and Lake Health Assessment methods.

The use of the health check methodology will be important in consolidating the ecology and water resource protection elements of the No.1 Document.

[4] European Commission, 2003, Guidance Document No 7, Monitoring under the Water Framework Directive

[5] Department of Water Resources Management of the Ministry of Water Resources, Technical Document for the Health Assessment of National-wide Rivers and Lakes - Indicators, Standards and Methods for River Health Assessment. (For pilot work). (Version 1.0) National Technical Working Group for the Health Assessment of Rivers and Lakes, Oct. 2010

7.3 Defining an environmental / ecological flow in a river

Until the 1960s water flow management in developed nations focused largely on maximising flood protection, water supplies, and hydropower generation. During the 1970s, the ecological and economic effects of these projects prompted scientists to look at the necessity to maintain certain fish species in water bodies. The initial focus was on determining the minimum flow necessary to preserve an individual species in a river. By the 1990s, scientists came to realise that the biological and social systems supported by rivers are too complicated to be summarised by a single minimum flow requirement. Since the 1990s, restoring and maintaining more comprehensive environmental flows has gained increasing support, as has the capability of scientists and engineers to define these flows to maintain the full spectrum of riverine species, processes and services.

The following aspects need to be taken into account in defining the ecological flow of a river. It is partially based on experience in Spain[6].

7.3.1 Ecological flow regime versus ecological flow

For many years the expression 'ecological flow' corresponded to a single value of flow without clear definition. Natural regimes have flow fluctuations according to the hydrological behaviour of watersheds, and sometimes these natural flow variations are the main factors determining the geo-morphological and biological characteristics of rivers. It is clear nowadays that the term 'ecological' should be applied not to a single value for the flow, but to a range of flow values which follows a variation pattern similar to the natural flow regime.

7.3.2 Flow and habitat requirements

The habitat requirement of the aquatic community is often defined by an 'indicator species' whose habitat needs represent or encompass those of the whole community. Often a large native fish species at the top of the food web pyramid will be considered as indicator. In smaller temporary or torrential streams, which naturally do not sustain any fish species, macro-invertebrates may be taken as indicator species. In the physical habitat two main components are often considered: the channel structure, (types of bottom substratum and quality of shelter), that for a range of flows is relatively independent of in stream flows; and hydraulic conditions (depth and velocity), which are flow dependent.

Some models rely on the biota density or biomass in the river as indicators. Other models like in Spain will look at the physical habitat needed to sustain population of specific species. In such a case preference curves of habitat and flows are derived for relevant representative species.

7.3.3 Minimum flow determination

Criteria for minimum flows are often determined by selecting the habitat-flow curves, which are those flows where the greatest rate of habitat change occurs for the more demanding stages of the species development.

[6] The Spanish Experience in Determining Minimum Flow Regimes in Regulated Streams, Diego Garcia de Jalon, 2003

Two flow values are often taken into account: 1) Basic flow which is the minimum flow needed for the conservation of the communities, and 2) Optimum flow which is the in-stream flow that produces a maximum value of potential habitat. The latter flow is the preferred reference flow for ecological enhancement.

7.3.4 Channel maintenance flows

Because of flow regulation by dams, high frequency floods below the dams are usually of less importance than in natural conditions and the channel size is reduced and invaded by riparian vegetation. This implies important modifications of the physical habitat provided by the river. In order to maintain or to restore the dynamic channel processes, the ecological flow regime should include flood events that correspond to the original full discharge of the river.

7.3.5 Ecological flow regimes

Habitat and in-stream flow requirements vary with seasons. For example spawning and embryo development periods require a certain level of flows without floods. During summer with critical high water temperatures, salmonids will require swift water currents and thus higher flows in order to compensate for lower dissolved oxygen. The annual and seasonal variability of the natural flow regime is an important factor structuring stream communities, especially controlling the biotic response to minimum flow conditions.

Thus, it is often necessary to define an ecological regime of flow. This regime may be established in two ways: 1) taking into account the needs of the selected indicator species, assuming different flow requirements of their development stages, and 2) taking into account the needs of the indicator species only for annual critical conditions in the dry season and giving a flow fluctuation proportional to the natural flow regime for the remaining seasons. This in-stream flow strategy of imitating nature is also necessary for the maintenance of geomorphologic processes and the conservation of biological integrity.

7.4 Restoration of water ecology in water bodies

This chapter provides a summarised conceptual framework for ecological restoration works of water bodies following degradation through water pollution[7].

7.4.1 Ecological inventory the watershed or sub-basin

The process begins with a review or inventory of existing information, designed to yield a preliminary evaluation of the types of restoration activities which may be feasible and appropriate to address degradation.

[7] A Decision-Making Guide for Restoration, USEPA, 1995

Sub-basin characterisation

Sub basin characterisation and data collection are the first steps in inventorying a watershed. Characterisation may include information on water quality, geochemistry, hydrology, fluvial geomorphology, substrate condition, flora, fauna, and, to the greatest extent possible, identification of stressor sources in the watershed.

In addition to physical and chemical characteristics of the watershed, land ownership and regulatory jurisdictions play an important role in determining opportunities for restoration..

Also included in the basic site characterisation is the acquisition of historical and current data on regional or landscape-scale habitat characteristics.

Identify nature of degradation

In some watersheds, point and non-point sources of pollutant loads have direct and predictable relationships to water body degradation. In many cases, however, the connection between load sources and degradation is less obvious, and physical habitat variation may play an important role in the nature and occurrence of degradation. Initial identification can make use of available information, including databases and past research studies on physical habitat degradation and associated degradation of beneficial uses.

Map opportunities for restoration

In mapping opportunities for restoration, it should be kept in mind that restoration approaches can have beneficial effects beyond the direct restoration of habitat. For instance, a stream segment might possess adequate functioning wetland habitat to support designated uses, but restoring degraded wetlands upstream might mitigate downstream excursions of numeric water quality criteria for metals.

7.4.2 Identify goals for restoration

Clarifying exactly what goals are appropriate for ecological restoration at a given site is critical to examining the worth of specific restoration techniques. Public participation is an important element in identifying goals for any restoration project. It is useful not only to improve the validity of restoration goals, but can be instrumental in finding necessary resources or funding.

Identify specific water quality standards addressed by restoration

As degradation is defined in terms of non-attainment of water quality standards, planning for restoration should be firmly based on specific water quality standards to be achieved, including criteria and designated uses. Standards may involve a specific reference to habitat use or other numeric or narrative criteria that potentially are addressed through ecological restoration.

Stakeholder participation to develop consensus on objectives

Under this task, participating programs, agencies, and stakeholders will develop consensus on goals and objectives for the ecological restoration project, consistent with the sub-basin ecological protection approach. Goals and objectives will mostly be directly related to meeting water quality standards.

Conduct eco-regional or landscape-level analysis

An eco-regional or landscape-level analysis can be used to determine the status of particular resource components of the aquatic ecosystem, describe existing reference sites, and identify any large-scale landscape condition that might inhibit achieving ecological restoration goals. Items addressed in a regional or landscape perspective include 1) endangered species, 2) critical resource type (e.g., wetland category), 3) reference conditions, and 4) large-scale problems

Determine ecological functions and values to be restored

When standards specifically mention ecological degradation, it is important to determine to what extent (and to what point in time) affected ecosystem functions and values can be restored. For some water resources, such as certain wild rivers affected by recent disturbances, restoration to a pristine, pre-disturbance condition may be realistic. For water resources in areas that are long-settled or surrounded by development, specification of a pre-disturbance baseline may be difficult.

Select restoration goals

The previous steps yield a list of ecological functions and values, and stakeholder consensus objectives, for consideration for restoration. These results are summarised in this task by selecting a set of potential ecological restoration goals for further consideration. Typical goals for restoration include meeting applicable water quality standards, maintaining a fishery potential, preserving specific habitat types.

7.4.3 Identify and select candidate restoration techniques

The key to identifying and selecting restoration techniques is to know how much is appropriate. That is, avoid unnecessary expenditure of resources trying to fix a problem that the ecosystem can fix on its own.

Identify candidate restoration techniques

This task includes a more comprehensive list of feasible ecological restoration techniques. In-stream, riparian, and upland techniques should be considered, individually and in combination. One form this task could take is listing categories of stressors or goals that must be addressed and associated restoration techniques that address the stressor to meet the goal.

Balance and integrate in-stream and watershed techniques

Restoration efforts can involve in-stream and riparian restoration of habitat and upland (watershed or source control) techniques. Achieving a balance among these components is important for many restoration projects. Addressing both symptoms (in-stream) and causes (in the watershed) is often desirable. Often, a series of complementary management actions at different locations in the watershed will result in greater success.

Evaluate costs and benefits

Selecting and prioritising restoration efforts must take cost into account. A selected restoration technique should be cost effective in addition to resulting in major environmental benefits. Thus, economic analysis is part of the process to determine whether restoration techniques are reasonable.

Select best combination of restoration options

Most restoration strategies will involve a combination of specific techniques. If more than one ecological restoration strategy is available for a restoration goal, the best restoration option or options should be selected based on technical and economic feasibility.

Assign priorities to restoration efforts

Restoration efforts can often address multiple ecological end-points. Given limitations of funding and human resources, assigning priorities to restoration efforts is important, so efforts providing the greatest ecological return, or addressing the most time-sensitive degradations, can be implemented first.

Plan for monitoring

In any restoration effort, monitoring is needed to evaluate progress in achieving goals. Planning for this monitoring must begin before the project is implemented and the characteristics of the water bodies are modified.

7.4.4 Implement selected restoration techniques

Identify incentives and mandates for action

Ecological restoration requires cooperation among programs and agencies that have not traditionally worked together. Identifying incentives and mandates to form the basis of joint action plans will focus on scheduling activities, securing the commitment of resources, and eliminating barriers.

Continue stakeholder involvement

Stakeholder involvement and buy-in is crucial to the success of most restoration efforts. Stakeholder involvement should begin early in the decision process, and should continue throughout. Ecological restoration projects have been excellent examples of coordination among agencies contributing their own unique expertise. Many restoration projects are driven by local initiative with resource agencies playing a support role.

Establish schedule and implement

A schedule should establish clear milestones to be completed in a realistic timeframe. The schedule should be keyed to project objectives and endpoints. Project milestones and measures of success can be grouped into three general categories: near-term, mid-term, and long-term. Examples of milestones could include 1) Near-Term Recovery - Improve physical habitat quality, 2) Mid-Term Recovery - Restore benthic macro-invertebrate community, and 3) Long-Term Recovery - Restore fish community.

7.4.5 Monitoring for success

Determining whether the goals of a restoration project are being achieved can only be accomplished by a well-designed monitoring program that evaluates, with an acceptable degree of certainty, whether habitat restoration has resulted in a significant improvement in water resource quality and the biological community of the water resource.

Identify assessment and measurement endpoints

Assessment end-points are ecological values to be restored, such as quantity and quality of habitat and water quality standards consistent with the designated use or uses of a water resource, numeric and narrative water quality criteria that are necessary to protect the use or uses of a particular water resource, and an anti-degradation statement.

Design data collection plan

goals and standards for data accuracy should be specified as a priority in data quality objectives. High variability or uncertainty in results, however, often reduces the usefulness of field data, especially for ecological measurements. In designing data collection plans, the water quality manager is frequently forced to evaluate trade-offs between an increase in uncertainty and the cost associated with reducing the uncertainty in the measured variables.

Collect and evaluate data

After the data collection plan is designed, data are collected and evaluated to determine whether desired benefits are being achieved. Data evaluation techniques depend on the design of the monitoring program and hypotheses to be evaluated.

Set schedule for continued monitoring

If restoration appears to be proceeding successfully and is meeting specified goals and milestones, the project will often enter a phase of assessing of water quality standards attainment, for which a program for continued monitoring should be established. This program will typically differ from the initial monitoring program, which has the burden of proving that the restoration technique can work in a given setting. Continued monitoring is designed to ensure that progress is ongoing and backsliding does not occur.

8 Tentative next steps

Possible next step can be spread into 3 different groups of activities.

1 Follow-up development work by DRC

2 Broader development work for the new regulatory regime

3 Scientific research works to advance water ecology security

The paragraphs below provides a non exhaustive list of activities that could be undertaken in the short and medium terms in each of the three categories.

8.1 Follow-up development works by DRC

This may include, but not be limited to:

- Publish technical papers in relevant journals and media on the importance of water ecology security to build awareness and support for the concept and the need for implementation
- Assessment of Chinese regulatory options to enable the implementation and enforcement of the Three Red Lines policy with a SWOT analysis of the current regulatory regime
- Development of a desk feasibility study of a new integrated Water Resources Impact Permit covering the Three Red Lines
- Development of rationale / requirements for a new Water Resources Impact Permit with regulatory impact appraisal
- Development of scenarios for water resources impact reduction at the WFZ level and at the sub-basin level also in trans-boundary (inter provincial) context
- Developing a cost-benefit analysis of a new permit regulation
- Develop WFZ scenarios to identify industrial sectors to be targeted by the new permit and production thresholds to trigger operator notification and permit acquisition for the 1st phase of implementation.

8.2 Broader development work for the new regulatory regime

This may include, but not be limited to:

- Pilot projects to demonstrate the feasibility and regulatory benefits of the new permitting process
- Establishing procedures and rules for inspection and Water Resources Impact Permit protocol writing to define Three Red Lines targets with operators during Phase 1
- Develop forms and procedures for application for the new permit
- Develop permitting process procedures for each red line and for the coordination of the writing and issuance of the new integrated permit
- Developing improved / enhanced inspection rules and procedures based on the new permit
- Developing an inventory of the largest water resources impacting operators to be targeted in the 1st phase implementation
- Management information system (MIS) for water resources pollution control monitoring
- Progressive development of health check for all water bodies
- Rules and procedures for water ecology security stakeholder engagement
- Clarifying and documenting the legal framework to launch the new integrated state level permit
- Clarifying the institutional framework for a new Water Resources Impact Permit coordinated by MWR involving MEP and other relevant authorities
- Training inspectors and permit writers in good integrated permitting and inspection practices under the new Water Resources Impact Permit regulation
- Establishing China adapted methodologies and rules for defining ELVs and mixing zones in surface water bodies
- Defining sectoral General Binding Rules (GBRs) for water quantity, efficiency and quality to simplify the permitting process and support the advancement of ELVs in various types of water bodies
- Establishing China adapted Best Available Techniques (BATs) for water use efficiency in all relevant industrial or utility sectors
- Establishing China adapted safe technologies for operators handling dangerous substances
- Establishing rules and methodologies for hazards prevention assessment and planning by operators handling dangerous substances
- Establish linkages with international networks of regulators and inspectors (like IMPEL) to share experience on good permitting and inspection practices

8.3 Scientific research works to advance water ecology security

This may include, but not be limited to:

- Development of methodologies for environmental/ ecological flow in Chinese rivers
- Development of guidance documentation for habitat and ecology restoration works
- Development of methodologies for cost benefit analysis of water ecology restoration works
- Developing a national database of baseline groundwater quantity, quality and trends to allow effective monitoring of groundwater abstraction
- Establishing China adapted general methodologies and rules for assessing the sustainability of groundwater abstraction by operators

Appendix 1

Appendix 1 The Elbe River Restoration Approach

(Inserted overleaf)

Ecological Security: Case Study 1

The Elbe River Basin Restoration Approach

1. Rationale

The Elbe River is Germany´s third largest river with a length of 1097 km, of which 726 km are located on German territory the rest extends into the Czech Republic. The Elbe River comprises a total catchment area surface of 148.000 km². The catchment area is divided between Germany (96.932 km²) the Czech Republic (50.176 km²) Austria (920 km²) and Poland (240 km²). The total number of inhabitants in the Elbe basin is in total 24.72 Mio inhabitants. Distributed between Germany (18.72 million inhabitants), the Czech Republic 5.97 and Austria 0.05 millions.

The Elbe River was one of the most polluted rivers in Western Europe until the political change with the unification of Germany took place in the year 1991. Until then the river was used by the former German Democratic Republic and the former Czechoslovakia as a waste water disposal facility as almost all industrial installations and public sewers drained into the Elbe River lacking any type of treatment This led in consequence to the situation that the River was ecologically destroyed on many stretches downstream of important waste water sources of industrial and municipal installations. The contamination of the Elbe reached such level that the usage of the water for agricultural use and drinking water was not possible. The ones to suffer from the pollution was the located population downstream of the polluters of the Elbe River. Hamburg, Germany´s second largest city, was directly affected by the severe pollution stemming from the east as complete oxygen depletion in summer and regular occurring fish mortalities were the rule. It is no exaggeration to state that Germany faced an aquatic emergency situation concerning the water quality of the Elbe River which was immediately addressed after the change of the political setting in middle Europe in 1990. Nearly 15 years later the environmental restoration and control of the contamination of the Elbe River became a story of success as the water of the river has improved in an amazing short period of time.

2. The International Commission for the Protection of the Elbe River (IKSE)

The International Commission for the Protection of the Elbe (IKSE) which was established in 1990 – only a few days after the reunification of Germany – and whose members are Germany, the Czech Republic and the European Community, can look back on considerable successes. In 1989 the Elbe was one of the most heavily polluted rivers in Europe, and there was a need for urgent action. The first steps of the IKSE were the initiation of the inventory of all industrial and municipal point sources and the formulation of a first action programme from 1992 – 1995 (emergency plan) and a river action plan for the timespan of 1996 – 2010.

3. First Action Programme from 1992 – 1995 (Emergency Programme)

The “First Action Programme (emergency programme) for the reduction of pollutant loads in the Elbe and its catchment area” and the “Immediate ecological measures for the protection and improvement of the habitat structures of the Elbe” document the basic work during the period from 1992 to 1995 which aimed at rapid elimination or minimisation of the worst sources of pollution and at maintaining and improving the morphological structures of the Elbe and its river meadows.

The Action Programme aimed to eradicate or reduce the most polluting point sources in order to diminish the pollution of the Elbe River and its tributaries in a relatively short period of time. The baseline for the formulation of measures within this emergency programme as well as for directing the investments into waste water treatment infrastructure was an inventory of all relevant industrial and communal point sources (direct dischargers) in the Elbe river catchment area.

The programme of measures contained the planning and construction of 139 industrial and communal waste water treatment plants (WWTPs) at direct discharge points of the Elbe River. All communal point sources with a pollution load of >20.000 EGW (population equivalent) were considered as priority sites for the installation WWTP. For industrial point sources a provisional reduction of 30 % of the load for 15 priority substances identified were agreed until the year 1995 as a transitional period.

Between the years 1991 and 1995 in the Elbe River basin a total of 126 WWTPs with a capacity of > 20.000 EGW (population equivalents) were constructed, 96 in Germany and 30 WWTPs in the Czech Republic. These installation have a sum of capacity of >12 million population equivalents.

Due to technical changes inside of industrial production sites and the treatment of waste water, but also by closing down numerous industrial installations (most of them in Germany) a relevant improvement concerning river pollution could be achieved (see table 1). At the several chemical and pulp production sites in the Elbe River, the following reductions of contamination could be reached between the years 1989 and 1995.

Table 1: Reduction of pollution at Chemical and pulp production factories

Chemical Oxygen Demand (COD)	reduction of the pollution load by:	775.500	tonnes per year, this means in percentage:	91,9 %
Ammonia (NH4-N)		24.920		90,4 %
AOX		2.045		80,6 %
Hg		17,1		88,5 %

Ambient monitoring in the river showed that the pollution load of the Elbe fell due to the operating of WWTPs until the year 1995 in comparison to the year 1989 concerning biological oxygen demand (BOD) by 40%, phosphorous and nitrogen by approximately 30%, mercury by 80%, cadmium by 20% and AOX by 50% respectively.

4. The long-term action plan (1996-2010)

The long-term “Elbe Action Plan” of 1995 contains further targeted measures for the period 1996 to 2010seeking to improve the Elbe Rivers quality. A stepwise approach was chosen to reach the desired targets in a realistic timespan.

The first step comprised the period until the year 2000 until then it should be possible:

- to use the Elbe river as drinking water supply requiring only simple technical means (sand and gravel filters);
- the Elbe river water quality should permit that commercial fishery is feasible;

- The water of Elbe River could be used agricultural use.

The second step comprises a timespan until the year 2010, then:

- the reuse of dredged river sediments as fertilizers for agricultural soils shall be possible;
- the biodiversity of the river should be close to the naturally expected situation;

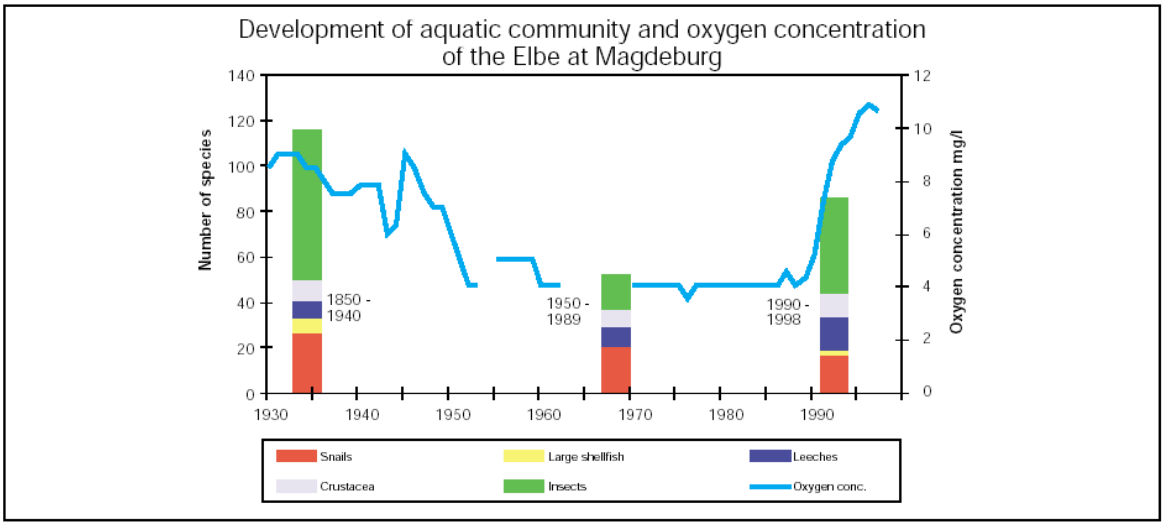
Numerous measures designed to achieve further improvements in the quality of the waters, protect the habitat structures of the watercourses and their riparian zones and minimise the risk of shipping accidents are intended to ensure development of the international Elbe and its tributaries in a manner compatible with nature conservation. All the programmes were based on inventories of the municipal, industrial and diffuse inputs of substances into the waters, and of the ecological condition of the Elbe and its river meadows. All measures are backed up by an international water quality measurement programme for documenting the development of water quality and checking progress, and also by extensive research in the fields of water pollution loads and ecology, an international warning and emergency plan for the Elbe, and recommendations and measures for preventing water pollution resulting from accidents.

Between 1990 and 2000, some 237 large municipal WWTPs were completed within the Elbe catchment area, and sewage system connections created for an additional 2.78 million people. The great reductions in waste water burdens from the municipal and industrial sectors led to a positive trend in the water quality of the Elbe and its tributaries. For the year 1997 the table 2 below reveals the emission situation of the Elbe River.

Table 2: Emission data for the Elbe River in the year 1997 by origins.

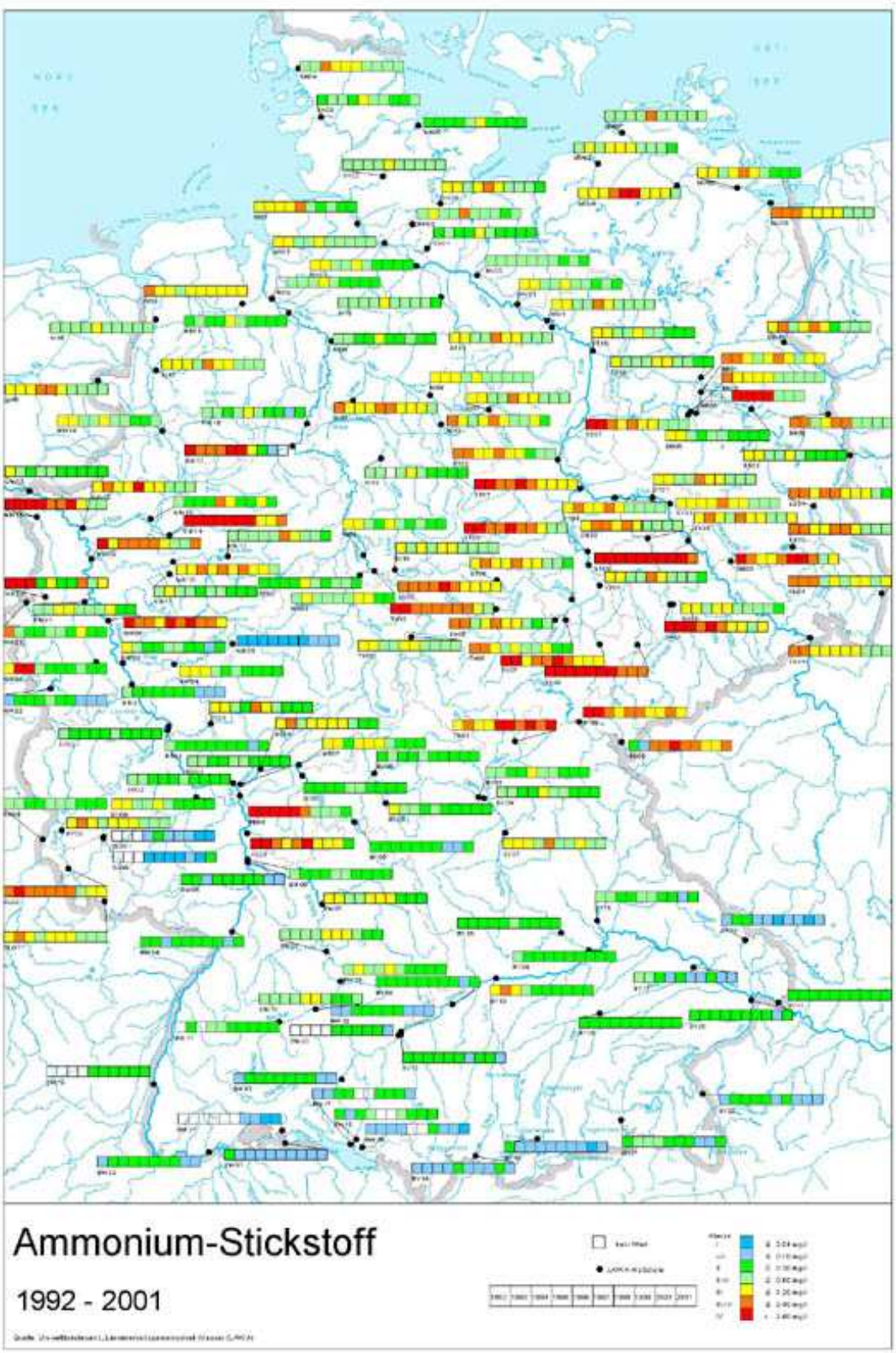
	Inputs	**N_{total} in t**	**P_{total} in t**	**AOX in t**	**Cd In kg**	**Hg in kg**	**Pb in kg**	**Cu in kg**	**Zn in kg**	**Cr in kg**	**Ni in kg**
Elbe	**Municipal**	3178	149	120.9	528	59	9207	7466	23799	1267	3342
	Industrial	32230	2380	53.9	695	376	7358	18055	107216	9010	13348
	Non point	106290	4620		3536	1009	11986	183221	867948	75967	62799
	Total	141696	7149	174,8	4759	1445	128551	208741	998964	86344	79490

The reduction of the pollution between the years 1990 until now is also revealed by the increasing biodiversity of the aquatic community of the Elbe River. Graph Xx shows as an indication of improving river quality as development of the aquatic community in the Elbe River in a former heavily polluted stretch of the Elbe River at the city of Magdeburg.

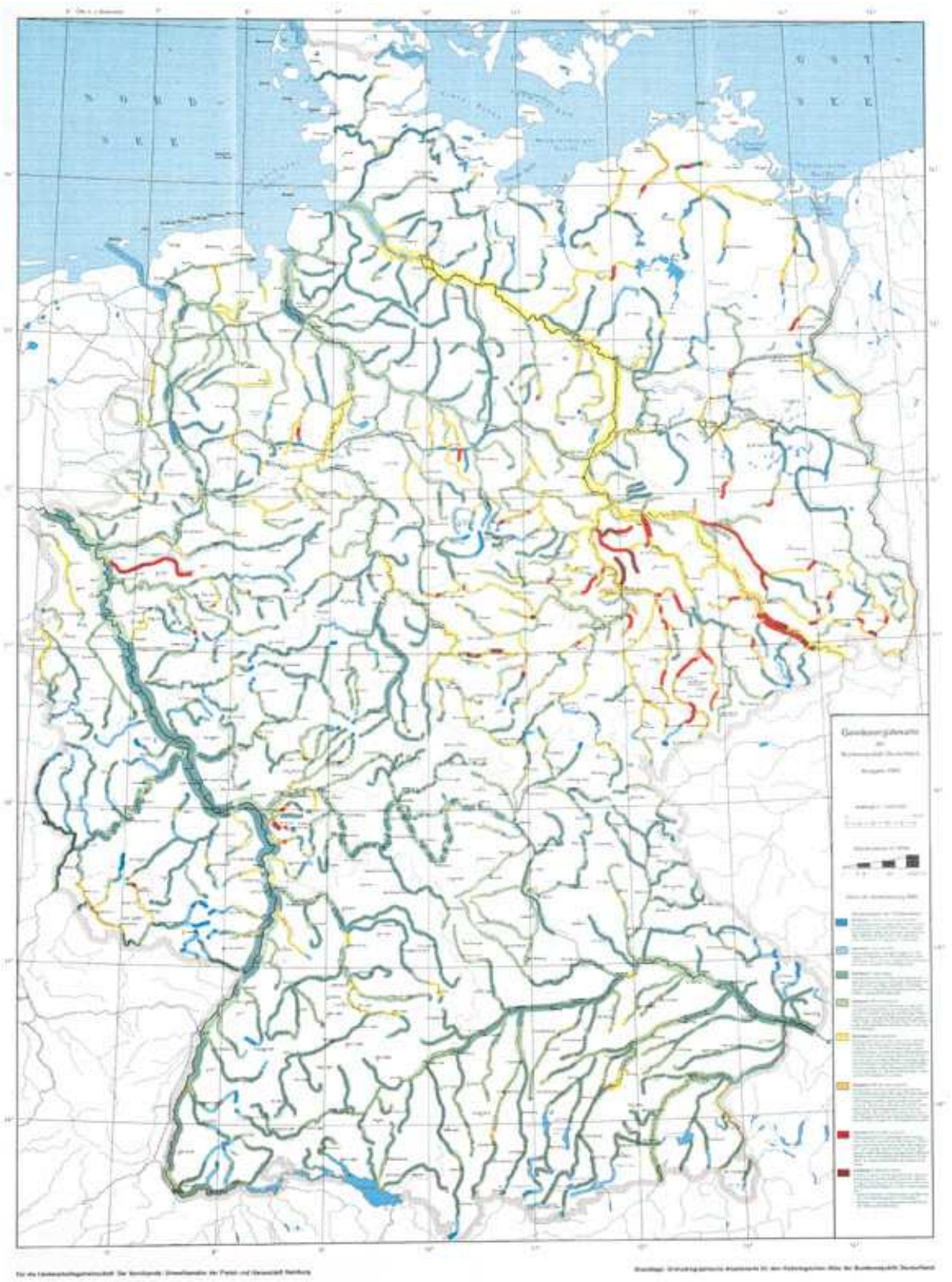


Graph 1: Development of the aquatic community and oxygen of the Elbe River at Magdeburg located on the middle stretch of the Elbe River

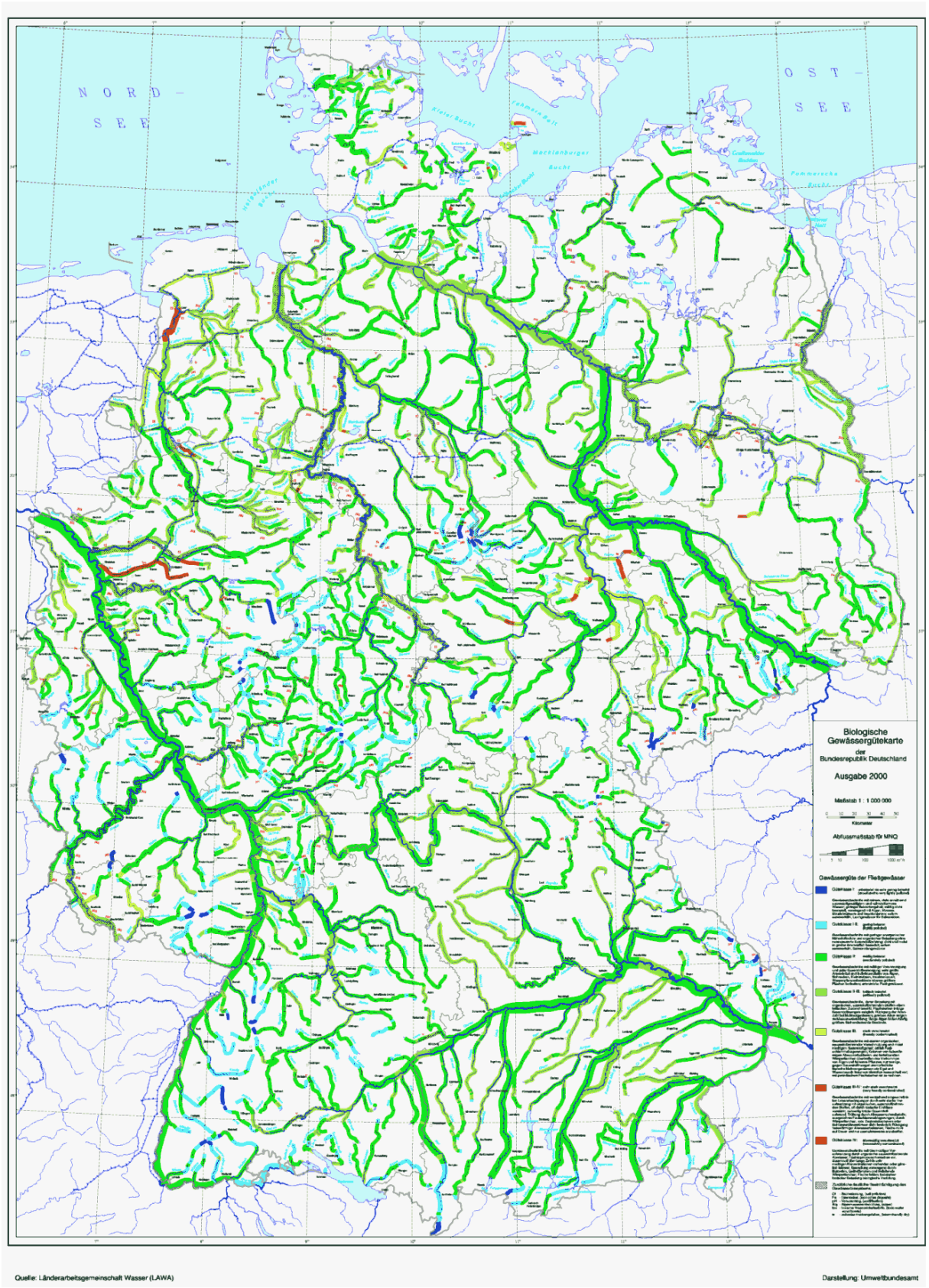
Apart from the continuation and development of the existing activities, key areas in the future will include preparing an “Elbe Flood Protection Action Plan” (2001) and improving the ecological condition of the Elbe and its river meadows by creating further protected areas. The map below shows the development over time for ammonia (mg/l) in the Elbe River as well as other rivers in Germany.



Map 1: Development of ammonia concentration in the Elbe River and other German surface waters between the years 1992 and 2002. (Each square on the time bar represents an average value for the year of observation).



Map 2: Biological quality classification of surface waters in Germany for the year 1990
(red refers to poor biological quality class, blue to best water biological quality class)



Map 3: Biological quality classification of surface waters in Germany for the year 2000 (red refers to bad biological quality, blue to best water biological quality), please note how the Elbe river basin area has improved.

Appendix 2

Appendix 2 Decision Support System for the Elbe River Water Quality Management

(Inserted overleaf)

Decision Support System for the Elbe River Water Quality Management

M. Matthies[a], J. Berlekamp[a], S. Lautenbach[a], N. Graf[a] and S. Reimer[b]

[a]Institute of Environmental Systems Research, University of Osnabrueck and [b]Intevation GmbH
Osnabrueck, Germany

Abstract: A decision support system (DSS) for integrated river basin management of the German part of the Elbe river basin is currently under development, which involves taking account water quantity, chemical quality and ecological state of surface waters. The Elbe is one of the largest river basins in middle Europe having multiple land and water use demands. A hierarchical approach was developed to meet the various spatial and temporal scales when dealing with hydrologic, ecologic, economic and social aspects related to water systems. Four subsystems were defined: catchment, river network, main channel and floodplain. For each module, a system diagram was worked out which describes the properties, processes and data influencing the water flow and substance load. The modules are connected by water and substance flow, which guarantee the interactions between the different scales and consequences of measures on all subsystems. In close collaboration with the users, management objectives, scenarios and measures were defined. The DSS integrates models, spatial and non-spatial data and analysis tools under a user-friendly GIS-based interface, which confronts the decision maker with possible measures as well as multiple management objectives. Three conceptual models were selected and coupled to meet the user requirements. A model for the calculation of the long-term nutrient discharges in 130 sub-catchments from non-point and point sources, a simulation model of the waste water pathways (point-sources) and the aquatic fate assessment was coupled with a GIS-based discrete digitized river network of the Elbe. For the precipitation-runoff simulation, a distributed conceptual hydrological model was selected and calibrated for the same sub-catchments. Long-term discharge time series from gauging stations are being used to calibrate the hydrological discharges. A transport and elimination model describes the downstream fate of the chemical. Temporal concentration distributions of chemicals in each river stretch can be calculated from variable and uncertain input data. With the example of phosphate attached to eroded soil particles the applicability of the Elbe DSS to support decisions for the improvement of the water quality is demonstrated.

Keywords: *River basin; Water quality; Modelling; Decision Support System*

1. INTRODUCTION

Integrated river basin management involves all management issues related to the supply, use, pollution, protection, rehabilitation and many others in a river basin. Integrated implies that relations between the abiotic and the biotic part of the various water systems, between the ecological and economic factors and between the various stakeholder interests are taken into consideration in decision process. Over the last decades river basin management has become increasingly complex. Increasing demands of society regarding ecological and chemical quality of river reaches, use and protection of water bodies and pollution with many different substances lead to new views and strategies towards policy making for river basin management (BfG 2002). So the new European Water Framework Directive consequently calls for a multidisciplinary approach of river basin management. A decision support system (DSS) for integrated river basin management of the German part of the Elbe river basin (Elbe-DSS) is currently under development, which involves taking account of the chemical quality and ecological state of surface waters. Moreover, protection against flood and floodplain inundation and the improvement of navigability are also part of the Elbe-DSS (BfG, 2001).

2. CHARACTERIZATION OF THE ELBE RIVER BASIN

2.1. Introduction

The Elbe is one of the largest river basins in Middle Europe having a length of approximately 1,100 km and catchment area of 148,000 km² from which about two third belong to Germany (Fig. 1). The mean annual discharge into the North Sea is 877 m³/s. The catchment area can be divided in three main natural regions: The Pleistocene lowlands, the loess region and the mountain area. The hydrogeology is dominated by bedrock aquifers (mountains mainly in the southwest) and porous

Figure 1. Elbe river basin

sediment aquifers (lowland). Almost 25 million people live in the river basin. Chemical and others industries, coal (lignite) and ore mining, manufacturing, and agriculture are located in the river basin. Point as well as non-point sources discharge nutrients, heavy metals, pesticides, persistent and many other industrial, agricultural and household chemicals into the stretches. In particular after the reunion of Western and Eastern Germany, various measures and the collapse of the industry had positive effects on the water quality. However, the Elbe and its tributaries are still far from being in a good chemical and ecological state. Although up to 80% of the original floodplains are lost due to embankment, the Elbe riverscape still has many reaches in near natural state. In 1997 UNESCO included the middle Elbe into the list of biosphere reserves. In August 2002 the highest flood of the Elbe since many years occurred with an estimated damage of approximately 9.2 billion EURO only in Germany. High waters resuspended a lot of sediments and transported it to the inundation areas. Sediment particles are associated with microorganisms and toxic chemicals, such as heavy metals and persistent organic pollutants, leading to the contamination of large areas.

3. DESIGN OF ELBE-DSS

A DSS is an interactive, flexible, and adaptable computer based information system specially developed for supporting the recognition and solution of a complex, poorly structured or unstructured, strategic management problem for improved decision making. It uses data and models, provides an easy, user-friendly interface, and can incorporate the decision's makers own insights. In addition, a DSS is built by an interactive process (often by end-users), supports one or more phases of decision making and may include a knowledge component (Delden 2000, modified from Turban and Aronson, 1998). Originally developed to support business managers in a company DSS has attended much interest in the environmental management. The consideration of environmental and ecological aspects for the sustainable management of land and water use in cities, regions or whole countries requires the development of appropriate instruments for policy making (BfG, 2000). Up to now, most DSS were developed for specific purposes such as flood protection, floodplain ecology or management of estuaries (RIKS, 2003).

The Elbe-DSS is the first project, which covers strategic water policy issues of different spatial and temporal scale for a large river basin. Therefore, a feasibility study was performed to elaborate the most prominent issues for the Elbe river management (BfG, 2001). User needs were identified by repeated discussion with representatives from the international, national, regional and local authorities. Since many projects were carried out in the Elbe river basin after the German reunion in 1990, a lot of results, simulation models and data sets were already available. Thus the development of the Elbe DSS could build on a large and current data and knowledge base, which are to be integrated in a flexible, user-friendly system. A preliminary system design was derived in the feasibility study and stepwise refined. Scenarios and measures for various identified management objectives were defined. Appropriate models were selected which deliver indicators to compare the impacts of specific measures and to support decisions to meet user requirements. Data sets of the catchment and river network were collected to support the model calculations. The Elbe-DSS will be implemented using the DSS-generator

software Geonamica developed by RIKS (Hahn and Engelen, 2000). It will consist of a GIS-based user interface, which allows flexible easy-to-use access to pre- and user-defined scenarios. A data base management system (DBMS), model base management system (MBMS) and a knowledge-based tool box are integrated under the graphical user interface.

3.1. Spatial scale and hierarchical approach

Management issues often depend on a specific temporal and spatial scale. For instance, substance discharge into the North Sea is determined by the discharges in the whole catchment, whereas protection against flood damage in a city requires local constructions such as dikes or polders. Also the decision makers have different responsibilities in water management, making an overall systems view difficult. On the other hand, decisions on the catchment scale influence local situations and vice versa. Therefore, the whole river basin was divided into four subsystems, called modules, to allow for better representation of management objectives and scenario development. The modules are connected by water and substance flow, which guarantee the interactions between the different scales and consequences of measures on all subsystems. The four modules are: catchment, river network, main channel and floodplain. A hierarchical approach was developed for the stepwise refinement of the DSS design (Fig. 2).

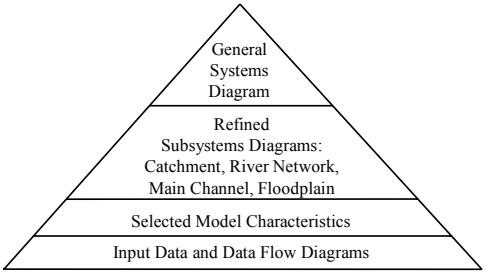


Figure 2. Hierarchical approach

The general systems diagram depicts the relations between the four modules (top level). In a second level all processes of the water flow and quality in each subsystem are laid down. Management objectives are related to the modules and scenarios and measures are defined (second level). In the third level, selected models and their coupling are characterized according to their spatial and temporal scale. Finally, in the bottom level all input data are discovered and their flow through the subsystem is described with data flow diagrams. This hierarchical approach ascertains that the users of the DSS are not lost in a too complex software environment.

3.2. System Diagrams

General Systems Diagram (Fig. 3): In the general systems diagram only the main systems elements are indicated with their interactions. Both water quantity issues, e.g. provision with enough water for various users, as well as quality issues, e.g. clean drinking water are considered. Each of the four subsystems is described by its geometrical, environmental, hydrological and other characteristics. They determine the discharges in the catchment and the chemical substance flow from the catchment to the river network and further downstream. The whole river network is

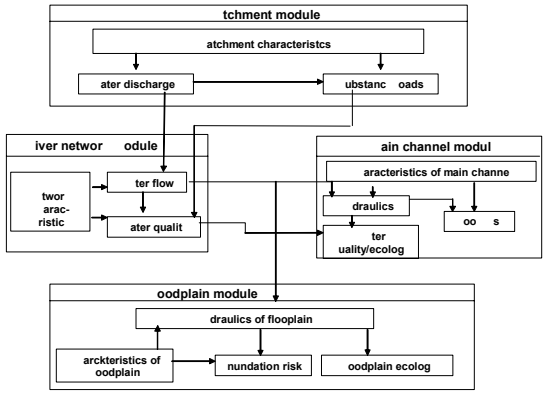


Figure 3. General systems diagram

Catchment module (Fig 4): The system diagram of the catchment depicts all system elements and their relations in more detail. Important catchment characteristics are the topography, soil properties, precipitation, land-use and hydrogeology. The quantity of discharges is determined by the various hydrological processes such as evapotranspiration, infiltration and surface run-off. The infiltrated water moves by interflow and groundwater flow into the river network. Also discharges from treated and untreated sewage water are considered. The third block describes the quality of discharges into the river network, which are driven by substance run-off from land (non-point sources of agrochemicals) as well as from point sources.

River network module (Fig. 5): The river network receives the discharges from the catchment. A digital geo-referenced river network is attributed with the locations of the point sources. The long-term historical time series from

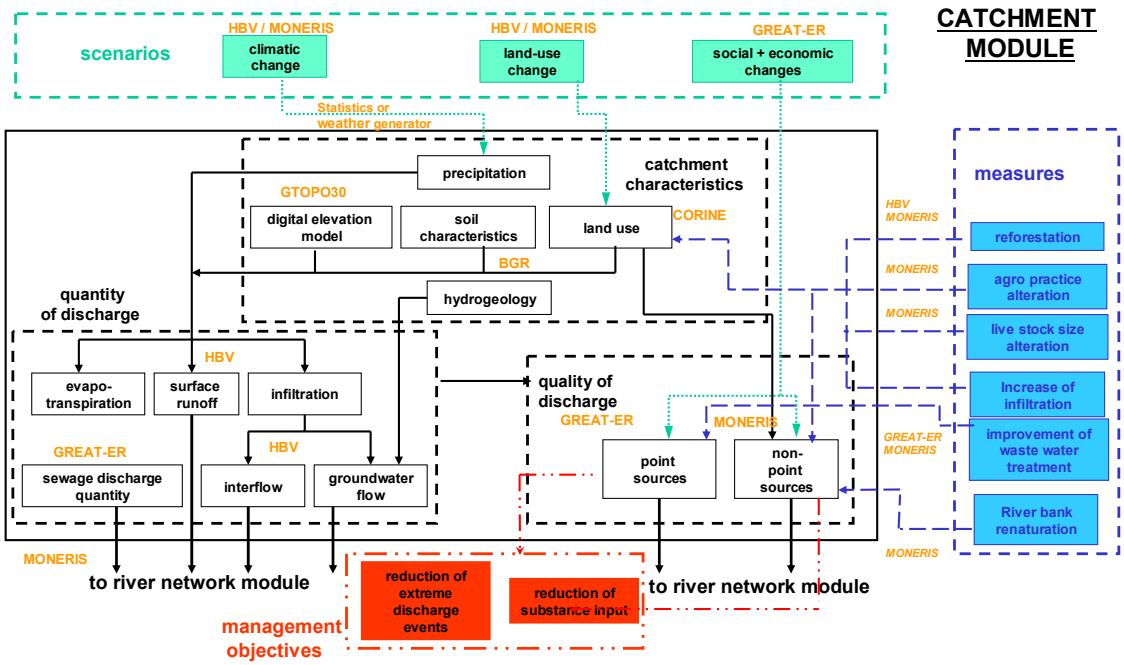


Figure 4. System diagram of the catchment module

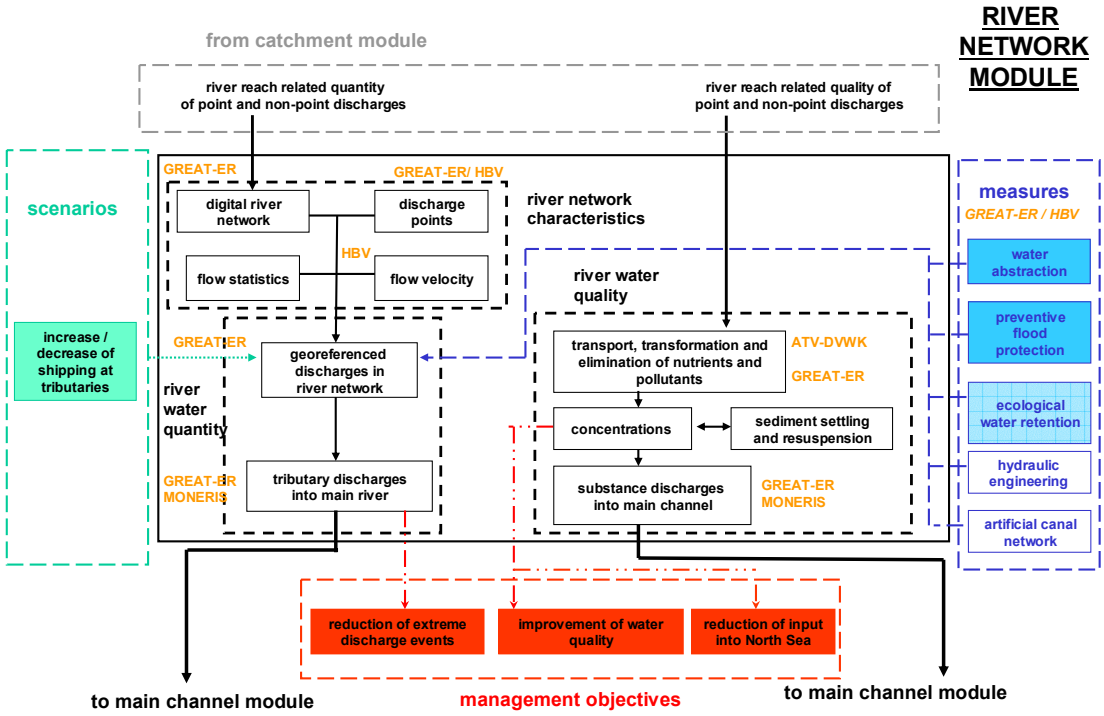


Figure 5. System diagram of the river network module

gauging stations are statistically analyzed to derive mean and variability of the discharges. Moreover, with a rainfall-runoff model daily discharges can be calculated. Water quality is determined with a transport, elimination and transformation model to deliver substance loads as well as concentration patterns along the river net.

3.3. Management objectives, scenarios and measures

Around the system diagrams in Fig. 4 and 5, management objectives, scenarios and measures are indicated. They are defined as follows:

- A management objective describes the state, which should be achieved to meet legislative or other goals.

- A scenario is a pathway into future determined by climate, hydrological, economic, ecological and/or social changes in the catchment.

- A measure is an action taken to achieve the objective.

Please note that scenario is differently defined than in the usual way.

Catchment module (Fig. 4): Indicated at the bottom of Fig. 4 are the management objectives of water quantity and quality management, namely the reduction of substance input into water systems. Three sets of pre-defined scenarios (top of the diagram) can be investigated: climate change, land-use change and socioeconomic change, e.g. demographic growth or decline. They influence the land-use, water cycle and substance impact on water systems. Moreover, various measures are indicated at the right hand side, which the water manager can select to reduce nutrient or other substance discharge. Point as well as diffuse sources can be investigated. Typical measures are local or regional change of agricultural practices to minimize nutrient input (see 4.), deforestation or soil degradation.

River network module (Fig. 5): There are three management objectives in Fig. 5, namely the improvement of the water quality, the reduction of extreme flow events (high water and low water) and the reduction of substance into the estuaries of the North Sea. They can be achieved by various measures indicated at the left hand side. The scenario of increased shipping on the tributaries Saale and Havel was skipped after the flood in August 2002.

3.4. Model selection and coupling

Figs. 4 and 5 also indicate the selected models to calculate indicators, which are used to support the decision making for a specific management objective. Only calibrated and validated models were included in Elbe-DSS. For the precipitation-runoff simulation, HBV-D was selected (Krysanova et al., 1999). HBV-D is a distributed conceptual hydrological model, which is being calibrated for 132 sub-catchments of the German part of the Elbe. It delivers daily discharges as well as any other time-period. Also long-term flow statistics can be created. Besides that, historical time series from 196 gauging stations are used to cover the long-term discharge variability. Nutrient loads (phosphorus, nitrogen) are calculated by the model MONERIS (Behrendt et al., 1999). It is also parameterized for the 132 sub-catchments and allows the average long-term simulation of P- and N-loads from point and non-point-sources. For the river network GREAT-ER is integrated into Elbe-DSS (Matthies et al., 2001, Matthies et al., 2003). The whole digital river network is divided into reaches of about 2 km length giving a number of approximately 33500 reaches in the German part of the Elbe River (without tide influenced coastal sub-catchments). GREAT-ER delivers concentrations of hazardous substances released by point sources, e.g. sewage treatment plants. The water quality simulation model developed by ATV-DVWK (2003) will be included and coupled to the river network.

3.5. Data support

Spatial as well as non-spatial data are collected from various data sources (given in parentheses): Land use (CORINE, Federal Statistical Office), digital terrain model: GLOBE G.O.O.D (GLOBE Project), soil properties, hydrological and meteorological data (Federal Agencies), census data (Federal Statistical Office), waste water treatment data and discharge consents (Federal and State Environmental Agencies), monitoring data (various sources) and many more.

All spatial data sets were processed with a GIS (ArcGis, ArcInfo, ArcView) to produce a consistent geo-referenced data basis, which is coupled to the simulation models.

4. WATER QUALITY ISSUES

Phosphate is the major cause of the eutrophication of fresh waters. Large parts of the Elbe River and its tributaries are still in a eutrophic or oligotrophic state although much effort has been made in the last decade to improve the Elbe River water quality. With the example of runoff of phosphate attached to eroding particles the applicability of the Elbe-DSS for sustainable water management is demonstrated. The sub-catchment of the Saxonian Mulde with a size of 6,221 km² was selected. The Mulde is a tributary of the Elbe, which has its source in the highlands and flows through agricultural and highly industrialized areas. The upper part of the catchment is hilly area, which has a high potential of soil erosion. Two variants of agricultural practices were compared: a conventional and one with minimized tillage operations. Minimized tillage operations means that crop residues are left on the field to increase the soil cover. With conventional agricultural practices high soil loss could be observed in the highland regions. An annual averaged amount of eroded soil of 3.7

t/(ha*a) was calculated. A total amount of 249,022 t/a is transported to the adjacent rivers, which is equivalent to 385 t/a of phosphorus compounds. Most of the arable land is cultivated with grain and corn. An additional cover of bare soils in the growth period of grain (April to July) by litter residues would reduce the erosion of soil to 1.4 t/(ha*a). Particularly areas with high soil loss are affected (Fig. 6). This measure would minimize the sediment impact on the rivers to 76,407 t/a, which is 191 t/a of phosphorus compounds.

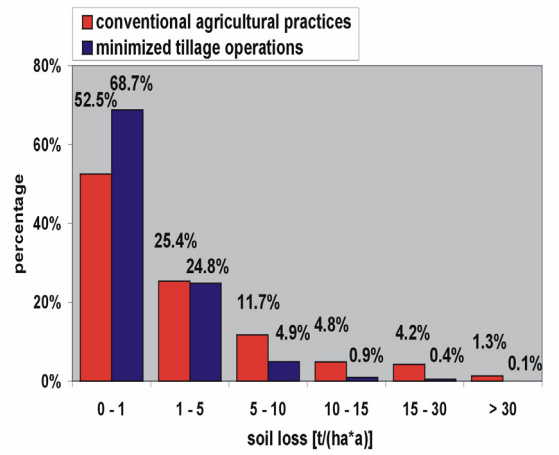


Figure 6. Soil losses with conventional and minimal agricultural practice.

5. OUTLOOK

After finishing the comprehensive systems analysis Elbe-DSS is now in the phase of implementation and calibration. A first prototype includes land-use scenarios and measures on long-term water quantity and quality issues. Next phase will integrate dynamic models into the modelling framework.

6. ACKNOWLEDGEMENTS

The authors wish to thank the DSS Development Team for their kind collaboration, Bundesanstalt fuer Gewaesserkunde (German Federal Institute for Hydrology), Federal Minister for Education and Research and Federal Environmental Protection Agency for their financial support and data supply.

7. REFERENCES

ATV-DVWK, Water quality model, http://www.erftverband.de/aufgaben/projekt/gwguete1/kurzbesc/abstract.htm, 2003.

Behrendt, H., Huber, P.-H., Opitz, D. Schmoll, O., Scholz, G, Uebe, R., Naehrstoffbilanzierung der Flussgebiete Deutschlands, UBA Texte 75/99, Berlin, 1999.

BfG (Bundesanstalt fuer Gewaesserkunde, German Federal Institute of Hydrology), Decision Support Systems (DSS) for river basin management. Koblenz, 2000.

BfG (Bundesanstalt fuer Gewaesserkunde, German Federal Institute of Hydrology), Towards a Generic Tool for River Basin Management - Feasibility study, Koblenz, 2001.

BfG (Bundesanstalt fuer Gewaesserkunde, German Federal Institute of Hydrology), Projekt Elbe Oekologie, http://elise.bafg.de, 2003.

RIKS (Research Institute for Knowledge Systems), Maastricht (Netherlands), http://www.riks.nl/projects/WADBOS, 2003.

Delden, H. van, A generic approach for the design of Decision Support Systems for river basin management. University of Twente and INFRAM, Project Report No. i312, 2000.

Hahn, B., Engelen, G., Concepts of DSS Systems. In: BfG 2000, pp. 9-44.

Krysanova, V., Bronstert, A., Wohlfeil, D.-I., Modelling river discharge for large drainage basins: from lumped to distributed approach, *Hydrolog. Sci. J.* 44 (2), 313-331, 1999.

Matthies, M., Berlekamp, J., Koormann, F., Wagner, J. O., Georeferenced regional simulation and aquatic exposure aseessment. *Wat. Sci. Techn.* 43(7), 231-238, 2001.

Matthies, M., Klasmeier, J., V., Geo-referenced stream pollution modeling and aquatic exposure assessment. MODSIM 2003.

Turban, E., Aronson, J. E., Decision Support Systems and Intelligent Systems. 5th Edition, Prentice-Hall, 1998.

Appendix 3

Appendix 3 Environmental challenges for the Hamburg stretch of the River Elbe and its catchment with regard to the Water Framework Directive

(Inserted overleaf)

Germany

Environmental challenges for the Hamburg stretch of the River Elbe and its catchment with regard to the Water Framework Directive

Susanne Heise[1], Wolfgang Calmano[2], Wolfgang Ahlf[2], Walter Leal[3], Dörte Krahn[3]

[1]Hamburg University of Technology / TuTech Innovation GmbH
Centre for Integrated Sediment Management
Eissendorfer Str. 40
21073 Hamburg
Germany
E-Mail: s.heise@tu-harburg.de

[2]Hamburg University of Technology
Institute of Environmental Technology and Energy Economics
Germany

[3]TuTech Innovation GmbH
Department of Life Sciences
Germany

Keywords:
Germany, Elbe, Hamburg, river mouth, sediments, pollutants, morphology

watersketch

Content

Abstract

The part of the Elbe that flows through Hamburg will not comply with the objectives of the Water Framework Directive in terms of river morphology, ecological and chemical criteria. Due to the demands and activities of the Port of Hamburg, the river has been morphologically modified in terms of navigational depth and container transfer. But the lower Elbe is also characterised by the impacts of former storm surges that have led to the extensive embankment of the river. All these activities have created a river system, in which shallow areas are reduced and the volume of light-limited and anoxic waters increases, leading to increasing oxygen depletion in summer. Even though the quality of the Elbe water has improved during the 1990s, this oxygen depletion threatens the partially recovered fish diversity in the area.

Measures discussed to improve the situation include the maintenance and support of shallow water areas, in which oxygen is produced by phytoplankton organisms, and the further reduction of nutrient emissions into the Elbe River in order to reduce the overall mass production that causes the oxygen-demanding degradation process at the river bottom. Measures that increase the dysphotic water bodies, such as further river deepening plans and relocation of dredged material in the zone sensitive to oxygen depletion, are controversially discussed in this respect.

Morphological changes are also discussed as one reason for increasing sedimentation in the harbour area. As this material is mostly contaminated, it is subject to restrictions in terms of handling and treatment. The increase in sediment that needs to be dredged has reached an extent that threatens the existence of the port, so that short-term solutions needed to be found. Disposal in the North Sea is the option currently carried out. To some extent adverse impacts are to be expected and conflicts will arise with regard to compliance with the WFD as this measure opposes the non-deterioration principle.

The main reason for the persisting contamination of sediment in the Elbe River has been identified as a legacy of past upstream pollution in the Czech Republic and in the area of the former GDR. Even though industrial emissions probably also need to be reduced in Hamburg itself, a prioritization of sites would show that measures would be most effective if applied in the areas upstream. Financial constraints of the Federal States in which these sites lie, make implementation of solutions difficult. A river basin approach with – also financial - cooperation of all stakeholders beyond political borders is required in order to solve historical contamination and in order to address the interactions between different sites in a river basin.

1 Introduction

The quality of the Elbe in Hamburg is influenced by the industrial and political history upstream, by emissions of the big city with extensive industrial activities, by the morphological changes due to the construction and maintenance of Germany's largest port, and by the tides that strongly affect the sediment dynamics in Hamburg.

Sediments are an important topic in Hamburg – because of their quantity and their quality. These sediments originate partly from upstream, but to the greatest extent from the North Sea. They settle in still water zones of the port, e.g. harbour basins, from where they have to be actively removed in order to maintain navigational water depth. As sediments tend to accumulate contaminants, a large volume of what needs to be dredged in Hamburg cannot be relocated to the sea but needs to be treated or disposed of on land at high expense. Therewith, the quality of sediments is an economic factor. Naturally, it is also of environmental importance, as contaminants can be remobilised when sediments become resuspended – by natural events such as floods or by anthropogenic activities like relocation of dredged material. Even though their quality has been given little attention in the Water Framework Directive, they ought to be considered as a secondary source of pollution, which needs to be addressed and for which measures need to be suggested in River Basin Management Plans. For Hamburg any such measures will be of little use when limited within the boundaries of the city, as the main problems derive from upstream in terms of quality and from the North Sea in terms of quantity. Even though Hamburg also necessarily has its own share in causing environmental problems, long-term solutions can only be found in the sustainable management of the whole river basin, which requires community-supported long-term strategies that are aware of and address the different interests, uses and functions in the catchment area – from the upper Elbe to the estuary.

2 Background information

2.1 The current situation

2.1.1 The Elbe

The Elbe River is one of the major rivers in Western Europe. From its spring in the Giant Mountains ("Krkonoše Mountains", Czech Republic) to its mouth at the North Sea near Cuxhaven (Germany) it covers a distance of 1,091 kilometres and a catchment area of 148,268 km2 – one third of it located in the Czech Republic and two thirds in the Federal Republic of Germany, smaller areas belonging to Poland and Austria. Along its way the catchment drains some of North and Central Europe's major cities including Prague, Dresden, Berlin and Hamburg. The Elbe River flows through Bohemia, the Elbe Sandstone Mountains and drains the Ore Mountains before it reaches the Middle and North German Lowland. The Mulde flows into the Elbe at river-km 260 (from the Czech-German border), Schnackenburg at the former East-West German border is at river-km 480, Hamburg at river-km 620 and the North Sea at approx. river-km 730. Downstream of the weir in Geesthacht, the river is influenced by the tide for more than 100 km until it flows into the North Sea at Cuxhaven. In this area the Port of Hamburg is situated. With respect to the WFD the Elbe River basin consist of three different types of waters, river, estuary and coastal water.

as discharge system for various industrial and municipal purposes. Waste water was released untreated into the river system in former East Germany (GDR) and Czechoslovakia. These contaminants nowadays form a "legacy of the past" as they are enriched in the Elbe sediment and transported downstream when resuspended. This is expected to influence the achievement of the objectives of the WFD (Heise et al, 2005).

For the implementation of the Water Framework Directive, the Elbe River Basin has been divided into 10 coordination areas (Fig. 2). The upper and middle Elbe (HSL), the upper Moldau/Vlatava (HVL), the Berounka (BER), the lower Moldau/Vlatava (DVL), the Eger and lower Elbe (ODL), Mulde-Elbe-Schwarze Elster (MES), Saale (SAL), Middle Elbe/Eide (MEL), Havel (HAV) and the Tidal Elbe (TEL). This report focuses on the Tidal Elbe including its major city Hamburg.

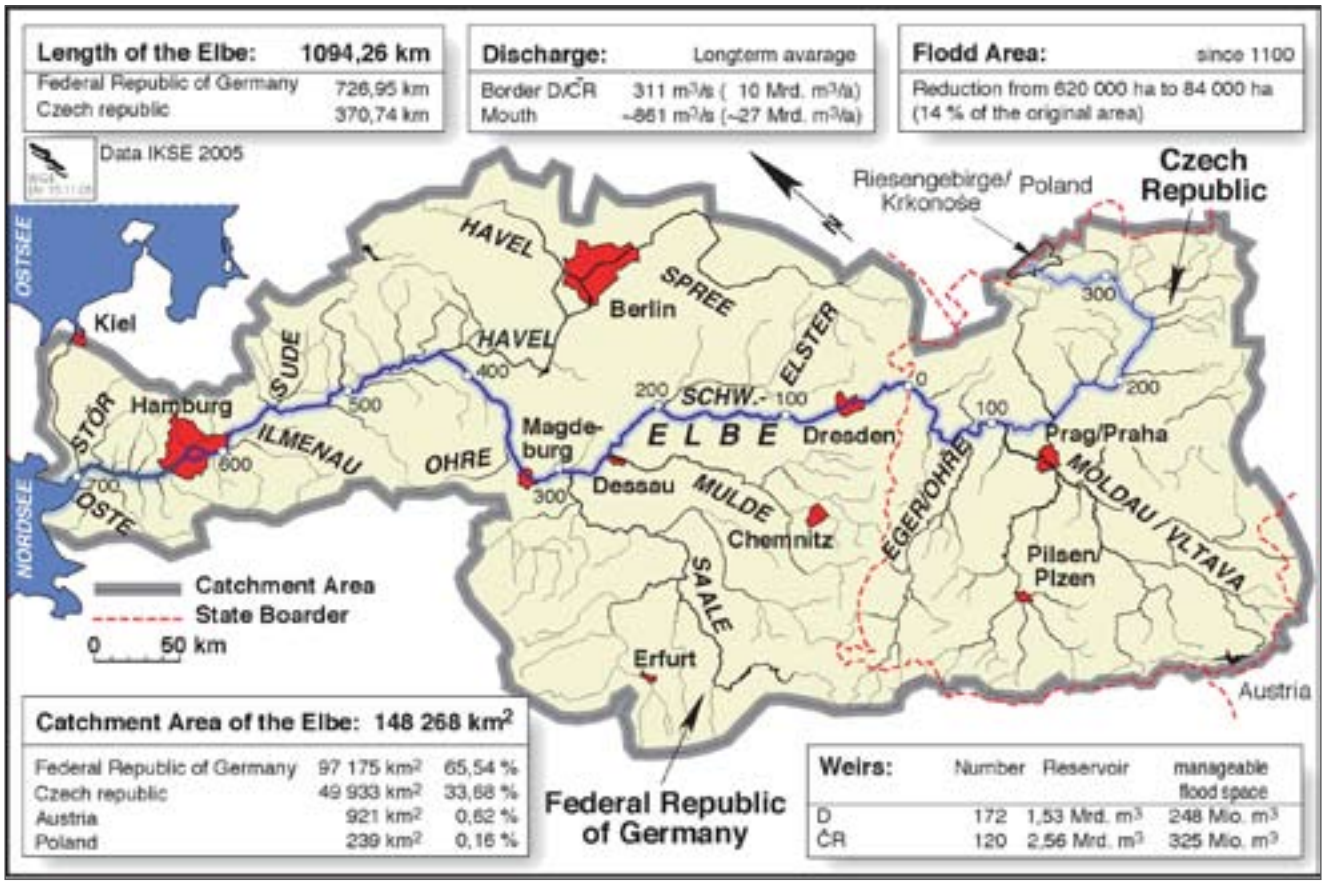


Fig.1: Characteristics of the Elbe Catchment Area (Image: ARGE-Elbe)

The most important tributaries of the Elbe River with respect to the total amount of water and contaminants are Havel, Saale, Elster, Mulde, Moldau and Eger.

During the 1970s the Elbe River was one of the most polluted rivers in Europe. Especially during the time of the iron curtain, the Elbe River and their tributaries were used

Fig. 2: WFD-coordination areas of the Elbe catchment (Image: IKSE)

2.1.2 Hamburg as part of the Elbe Catchment

With 1.7 m inhabitants Hamburg is the second largest city in Germany and its 3rd largest industrial area, comprising automobile industry, precision engineering, mechanical engineering, chemical production, metal industry, and oil processing industry. The most important industry in Hamburg, however, is the harbour - in terms of international reputation, employment and income for Hamburg.

Fig. 3: View over parts of the Hamburg Harbour area (Image: Wassergütestelle Elbe)

Directly or indirectly, 131.000 people are employed in Hamburg in connection with harbour activities adding up to 12.6 % of all jobs in Hamburg (Freie und Hansestadt Hamburg, 2006). Accordingly, the harbour is of high economical importance for the city.

Immigration, economic growth and an employment increase at the beginning of the 1990s led to a rise of the region around Hamburg to one of the most important German Metropolitan regions.

Borne from the realisation, that increasing economical demands and challenges could not be tackled by one Federal State alone, Hamburg agreed with its adjacent neighbours, Lower Saxony and Schleswig-Holstein, to increase cooperation in the metropolitan region, to create a common job market and a unified economical region. The "Metropolregion Hamburg" now comprises 800 cities and municipalities and 4.2 m inhabitants (Metropolregion Hamburg, http:// homepage.hamburg.de/redaktionhh/metropolregion/Broschuere_zur_Metropolregion)

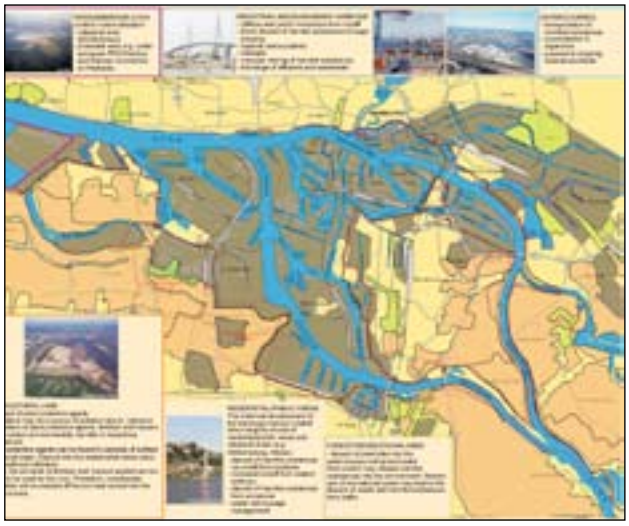


Fig. 4: Land use in Hamburg (Image Watersketch)

Open air space and buildings: 36%

Agriculture: 27%

Traffic area 12%

Lakes, rivers and canals 8%

Recreational areas 12%

Others 5%

10% of the area is used in connection with harbour activities.

Fig. 4 depicts the land use in Hamburg. For a large part the two Elbe sections, the Northern and the Southern Elbe River, are surrounded by industrial areas. The surface area that is taken up by activities related to the harbour function makes up approximately 10 % in Hamburg. It is mainly the south-east area directly after the division of the Elbe river into the two sections and the region North of the Northern Elbe, which are used for living and recreational purposes. It should be stressed that extensive agricultural areas are located south-east of Hamburg (z.B. "Vierlanden") and downstream of Hamburg ("Altes Land").

2.1.3 Hamburg and the Tideelbe

Like all rivers that are influenced by the tides the estuary downstream of Hamburg shows an area of high turbidity (Fig. 5).

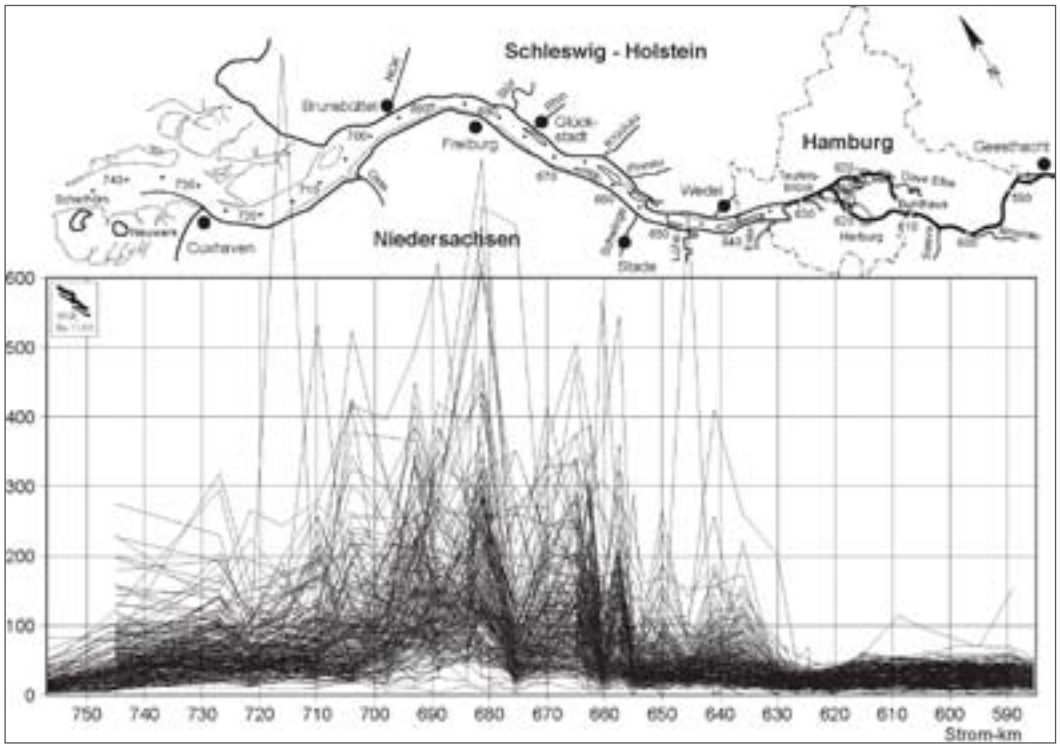


Fig. 5: Longitudinal profiles of suspended matter along the tidal area downstream of Hamburg between 1979 and 2003 (from Bergemann, 2004)

The high concentration of suspended matter results from a net transport from the North Sea upstream towards Hamburg. Its extent varies with the tides, the morphology of the river, the river discharge and the composition of suspended matter (Bergemann, 2004). During times of low water discharge of the Elbe, the turbidity increases and material is transported towards Hamburg. Flood events in the catchment on the other side can "push" suspended matter into the North Sea. The turbidity maximum and sediment dynamics in the tidal area are of high economical importance. The solid matter that is transported to Hamburg from the North Sea increases the amount of material that settles in the harbour basins and therewith the volume of material necessary to be dredged to maintain navigational water depth. On the other side, this material is relatively little contaminated and dilutes the contaminant concentration that is introduced to the harbour with the Elbe from upstream. Hence, hydrodynamics of the river and the extent of mixing of estuarine with fluvial sediments affect the categorisation of dredged material in terms of fate of treatment.

2.1.4 The ecological situation of the Elbe in Hamburg

The ecological situation in Hamburg is influenced in terms of chemical quality by the dissolved or – more importantly – particle bound contaminants that are transported towards Hamburg by the Elbe. It is also influenced by industry emissions within the Hamburg Area. For 2001 the EPER[1] listed four industrial plants in Hamburg that emitted notifiable concentrations, such as 1,2-dichlorethane, phenol compounds, arsenic, cadmium, copper, nickel, lead and zinc into surface waters. The relative contribution of these sources to the contamination of water and sediment within Hamburg is difficult to estimate due to the high immission in the Elbe upstream of Hamburg. A recently prepared report for the Hamburg Port Authority lists the different areas of concern along the Elbe River with regard to the extent of their contamination (Heise et al, 2005). A comparative risk analysis that would quantify the contribution of sources to downstream regions has not yet been performed but has been planned.

Another important factor that affects the ecology within the Hamburg Elbe area is the morphology of the river and how it has been altered. Long-term modifications of the river, e.g. deepening of the stream, building of dikes and river embankments etc. have led to extensive challenges in water current velocity, transport and sedimentation patterns of material and tidal ranges. Effects on the macrozoobenthos community, algae growth and fish diversity are strongly suspected (see below).

The results of the first monitoring for the WFD that was supposed to give an indication on which areas will achieve the quality norms of the WFD and which will probably fail, is presented in Table I. No difference between the four water bodies that are differentiated along the Tidal Elbe can be observed. The objectives of the WFD will only be achieved where water supply and free passage of water bodies are observed. All water bodies are therefore likely to fail all other criteria.

[1] European Pollutant Emission Register

Waterbody	Biological quality components				Hydromorphological quality components			Physical-chemical quality components		Integrative assessment		
	phytoplankon	Macrophytes and phytobenthos	Benthic invertebrates	fishes	Water supply	Passability	Morphology	General conditions	Specific contaminants	Ecological status	Chemical Status	Total evaluation
Elbe (East)			☹	☹	☺	☺	☹	☹	☹	☹	☹	☹
Harbour			☹	☹	☺	☺	☹	☹	☹	☹	☹	☹
Elbe (West)			☹	☹	☺	☺	☹	☹	☹	☹	☹	☹
Elbe (transitional zone)	-		☹	☹	☺	☺	☹	☹	☹	☹	☹	☹

	Compliance with target values unknown	☺	Compliance with target values probable	☹	Compliance with target values improbable

Tab. I: Results of the monitoring (translated and modified from ARGE-Elbe, 2005)

2.2 Pressures

With regard to pressures that will negatively influence European and/or national Directives, the following challenges need to be differentiated:

2.2.1 Environmental risks

Environmental risks in Hamburg have been voiced with regard to the following issues:

a) Legacies of the past. In 2005, six historic contaminated sites with significant effects on the water quality in Hamburg and seven sites, which were strongly suspected to have significant effects, were identified (Freie und Hansestadt Hamburg, 2005). The main contribution due to old legacies seems to be introduced with water and sediment from upstream areas. In the A-report to the WFD, 17 groundwater bodies have been identified in the Elbe catchment, for which compliance with the WFD objectives is unclear or improbable due to old legacies: All of these are either in the Mulde-Elbe-Schwarze-Elster- (MES), Saale- (SAL), Middle Elbe-Eide- (MEL), or Havel- (HAV) coordination area. Extensive industrial production areas in former Czechoslovakia and the German Democratic Republic left large volumes of highly contaminated soils and sediments, which still pose a risk to downstream areas even though industrial emissions have been largely reduced (see Heise et al. 2005).

b) Current industrial emissions. Annex A1 of the "Commission Decision 2000/479/EC of 17 July 2000 on the implementation of a European Pollutant Emission Register (EPER) according to Article 15 of Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC)" states threshold levels for substances above which releases by industry to the environment have to be reported to the European Pollutant Emission Register (http://www.eper.cec.eu.int/eper/). In Hamburg Harbour, five industrial plants have reported to exceed emissions of those substances in direct releases to water (EPER – data from 2001). In the whole Elbe catchment, 179 industrial plants have been reported in 2005 to emit substances above the criteria given in the aforementioned Council Directive 96/61/EC or of priority substances for which limit values have been set in the daughter guideline 76/464/EEC (IKSE, 2005).

c) Oxygen depletion during summer months. After a recovery of the water quality of the river in the 1990s, the naturally occurring phenomenon of an oxygen decrease in the Hamburg region over the summer months has become more dramatic since 2000, resulting in the death of a large number of fish in some years. A number of hypotheses try to explain this trend that it may be caused by events such as the uninhibited plankton growth due to the reduction of inhibiting contaminants in the water, the increase of the dysphotic water body due to the continued deepening of the river, or the reduction of shallow water environments through active measures (ARGE-Elbe 2004).

d) Nutrient loads. Nutrient loads of the Elbe at Seemannshöft in Hamburg between 2000 and 2002 for total nitrogen were 126.000 t/a and for total phosphorus 5.633 t/a (median values). Both derived mainly from diffuse agricultural emissions from the whole Elbe catchment (Behrendt et al. 2002).

e) The disposal of dredged material into the North Sea. The disposal of potentially contaminated material in the North Sea in an area belonging to the Federal State "Schleswig-Holstein" has raised concern with regard to possible contamination of fish and impacts on the marine environment (Nix 2005; "Kontroverse um die Verlagerung von Baggergut" Die Welt, Artikel vom 11.03.2006)

f) Morphological changes such as diking and deepening of the river in the area of Hamburg led to an increase in the tidal range at the measurement pole in St. Pauli from 2.60 m in 1963 to 3.35 m in 1978 (WWF 2003). In 2004 the tidal range in Hamburg was 3,57 m. This development has led to a decrease in the freshwater tidal flood plains, which are exceptional biotopes home even to endemic plant species. Nature protection groups like the Bund fuer Umwelt und Naturschutz Deutschland (BUND) demand the integration of the remaining tidal floodplains into the "Flora and Fauna Habitat"-areas (FFH) (BUND Hamburg, 2004).

2.2.2 Economical aspects

a) In order to keep the Harbour functional, a minimal navigational depth must be maintained. For this reason, dredging activities are necessary. Depending on the degree of contamination, the dredged material is either treated (size classification and separation, dewatering)

and disposed of on land, or relocated to the Elbe. Restrictions with regard to time and environmental parameters are specified that need to be observed during dredging and relocation operations (Freie und Hansestadt Hamburg 2002):

- Relocation is only allowed during ebb tide in order to reduce sedimentation in shallow areas.
- Relocation is forbidden between April and August (fish breeding season).
- In September and October, special attention needs to be paid to the oxygen concentration that must not decrease below 6 mg/l.

The amount of material that needs to be dredged per year has risen dramatically. From approximately 2 to 3 m m^3/a until 1999, it has risen to almost 9 m m^3/a in 2004 (HPA 2005). This situation has become increasingly difficult, as the space for on land disposal of contaminated material is limited, treatment and disposal itself is expensive, and relocation of material during summer is not allowed. Additionally, simulation models showed that due to an effect called tidal pumping, approximately 80 % of the material that is relocated just downstream of Hamburg is transported back to the Harbour area (Glindemann, personal communication).

In search for a practical and economically feasible short-term solution, HPA and the Waterway and Shipping Directorate in charge (WSA Nord) developed a sediment management concept for the Tidal Elbe, advised by the Federal Institute of Hydrology and the Institute for Hydraulic Engineering. This concept envisaged a disposal of 4.5 m m^3 altogether of dredged material in the North Sea between 2005 and 2008 (Ministerium für Landwirtschaft, Umwelt und ländliche Räume 2005; HPA 2006). It is currently being investigated to what extent these plans collide with the OSPAR and London Conventions and the national "Guidelines for the Treatment of Dredged Material" (HABAB, BfG 2000).

b) On 12.09.2006 the official request for the next deepening of the Elbe was handed in by the Hamburg Port Authority (HPA) and the Waterway- and Shipping Office (WSA) Hamburg to the responsible authorities (Press release 12.9.2006, City of Hamburg). In order to stay competitive with other large harbours, the HPA plans a deepening of the Elbe River by 1m. This would allow container ships of the new generation with a capacity of 8000 TEU[1] and a depth of up to 14.5 m to enter the port (Ginzky 2005). Deepening of rivers can affect current velocity, tidal range and sediment transport. Beside other factors, the deepening of 1999 is being discussed in the media as a reason for the increase of sedimentation in the harbour area. The potentially increasing risk of storm surges with increased tidal ranges unsettles residents downstream of Hamburg. The City of Hamburg started a campaign in which a facilitator was instated to communicate the situation to the concerned public.

2.2.3 Social aspects

The attitude of the public towards the quality of the Elbe River can be assessed as positive and the official Elbe-Bathing Day on 17 July 2005 (Fig. 6) was regarded as a success. However, a number of nature protection groups warned that not all is well with the Elbe (e.g. Rettet-die-Elbe e.V., BUND, NABU). Awareness of contamination in sediments is low. However, the current disposal of material in the North Sea and the plans of the deepening of the Elbe raised a lot of concern and gained attention in the regional and national media[2]. Most public concern is centred around human health and safety risks, e.g. the increase of flood risks as a consequence of the river deepening, and employment.

Fig. 6: Elbe Bathing Day on 17 July 2005 (Image RiverNet).

Impacts on the Elbe fishery are another issue that is tackled by media and brought to public attention in connection with measures carried out in the Hamburg region of the Elbe. Only 4 to 5 fishermen still work on a full-time professional basis in this area and approximately 10 times more people on a sideline basis. The Elbe fishery is a very traditional profession and valued as part of Hamburg's history, as is the fish market – one of Hamburg's main attractions. The fishermen's observations with regard to the quality of the Elbe waters and the abundance of fish have a high credibility with the public. Reports in the newspapers about unusually large amounts of dead fish repeatedly caught since the year 2000, which coincided with the last deepening of the river and the removal of 10% of the freshwater wadden area "Mühlenberger Loch" in favour of a new airstrip of the Airbus company increased public concern about planned measures in the Hamburg region[3].

Promises of the Airbus industry to employ several thousand people in the process of building the new Airbus A380, however, resulted in controversial discussions and conflicts between those people that saw their jobs being threatened by environmentalists, and those people that wanted to prevent the extension of the airfield either because they wanted to keep the quality of the suburban area that was going to be sacrificed for the airstrip or because they wanted to save the nature protection area "Mühlenberger Loch" from destruction[4].

[1] TEU – Transport Equivalent Unit

[2] http://www.abendblatt.de/daten/2005/07/27/463615.html
http://www.welt.de/data/2005/07/28/751742.html
http://www.abendblatt.de/daten/2005/08/01/465262.html
http://www.abendblatt.de/daten/2005/08/13/470306.html

[3] „Tote Hose in den Netzen" – Hamburger Morgenpost, 07.06.2001

[4] http://www.abendblatt.de/daten/2004/10/26/356608.html
http://www.abendblatt.de/daten/2003/09/30/213601.html
http://www.abendblatt.de/daten/2003/03/01/129586.html

2.3 Impacts on the Environment

2.3.1 Chemical contamination

The quality of the water has improved a lot since the 1990s. A persisting problem, however, are contaminated sediments that can re-introduce dangerous or potentially dangerous substances into the water column if resuspended. Via bottom-dwelling organisms, contaminants may also enter the food chain by direct contact. In Fig. 8, average chemical data of sediment cores from annual samples of two stations between 2001 and 2004 are compared. For comparison an area directly upstream of Hamburg (Bullenhausen) and an area further downstream, in the western part of Hamburg (Parkhafen) (for locations see Fig. 7) were chosen. Depicted are chemical concentrations as percentage of the sediment target values according to the current ARGE-Elbe Classification (ARGE-Elbe 1996). The figure shows, that a) most heavy metals, some PCBs and TBT exceed the target values and that b) the contamination upstream of Hamburg is higher than in the Harbour area. The decrease is due to the diluting influence of relatively clean material that is transported into the region by the tides, but it also demonstrates the high impact of sources upstream of Hamburg.

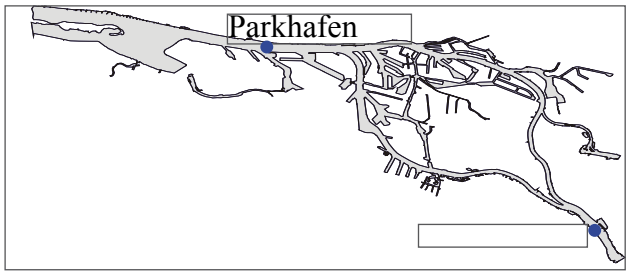


Fig. 7: Positions of compared sediment core analyses in the harbour

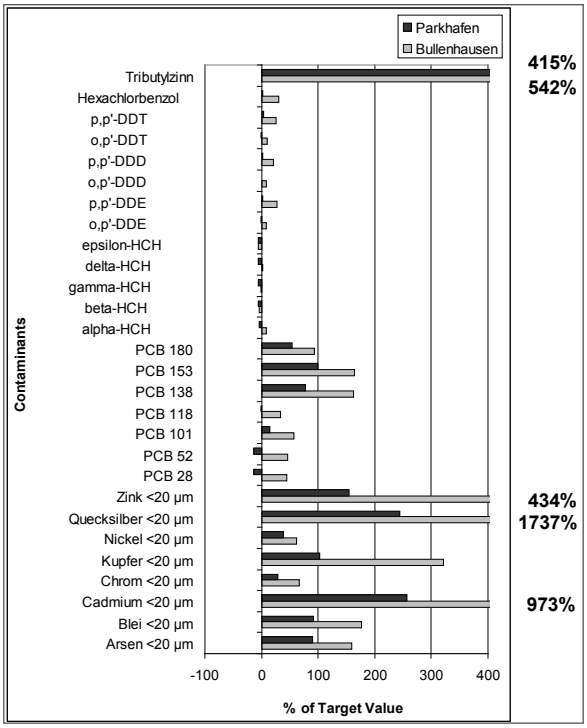


Fig. 8: Contaminants according to the ARGE-Elbe Classification, measured in sediment cores between 2001 and 2004. Data: HPA

A contaminant, whose emission in the Elbe River is mainly restricted to Hamburg, is tributyltin (TBT), which has been used extensively in antifouling paints for decades. TBT is a toxic substance with estrogenic effect and very low effective concentrations. Figure 9 shows the increase of TBT in sediments in the centre of the harbour area and especially near the "Reiherstieg", where traditional dock yards and small harbours are located.

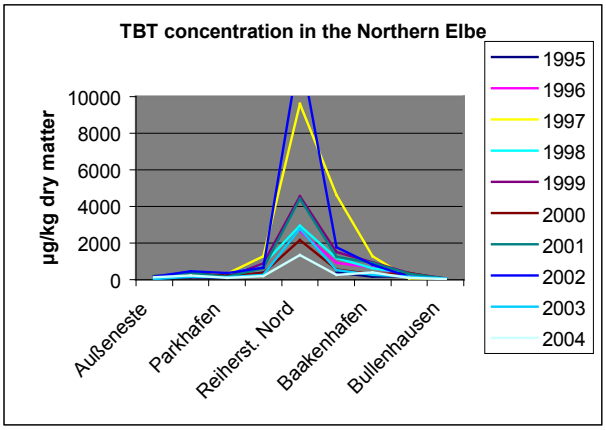


Fig. 9: TBT Concentration in the northern part of the Elbe River between 1995 and 2004. Data: HPA (Heise et al. 2005)

Concentrations have been decreasing since its ban by the IMO (International Maritime Organization, www.imo.org) in 2001. According to this "Antifouling Convention", application of TBT containing paints had to cease by 2003 and by January 1, 2008, a complete ban on the presence of organotins acting as biocides in antifouling paints should come into force. Even though the degradation rate of TBT in sediment is low, this substance will not continue to be an environmental problem. However, doubts have been voiced whether so called "booster biocides" that were recently introduced as alternatives to organotin compounds in antifouling products and which are mostly based on copper metal oxides and organic biocides (e.g. Irgarol 1051, diuron, Sea-nine 211, dichlofluanid) will not create a new environmental problem (Konstantinou & Albanis, 2004; "Science for Environment Policy" 2006).

2.3.2 Habitat preservation

There has been a lot of debate about the Flora Fauna Habitat (FFH) areas to be assigned in the Hamburg region. The European Commission criticised in the first proposal handed in by Hamburg for its FFH and EU-Bird protection areas that habitats in the estuary and for characteristic fish species such as Allosa fallax (germ. "Finte") and Lampreta fluviatilis (German „Neunaugen") were missing. Currently, Hamburg has assigned 14 FFH areas and 6 EU-Bird protection areas, which add up to 8 % of the Hamburg region. With regard to the critical points mentioned by the EU Hamburg argued that estuaries, defined as brackish water zones, commenced further downstream and outside of Hamburg borders. New FFH areas inside the harbour, as suggested by the EC for the protection of fish habitats, were seen unnecessary as the listed fish species were either not considered Elbe-specific or as protected by other FFH areas (press release Stadt Hamburg from 18 January 2005).

Whether the FFH areas that have been designated will eventually protect the rare tidal floodplain forests in Hamburg has been questioned by WWF and BUND. The rise in medium tidal high water due to the morphological modi-

fications of the Elbe river (see below) is not tolerated by the forest and a withdrawal to the hinterland is usually restricted by dikes (WWF 2003)[1].

2.3.3 Morphological changes

Currently, an environmental impact assessment for the planned deepening measure is carried out, with publication expected at the end of the year 2006. However, following the last deepening activity, a number of changes were observed and listed by the WWF (2005)[1]:

a) Increase of tidal range: Reduction of low water level at Bunthaus (upstream of Hamburg) by 5.7 to 8.5 cm, increase of upper water level at St. Pauli (in Hamburg) by 5 cm. This impact had been predicted by the authorities.

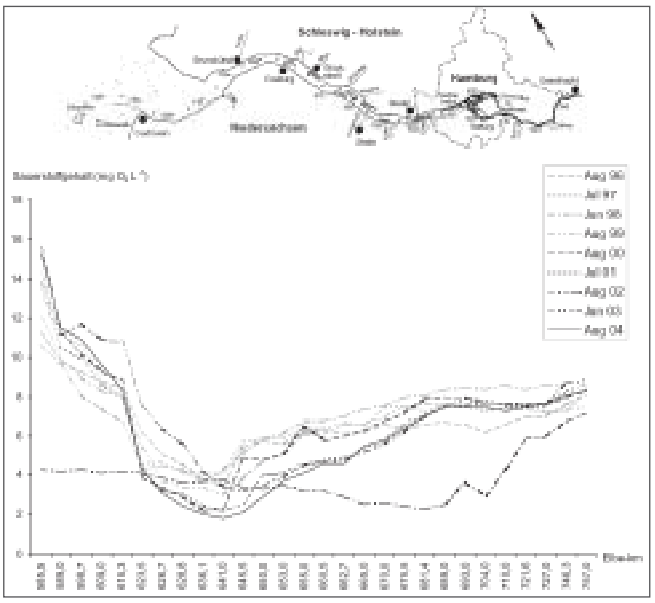


Fig. 10: Comparison of longitudinal profiles in the Tideelbe in the years 1996 to 2004 at times of extensive oxygen depletion. Data from ARGE-Elbe. (WWF, 2005, by Kerner & Jacobi)

b) Intensification of the oxygen depletion in Hamburg (predicted effect exceeded) Since 1999, a trend to lower minima and wider effected areas has been observed. The oxygen concentration below which fish are endangered is estimated to be 3 mg/l. In 2005, oxygen concentrations dropped below 2 mg/l in Seemannshöft (Fig. 11), resulting in a large number of dead fish (Hamburg Morgenpost, 6.7.2005). Reasons for the oxygen depletion may be manifold.

Fig. 11: Overview over dissolved oxygen concentrations in Bunthaus (BU) and Seemannshöft (SH) and Water temperature (SH:TW) over the last 6 months (Data and Graph: BSU Hamburg)

The ARGE-Elbe suggested next to the river deepening the removal of shallow water areas like side branches of the Elbe, harbour basins and the Mühlenberger Loch. Shallow areas serve as oxygen production areas, while large volumes of dysphotic water bodies that are increased by the deepening measures, shut off the phytoplankton from the light, preventing photosynthesis and initiating oxygen-demanding degradation processes (ARGE-Elbe, 2004). The influence of potentially increasing water temperatures of the Elbe river due to climate warming on oxygen concentration has not been quantified yet to the authors' knowledge but can not be excluded.

c) Increased sedimentation at shallow areas and in anabranches of the Elbe (predicted effect exceeded).

d) Increase of maintenance dredging in Hamburg (predicted effect exceeded)

e) Increase of the fine grain sediment fraction in the whole area of the Tideelbe (predicted effect exceeded)

f) Increase of net-transport of sediment towards Hamburg (not quantifiable).

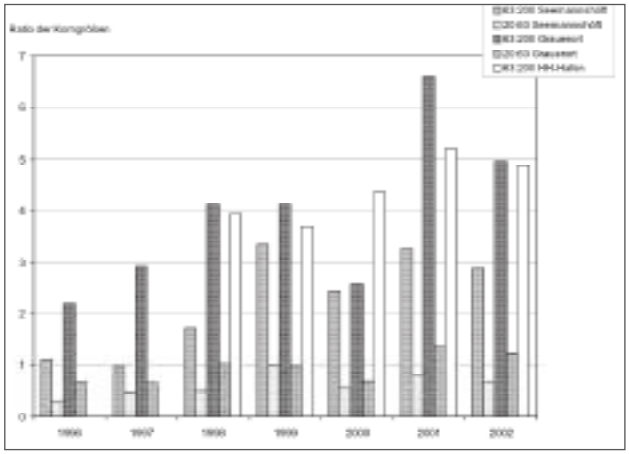


Fig. 12: Changes of ratios in grain sizes <20 to 20-63µm and <63 to 63-200 µm in suspended matter at three different locations in the Hamburg Area between 1996 and 2002 (WWF, 2005). Data: ARGE Elbe, Sedimentkataster

Fig. 12 depicts the increase of the grain size fraction <63 to 63-200 µm in the Hamburg area from 1996 to 2002. A higher content of fine material induces habitat changes and can have adverse impacts on fish and invertebrates. In addition, this is material that adsorbs contaminants and stays resuspended in the water column for a longer time. Therefore, impacts need to be analysed with respect to the water quality as well as to the diversity of organisms in these areas.

[1] http://fhh.hamburg.de/stadt/Aktuell/pressemeldungen/2005 januar/18/2005-01-18-bsu-hafen.html

2.3.4 Disposal of dredged material in the coastal area

The Hamburg Port Authority (HPA) sees a main cause for the increasing amounts of dredged material in the relocation of dredged material downstream of Hamburg. Due to a dominant upstream transport of sediment during flood tides ("Tidal pumping"), about 80 % of the material that is discharged in that area is transported back into the harbour. Hence, plans are currently being developed to break the build up of material by relocating it in the coastal area outside the effect of tidal pumping. Other possibilities including the building of an additional upland disposal site have been considered. For long term management, a concept for a sustainable development of the Tidal Elbe River is being discussed[1].

Chemical analysis of the material that is going to be relocated showed increased concentrations of HCH, DDT and chlorobenzenes (BfG 2005), which require a classification of the material into class 3 according to the national "Guidance on Handling of Dredged Material in Coastal Areas" (Handlungsanweisung für den Umgang mit Baggergut im Küstenbereich, BfG, 1999).

The preliminary evaluation of ecological effects and potential conflicts due to the relocation or disposal of this material to different areas is depicted in Table II. As can be concluded from this table, disposal at any of these locations will potentially lead to conflicts with the objectives of the Water Framework Directive, and all except Tonne 3 show potential conflicts with the Flora and Fauna Habitat Directive. It has been decided to use Tonne 3 as disposal site, but at this site also, medium impacts on oxygen content, nutrient concentrations, contaminant concentration, ecotoxicological effects and potential adverse effects on the existing fauna are to be expected (BfG 2005).

Impacts	Tonne 3 54°01'N/07°58'E	Station Bake ca. 748	LZ4b ca. km 733	Wedel ca. km 638
Change of Bottom sediments	?	?		
Turbidity increase				
Oxygen content				
Nutrient concentrations				
Contaminant concentrations				
Ecotoxicological effects				
Impacts on Fauna	?	?	?	
Impact on Flora	?	?	?	?
Natura 2000				
EU-WFD	**	**	**	**

Adverse impact/conflict potential	low	medium	high
	Conflict potential, Flora and Fauna need to be evaluated		
**	Potentially large conflicts, exceptions possible		
?	Data evaluation not yet finished		

Tab. II: Preliminary evaluation of ecological impacts and conflict potentials through relocation and disposal of dredged material (from BfG, 2005, modified)

This classification does not necessarily forbid any relocation but requires the evaluation of other options giving due consideration to potential ecological and economical impacts. If class 3 material is relocated, volumes and contamination need to be reported to OSPAR[2] and LC[3]-Commission, and OSPAR needs to be informed about the reasons for this decision. Also, the ecotoxicological class of this material requires a case by case decision.

[1] Concept for a sustainable development of the Tidal Elbe River as an artery of the metropolitan region Hamburg and beyond. HPA 2006,http://www.hamburg-port-authority.de/images/stories/download/Strategiepapier_Tideelbe_komplett_english_final_ 051006.pdf

[2] Oslo-Paris Commission (for the protection of the North Sea and the North East Atlantic)

[3] London Convention - Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972

2.3.5 The Impact Matrix

The Impact matrix (Table III) summarises impacts specific to Hamburg in this part of the Elbe River due to various stressors on physico-chemical quality elements, biological quality elements, and hydro morphological elements.

The matrix was created on the basis of reports of the Department of Civil Engineering and Environment (BSU) in Hamburg on the implementation of the Water Framework Directive (Freie und Hansestadt Hamburg, 2005), on the C-report of the Elbe River Board/ARGE-Elbe for the tidal Elbe (ARGE-Elbe 2005), on Nehring & Leuchs (2000) and on the Neozoa-report by Gaumert (ARGE-Elbe 2000). The judgement on the extent of impacts portrayed in this article is mainly due to the authors' evaluation of above reports. Where the matrix claims that impacts are "suspected", this information is based on scientific research carried out by the ecotoxicological working group of Dr. Wolfgang Ahlf at the Technical University Hamburg Harburg. Ecotoxicological analyses of sediment and water from the Elbe River in Hamburg have shown significant inhibition of test organisms (worms, bacteria, algae) in various sampling surveys, covering the years 1994 to 2000 (e.g. Ahlf 1996; Ahlf et al. 2002). This inhibiting effect can, however, not be attributed to a specific diffuse or point source. Together with the low abundance observed in benthic macrofauna, a significant impact due to the mixture of different contaminants that reach Hamburg from upstream or are emitted in the vicinity is strongly suspected.

	Impacts =>	Physico-chemical quality elements											Biological quality elements						Hydromorphological quality elements				
<= Pressure		Transparency	Temperature	Oxygen conditions	Conductivity	Salnity	Nitrogen	Phosphorous	Suspended solids	Acidification	Priority substances	Other pollutants	Phytoplankton	Planktonic blooms	Macrophytes	Benthic invertebrates	Fishes	Pathogens	Hydrological regime	Morphology	River continuity	Tidal regime	Properties of river bed
Diffuse sources	Scattered settlements sewage																						
	Agriculture diffuse																						
	Forestry																						
	Urban storm waters																						
	Atmospheric deposition																						
	antifouling-emission from ships and dockyards																						
	upstream sources																						
	Relocation of dredged material																						
Point sources	Industrial wastewaters																						
	Municipial wastewaters																						
	Mining																						
	Contaminated lands																						
	Animal husbandry																						
	Solid waste management																						
	Aquaculture																						
	Peat production																						
Abstraction	Raw water supply																						
	Agriculture																						
	Industry																						
	Fish farming																						
	Hydropower																						
	Open cast coal mining																						
Morphological pressures	Dams (transversal)																						
	Weirs (transversal)																						
	Longitudinal embankments																						
	Straightening and widening																						
	Dredging																						
	Urbanisation																						
Hydrological pressures	Flow regulation (rivers)																						
	Hydropeaking																						
	Level regulation (lakes)																						
	Change in riverprofile																						
Other anthropogenic pressure	Recreation																						
	Fishing/angling																						
	Climate changes/increasing flood frequency																						
	Land drainage																						
	Overgrazing																						
	Introduced species																						
	Introduced diseases																						

not significant for this case study
No effect
Low impact
Moderate impact
High impact
Suspected impact

Tab. III: Hamburg-specific impact matrix

3 The problems and their transnational dimensions

The environmental challenges that arise in the Hamburg area derive from a) its location downstream of a river basin with (historically) extensive industrial emissions; b) the activity of the port which demands extensive anthropogenic modifications of the Elbe in Hamburg and which partly clashes with the objectives of European environmental regulations; c) the impact of a large city with 1.7 m inhabitants and industrial production and its vicinity to the North Sea, which leads to the tide induced sediment transport upstream and relatively strict regulations regarding disposal of dredged material in that area.

a) Figure 13 depicts the distribution of contaminants in sediments above current threshold levels in the Elbe Basin. It clearly shows that – originating from a certain source – downstream areas are impacted by transport of contaminants and that major sources for contaminants are located upstream. Addressing these risks posed by contaminants when drawing up the Programme of Measures for the EC seems essential. Only by applying a river basin management approach can the sediment quality in Hamburg be improved.

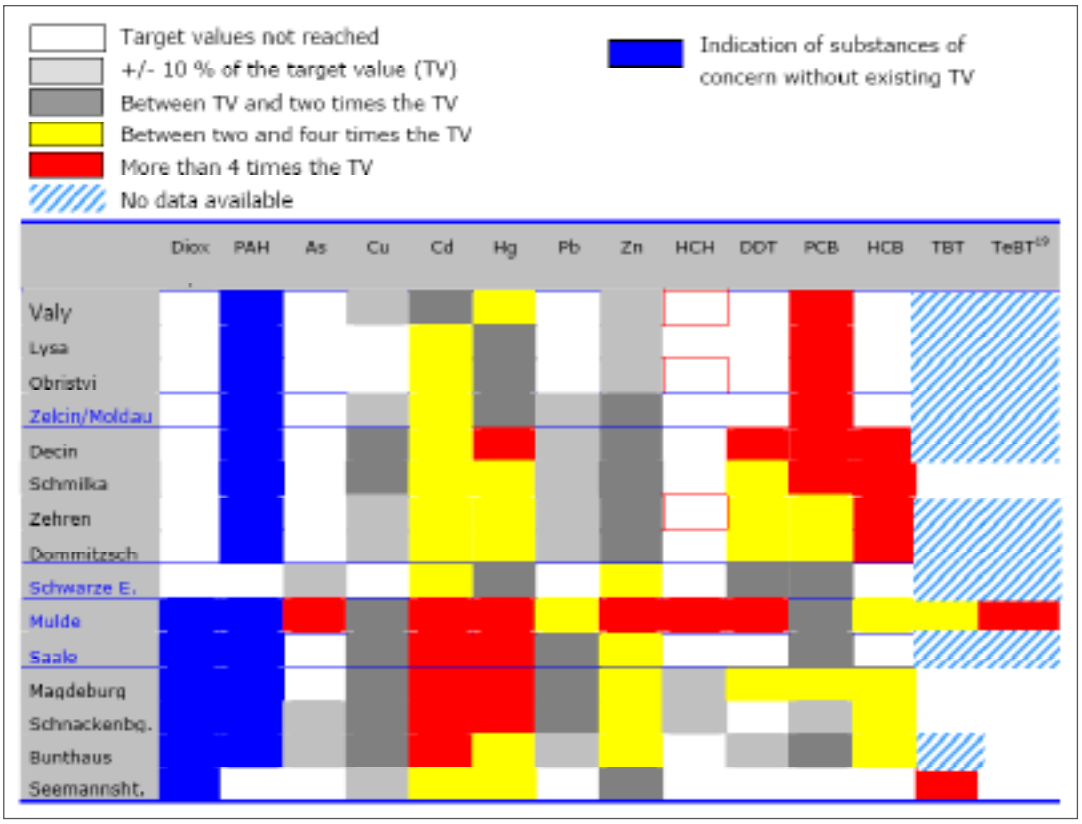


Fig. 13: Exceedances of target values for different „substances of concern" in different regions along the Elbe River (Heise et al. 2005)

b) Due to the morphological modifications that have been made so far, the harbour area has been tentatively classified as a "heavily modified water body". As has been shown in Table II, compliance with target values is unlikely, and neither the good chemical, nor the good ecological status will be achieved. Whether a good ecological potential as required for HMWB will be achievable, will need to be evaluated.

With regard to the Habitats Directive, the EC demanded that more sites of community importance needed to be identified in Germany, and it was proposed that the harbour waters in Hamburg were classified as FFH-region. In that case, a further deepening of the river would have been difficult as it would have been contradictory to the non-deterioration principle. Consequently, a political discussion including former German chancellor Gerhard Schröder resulted in the recommendation, that the harbour area would not be included in the Natura 2000 network. Nevertheless, on December 2005, the Commission sent Germany a final warning for not taking sufficient action to comply with a 2001 European Court judgement, which found that Germany had not submitted an exhaustive list of designated nature conservation sites under the EU Habitats Directive. If Germany fails to remedy this situation the Commission could take the case to court a second time and ask the court to impose a fine. Explicitly mentioned in this press report is the Elbe Estuary (Communiqué de Press from December 20, 2005, IP/05/1640).

c) The emissions of Hamburg itself being in the centre of a "catchment-coast continuum" (Salomons 2005) may also have an impact on the quality of the coastal zone, either from point sources such as communal waste waters and industrial effluents, or from diffuse sources such as run offs of storm water and from agricultural fields, as well as resuspension or relocation of sediment. This potentially affects not only the German coast but also Danish harbours and the Wadden Sea. Up to now, no quantitative assessment of the impact of diffuse sources on Elbe coastal waters has been carried out to the knowledge of the authors. Any future assessment would also need to address the effects of climate change.

4 Potential or implemented solutions

The diversity of interests in a region does not necessarily prevent achievement of environmental objectives. However, the predominance of economical interests as the highest weighted criterion may prevent sustainable management if it is in conflict with environmental and societal interests.

Minimisation of adverse consequences of former activities needs to be strived for. As in the case of Hamburg, the oxygen depletion becomes an increasing problem, which will also directly influence the WFD due to its effect on fish. Measures to reduce this impact could include a further reduction of nutrient input via waste water into the Elbe as well as improved maintenance through extending shallow water areas to enhance photosynthesis, delivering oxygen during the most sensitive summer months.

Solutions for dealing with contaminated sites outside its own responsibility have been practised in the 1990s by the Port Authority of Hamburg. Circumventing the Polluter Pays Principle, the port invested €150,000 in the construction of two settlement tanks for a Czech company that was known to be one of the primary emitters of mercury into the Elbe (Netzband & Reincke 2002). Consequently, the mercury load being emitting from this factory was reduced from 1.7 to 0.8 tons per year, cutting the total load of the river in 1995 by half (Fig. 14)

Currently, another concept for management of the tidal Elbe is in discussion seeking to combine engineering measures in the estuary, such as artificial islands, restoration of flood plains, and narrowing of the river mouth. It is anticipated that these measures will result in cushioning the tidal range, reduction of the flood-dominated sediment transport upstream into the river, lowering the storm surge peaks, and restoring biotopes. Long term, a concept like this, which has been developed by the Hamburg Port Authority in cooperation with the Waterway and Shipping Administration, will result in a reduction of dredging and sediment relocation activities as the current transport of sediment into harbour basins would be reduced.

The management concept will need to be environmentally compatible and socially acceptable while not compromising the economic function of the area.

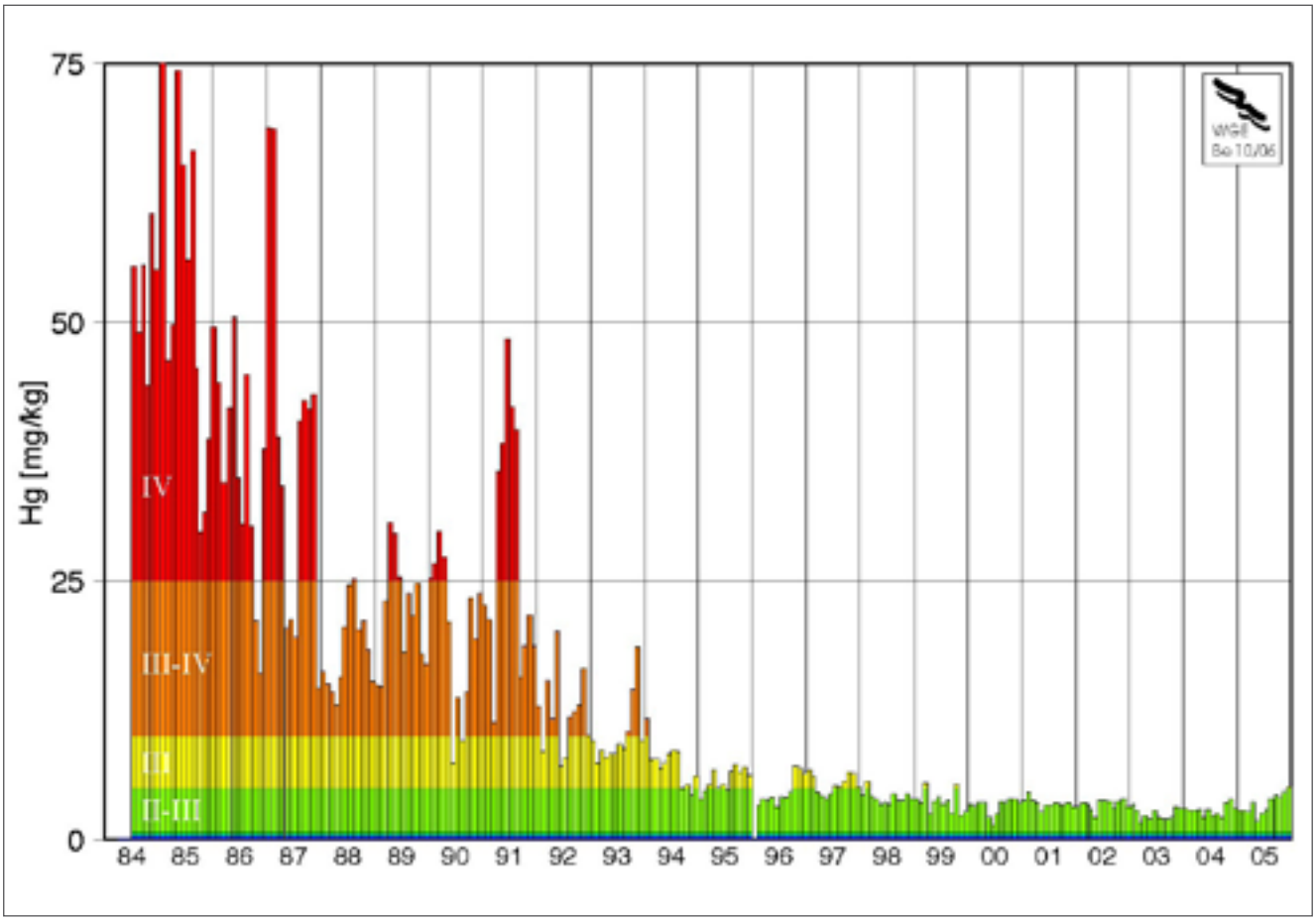


Fig. 14: Mercury concentrations in fresh sediments in Schnackenburg, former German-German border. Roman numbers are quality classes (rising contamination from I to IV) (Image: Wassergüteestelle Elbe)

5 Experiences gained and contributions made to sustainable river basin management

Experiences gained from the case study in Hamburg comprise the need for river basin planning. Hamburg is a good example of how site-specific problems can be caused by impacts upstream, which also can only be solved there, and how on the other hand, the catchment-coast continuum needs to be addressed as the specific site is interacting with areas downstream.

Hence, in cases when transregional or transnational problems along river basins occur, these can only be managed via a river basin approach. As an important early step in river basin management, a site prioritisation along a river basin has been suggested in order to allocate scarce financial resources where they can reach maximum effects (Apitz & White, 2003, Förstner et al 2004, Heise et al 2004). An example here is the cooperation between the Port of Hamburg and a company in the Czech Republic, where money was invested upstream outside the direct port's responsibility with a sustainable success for the whole German Elbe region.

6 Conclusions

The solution to existing or expected conflicts between different stakeholder groups, e.g. the sediment managers, environmentalists and citizens, who perceive a risk for their health or for their employment, can only be solved by long-term planning, communication and trust building. However, in urgent cases, such as the "sudden" and unexpected increase of sediment in the harbour which currently threatens its existence, developing a sustainable solution with participation of all stakeholders may not be suitable as this is a time-consuming process. If developments like this can not be predicted, short term solutions are needed, which may provoke conflicts with existing environmental laws. The disposal of contaminated dredged material in the North Sea is in conflict with the non-deterioration principle. The planned deepening measure of the Elbe may endanger compliance with the objectives of the Water Framework Directive and the Habitats Directive if effects of oxygen consumption become pronounced due to a shift of material towards finer grain sizes and loss of shallow water areas.

In order to manage this area sustainably, new concepts will have to be developed allowing to maintain the economic integrity but also reducing impacts on the environment. An approach to change the Elbe estuary morphologically, combined with a decrease of diking and creation of flood plains in order to modify sediment dynamics and tidal pumping effects, has been proposed by the Hamburg Port Authority. The concept envisions a reduction of incoming sediment volume while providing new habitats. If this concept is paralleled by measures in the upstream stretches of the river to improve the quality of the material that travels downstream, this may turn out to be a promising approach for a sustainable management of the Elbe River estuary.

7 References

Ahlf, W. (1996).
Bericht über ökotoxikologische Untersuchungen an Sedimenten aus der Elbe. Wassergütestelle Elbe, Hamburg. 09.96. pp.

Ahlf, W., Braunbeck, T., Heise, S., Hollert, H. (2002).
Sediment and Soil Quality Criteria. In: Burden FR, McKelvie I, Förstner U, Günther A (Eds.), Environmental Monitoring Handbook: 17.11 - 17.18. McGraw-Hill, New York

Apitz, S. and S. White (2003).
A conceptual framework for river-basin-scale sediment management. JSS - J Soils & Sediments (3): 125-220.

ARGE-Elbe (1996).
Umgang mit belastetem Baggergut an der Elbe. Zustand und Empfehlungen. Arbeitsgemeinschaft für die Reinhaltung der Elbe - Wassergütestelle Elbe.

ARGE-Elbe (2000).
Die Entwicklung des Fischartenspektrums der Elbe mit Berücksichtigung der Neozoen-Problematik. Thomas Gaumert, Wassergütestelle Elbe. 11p.

ARGE-Elbe (2004).
Sauerstoffhaushalt der Tideelbe. Download:http:// www.arge-elbe.de/wge/download

ARGE-Elbe (2005).
Sonderaufgabenbereich Tideelbe der ARGE-Elbe der Länder Hamburg - Niedersachsen - Schleswig-Holstein mit Wassergütestelle Elbe. EG-Wasserrahmenrichtlinie. Konzept zur Überwachung des Zustands der Gewässer, Bearbeitungsgebiet Tideelbestrom (C-Ebene). Umsetzung des Artikels 8 und des Anhangs V der Richtlinie 2000/60/EG. Entwurf. Stand 17.10.2005. Download: http://www.arge-elbe.de/wge/WRRL/WRRLStart.html

Behrendt, H., Bach, M., Kunkel, R., Opitz, D., Pagenkopf, W.-G., Scholz, G. and Wendland, F. (2002).
Quantifizierung der Nährstoffeinträge der Flussgebiete Deutschlands auf der Grundlage eines harmonisierten Vorgehens. - Forschungsbericht 29922285 im Auftrag des Umweltbundesamtes.

Bergemann, M. (2004).
Die Trübungszone in der Tideelbe – Beschreibung der räumlichen und zeitlichen Zusammenhänge. Download: httP://www.arge-elbe.de/wge/download

BfG (1999).
Handlungsanweisung für den Umgang mit Baggergut im Küstenbereich (HABAK-WSV). BfG-Nr. 1100.

BfG (2000)
Handlungsanweisung für den Umgang mit Baggergut im Binnenland (HABAB-WSV). BfG Nr. 1070

BfG (2005).
Abschätzung der ökologischen Auswirkungen der Verbringung von Baggergut aus der Hamburger Delegationsstrecke der Elbe auf die Umlagerungsstelle Tonne E3 nordwestlich von Scharhörn. Zwischenbericht. 113 pp + Annexe

BUND (2004).
Die Auenwälder der Elbe. Eine Rarität". Download: http://vorort.bund.net/hamburg/Auwald.139.0.html

Förstner, U., Heise, S., et al. (2004).
Assessment of Historical Contaminated Sediments and Soils: Substances and Areas of Concern in the Elbe River Basin. J Soils & Sediments.

Freie und Hansestadt Hamburg (2002).
Handlungskonzept Umlagerung von Baggergut aus dem Hamburger Hafen in der Stromelbe – 1. Fortschreibung; erarbeitet von der Behörde für Wirtschaft – Strom und Hafenbau – und der Behörde für Arbeit und der Behörde für Umwelt und Gesundheit – Amt für Umweltschutz, Gewässer- und Bodenschutz. 15.05.2002

Freie und Hansestadt Hamburg (2005).
Umsetzung der EG-Wasserrahmenrichtlinie (WRRL). Landesinterner Bericht zum Bearbeitungsgebiet Elbe/Hafen. Bestandsaufnahme und Erstbewertung (AnhangII/Anhang IV der WRRL). Freie und Hansestadt Hamburg. Behörde für Stadtentwicklung und Umwelt. 31.01.2005

Freie und Hansestadt Hamburg (2006).
BWA kompakt. Behörde für Wirtschaft und Arbeit. 01/2006.

Ginzky, H. (2005).
Die nächste Elbvertiefung – insbesondere die Berücksichtigung von Alternativen nach § 25 a WHG*. Natur und Recht 11: 691-696

Heise, S., U. Förstner et al. (2004).
Inventory of historical contaminated sites in the Rhine Basin and its Tributaries. Report commissioned by the Port of Rotterdam. download: wwww.tu-harburg.de/ut/bis/projects

Heise, S., Claus, E., Heininger, P., Krämer, T., Krüger, F., Schwartz, R., Förstner, U. (2005):
Studie zur Schadstoffbelastung der Sedimente im Elbeeinzugsgebiet. Commissioned by the Hamburg Port Authority.: Hamburg. 181

HPA (2005):
Situation der Baggergutverbringung in Hamburg und Sedimentbewirtschaftungskonzept an der Tideelbe – Aktueller Handlungsbedarf". Bericht der Abt. Prozess Wassertiefen, Hamburg Port Authority, Freie und Hansestadt Hamburg 1.4.2005

HPA (2006).
Umlagerung von Elbesediment nach Tonne E3. Bericht über Maßnahmen und Monitoring im Zeitraum August bis Oktober 2005. Download: http://www.hamburg-port-authority.de/images/stories/download/e3_bericht_05.pdf

IKSE (2005).
Internationale Flussgebietseinheit Elbe. Bericht an die Europäische Union. Dresden, 3.März 2005.

Konstantinou IK, Albanis TA (2004).
Worldwide occurrence and effects of antifouling paint booster biocides in the aquatic environment: a review. Environment International 30(2): 235-248

Ministerium für Landwirtschaft, Umwelt und ländliche Räume (2005).
Sedimentverlagerung: Schleswig-Holstein erklärt Hamburg gegenüber Einvernehmen. Information Landesregierung Schleswig-Holstein from 27.7.2005

Nehring, S., Leuchs, H. (2000).
Neozoen im Makrozoobenthos der Brackgewässer an der deutschen Nordseeküste; Neozoan invertebrates in the brackish waters at the German North Sea coast. Lauterbornia 39: 73-116

Netzband, A., H. Reincke, et al. (2002).
The River Elbe. A case study for the ecological and economical chain of sediments. J Soils & Sediments 2(3): 112-116.

Nix, H. (2005).
Schadstoffhaltiges Baggergut aus Hamburg wird auf See verklappt. Erst die Elbe zerstören, jetzt die Nordsee.... Waterkant (3).

Salomons, W. (2005).
Sediments in the catchment-coast continuum. J. Soils & Sediments 5 2–8.

Science for Environment policy (2006).
Alternative Strategies for Future Control of Antifouling Biocides. European Commission DG Environment News Alert Service. 12 October 2006

WWF, Ed. (2003).
Weniger Natur für mehr Schifffahrt? Ökologische Folgen des geplanten Ausbaus von Elbe, Außen- und Unterweser-download: https://www.wwf.de/imperia/md/content/pdf/presse/studie_weniger_natur.pdf

WWF (2003).
Flussvertiefungen contra Hochwasserschutz.

WWF (2005).
Die Elbevertiefung von 1999". Authored by M. Kerner & Anja Jacobi. download: http://www.wwf.de/imperia/md/content/pdf/fluesseundauen/4.pdf

Appendix 4

Appendix 4 Overview of French Environmental Administration and Permitting System

(Inserted overleaf)

1. Overview of French Environmental Administration

1.1 Management Structures

France has a centralised form of Government, and the State is ultimately responsible for industrial pollution control. This responsibility lies within the Ministry of Ecology and Sustainable Development (the "Ministry") and, specifically with its Directorate for Pollution and Risk Prevention. Other Directorates are concerned with the related matters of Nature and Landscape, Water, Environmental Evaluation and International Affairs.

The Ministry is directly responsible for the preparation of legislation (law) and ordinances (decree) and for the management of environmental inspection. The inspectorate services depend directly from the Minister. In regard to matters concerning industrial pollution control, the Directorate for Pollution and Risk Prevention assumes the lead responsibility but consults the other Directorates on related matters as necessary

The Organigramme in Figure 1 reflects the current management structure of the French Ministry with its six directorates: 1. DGAFAI administration, finance and international affairs, 2. D4E environmental evaluation & economic studies, 3. DE water, 4. ***DPPR pollution and risk prevention***, 5. DNP nature and landscape, 6. DGSNR nuclear safety and radioprotection.

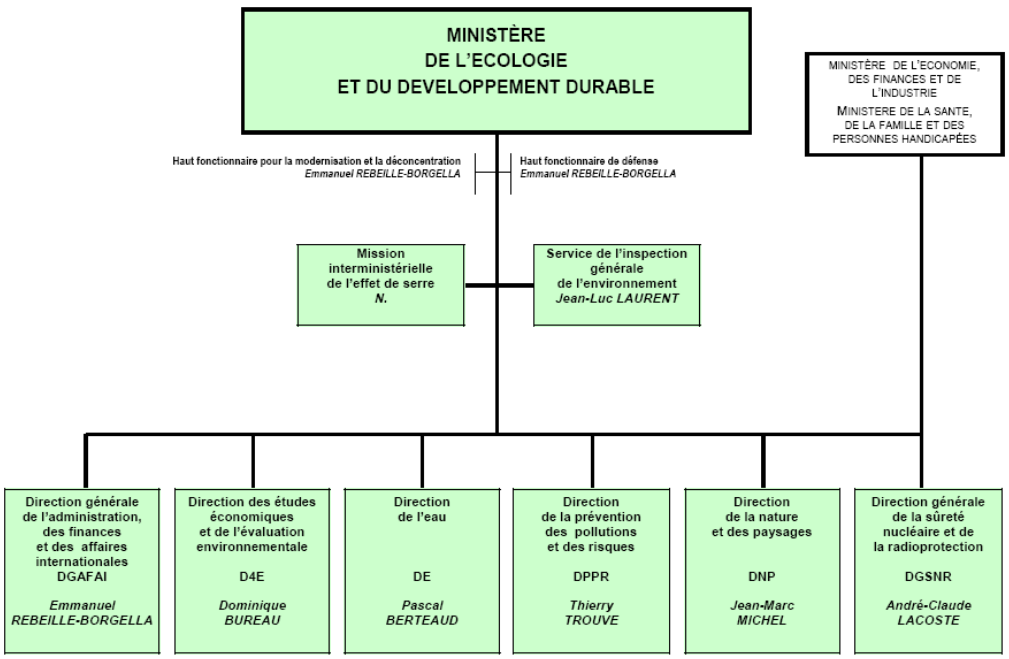


Figure 1: Structure of the French Environmental Ministry

1.2 Legislation and its implementation

In France, the first general text concerned with regulation of installations giving rise to nuisance or risk was the Imperial Decree of 15 October 1810. This has been progressively developed and modified over the years but has retained the principle of classification of industrial installations according to the level of nuisance to the environment or health risk to the neighbouring areas.

In regard to the prevention of industrial pollution and risks, the legislation implemented by the Ministry derives from the Law of July 1976 concerning classified installations and the introduction of the need of a permit to operate installation offering significant environmental risks. The Environmental Code of July 1976 and the associated implementation Decree of September 1977 set out the detailed provisions for an integrated approach to pollution and risk prevention in France.

According to these laws there are three categories of "installation" reflecting, in decreasing order, the associated levels of environmental nuisance or risk; i.e. those requiring "Authorisation" (permitting), those requiring "Declaration" (notification) and those described as "Uncontrolled".

Several important decrees amended the application of the basis law of 1976 to take into account further European legislation. In particular the Decree No 85-453 of 23 April 1985 taken for the application of the law No 83-630 of July 12, 1983 relates to the democratization of the public investigations and the environmental protection (modified) (OJ of April 24, 1985).

Impact study on the public health (not published in the OJ) Decree n° 2001-146 of 12 February 2001 modifying the decree n° 77-1133 of 21 September 1977 taken for the application of the law n° 76-663 of July 19, 1976 relating to the installations classified for the environmental protection (OJ of February 17, 2001).

The body of existing French environmental laws collectively covered well before the appearing of most EC directives, the integrated management requirement underlying the philosophy of the EC environmental regulations. In the case of the IPPC directive only the requirement to review permits had to be added.

This was covered by a minor modification requiring review of the permits of IPPC installations within 10 years, effectively completing transposition of the IPPC Directive into domestic French law. This and other relevant legislation was consolidated into a single Environment Act in 2000. This new body of legislation also implements the Seveso II Directive. The details of all relevant legislation are available on the Ministry website (http://www.ecologie.gouv.fr/rubrique.php3?id_rubrique=511) where it is updated every week. Copies are also available on CD ROM updated four times a year.

1.3 Environmental Management

Regulatory policies, objectives, strategies and priorities are set centrally by the Ministry and promulgated formally by way of the Administrative Circulars to Prefects. These circulars address priority sites and national strategic themes. The themes reflect national priorities and are designed to achieve improvements in pollution control and reduction of the risks associated with classified installations. They are generally issued annually and are publicly available. When these circulars are issued to the Directions Régionales de l'Industrie, la Recherche et de l'Environnement (DRIRE), these establish a regional implementation strategy, which is published on the Intranet. The opportunities for inclusion of local priorities at this stage appear to be limited, because of the limited staff available. Detailed local implementation arrangements, including work programmes for individual inspectors, are then agreed between the Regional Director, the Head of Division and the Sub- Division Heads.

Analogous arrangements apply to the central setting of standards and norms for DRIRE regulatory activities, including permitting, inspection and enforcement, and these are reflected in the documentation published by the Ministry on its website. Formally, regulatory decisions are taken and promulgated by the relevant Prefect (Préfet) on the basis of proposals made by the DRIRE. The authority within the DRIRE for deciding the substance of such proposals depends on the nature of the proposal and is reflected in a formal scheme of delegation applying to the staff of the DRIRE.

Under the direction of a Chief Inspector located in the Directorate for Pollution and Risk Prevention in the Ministry, responsibility for organisation and implementation of environmental regulation lies, in general, with the DRIRE in each of France's 24 Regions. The DRIRE were created in 1992 and are supported by inspectors in over 200 regional or local DRIRE offices in the 100 Departments of France. The authority for signing and issuing all environmental permits, prepared by the DRIRE inspectors, lies with the Prefect of the relevant Department. He or she is a civil servant and the formal representative of Central Government for administrative purposes in the Department. The Prefect has a wide range of responsibilities and, within limits, has discretion to modify the conditions in permits in order to balance the local factors and circumstances for which he or she is responsible.

A local Department of Health and Safety Committee advises him or her on technical matters and provides a channel for petitioners to make verbal representations. Environmental regulation on agricultural sites is organised and implemented at Department level by the Directorate for Veterinary Services (DSV) and, in Paris, environmental regulation is organised and implemented by the Technical Service for Inspection of Classified Installations (STIIC), located within the Prefecture of Police. Both are under the direction of the Ministry. Figure 2 reflects the environmental inspectorate's structure at the national, regional and departmental level. The staff from the Ministry of Defence carries out environmental regulation on defence sites subject to Seveso II and IPPC Directives.

In addition to pollution control and risk prevention, the DRIRE are also responsible for a number of regulations such as for vehicles safety, pressure vessels and measuring equipment, for nuclear safety, for the security of energy supply systems and for industrial research and development in the Region.

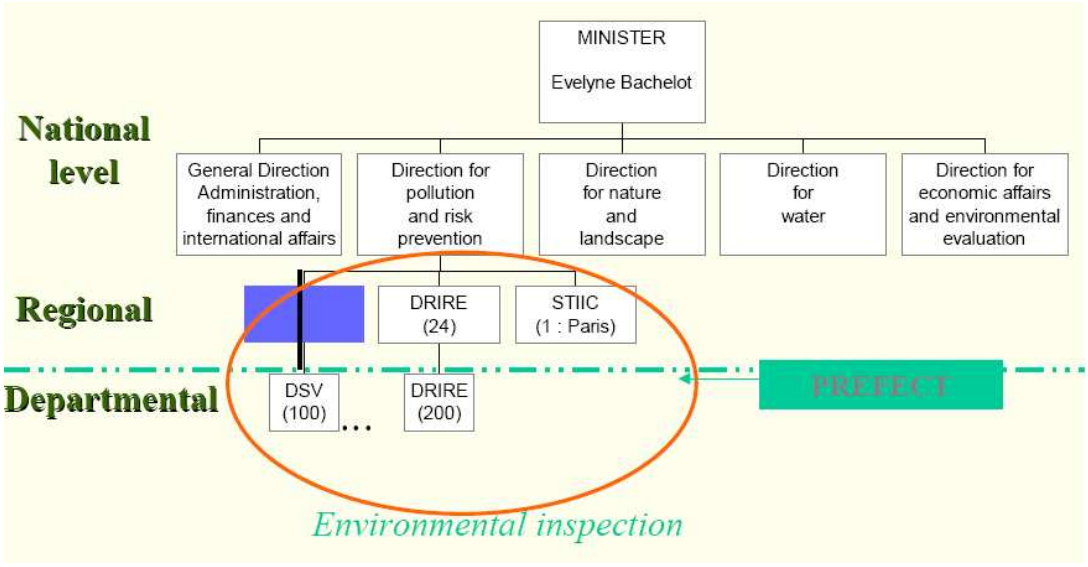


Figure 2: Hierarchical dependence of environmental inspectors in France

In regard to pollution control and risk prevention, individual local DRIRE inspectors are responsible for all regulatory aspects on sites under their control. These include permitting, inspection, enforcement and advising on appropriate penalties in relation to enforcement action.

These are around 500 000 installations falling under the requirement of the classified installation among which around 63 000 sites are subject to a (preliminary) authorization. The figure 3 documents the number of installations requiring permitting in France in 2003.

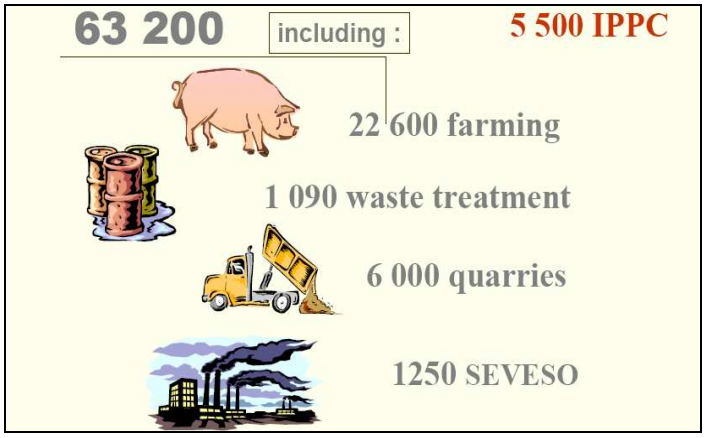


Figure3: French classified installations requiring permitting

The French SEVESO II sites include around 670 Upper tier establishments and 570 Lower tier establishments which are all mainly chemical facilities & refineries, LPG & oil or fertilizers bulk storages . There are 44 such sites in Alsace and 43 sites in Lorraine.

On monitoring or inspection, specifically, the Directorate prepares a National Yearly Action Plan based on thematic priorities. With regard to national follow-up, or review of delivery of tasks, the Director for Pollution and Risk Prevention and his Chief Inspector meet with each of the Regional DRIRE Directors and their Heads of Environmental Inspection annually. The Ministry also arranges general inspections of the environmental inspection function in

Regional DRIREs. They appoint independent, experienced individuals for this purpose and about five such inspections are conducted every year, so each Regional DRIRE inspectorate is inspected about once every five years on the specific activity of environmental inspection..

Inspection activities are funded wholly by the State by way of general taxation, which includes the environmental fees and charges levied on industrial installations. Previously these inspection activities had been funded in part, and directly, by these fees and charges. The fees and charges do not cover however the full regulatory costs, however, and no attempt is currently made to match fees and charges to the costs of regulation.

In regard to development of new legislation, and identification of any shortcomings with existing legislation, there is a direct line of communication from inspectors in the field, by way of line management, to the Ministry. Industry also has the opportunity to make relevant input to this activity.

As said earlier the DRIREs are not responsible for inspection of defence establishments or farming installations, but sites belonging to the State or to Municipalities are regulated in the same way as if they were operated by private operators. Visits to classified sites covered by declarations (notification) are usually carried out only as a result of public complaints or as part of a campaign of inspection of particular industries or types of site.

In cases of imminent danger, an inspector must seek authorisation from the relevant Prefect before he or she may close down or suspend operation of the offending installation.

The main pieces of legislation that interact with environmental legislation on classified installations are those relating to worker safety, public health and urban planning. Worker safety is regulated by a single, national authority, which does not report through the Prefect. The authorities responsible for the other aspects interact with the Prefect in the same way as does the DRIRE. A hierarchical process for resolution of any conflict between these regulatory regimes is available, but informal contact between the relevant authorities at Department and Region levels is encouraged and such conflict appears to be rare.

There is a considerable amount of interaction between IPPC regulation and urban planning. Urban planning is actually the responsibility of the Municipalities but the Prefect may over-rule the Mayors if necessary. As regards any matter concerning the interaction of worker safety and environmental protection, informal meetings are held with the authority responsible for the safety of workers once a year, both regionally and locally. One of the ways by which conflict between regulatory regimes is avoided is by having goal-based conditions in permits. This means that the permit describes the desired outcome and it is a matter for the operator to decide how that is to be achieved in a way that is consistent with all regulatory requirements.

The State sets standards for Emission Limit Values, Environmental Quality Standards and Best Available Techniques (BAT). Site-specific BAT assessments are undertaken by the DRIRE. The BAT for an installation is addressed when deciding applications for new permits. For IPPC installations, the BAT is assessed at least every 10 years as the permit is reviewed. For non-IPPC installations, there is no minimal frequency for the assessment of the BAT. These assessments are guided by EC BREFs, where available. Résumés, in French, of those EC BREFs already issued have been placed on the Ministry website, and the intention is to translate all BREFs and to produce guidance on how to use them.

The authorization of all classified installations fixes the operating conditions to be respected by the establishment to ensure the safety of the employees and neighbouring population and the protection of the environment. Inspections of the classified installations include the assessment of the applications of authorization with recommendations and conditions of operations as well as the periodic control and follow-up of the installations over their operational life. The inspectors are sworn in government officials, engineers and technicians.

In 2003, approximately 1700 new authorizations were granted (new installations or extensions) and 12500 visits and inspections were carried out by the DRIREs. The prefects in addition signed 2200 warning suggested by the inspection, which were followed by around 500 administrative sanctions. The DRIREs in parallel transmitted 1050 official reports to the courts.

Following the AZF catastrophe, 9 new technical poles for specific accidental risks were created within the DRIREs, to ensure domestic as well as international missions.

In order to make most effective use of the reinforcement allocated recently to the DRIRE a new programme of modernization of the inspection was also introduced. The programme detailed enhanced methodologies and procedures for project piloting, organizational management, training and information management. The objective is to achieve conformity of the procedures followed by the inspection of the classified installations with the international quality standard ISO 9001. The program comprises enhanced actions with regard to number and depth of periodic inspections, time of the authorization process, response to complaints, and transparency of procedures and decisions.

1.4 Support Structures for the Environment

INERIS the National Institute for Industrial Environment and Risks; **http://ineris.aida.fr** is the main technical support structure to the inspection works of the DRIRE. INERIS assists administrations in their actions regarding safety, health and environmental protection. This support results in particular in the supply of services of study and counsel regarding

- Accidental risks: Identification, analyses and hierarchy of the risks - Installation of system of security management - lawful support – third party expertises - preparation of emergency plans, etc.
- Chronic risks: Measurements of the pollutants in the air, water and the grounds - characterization of polluting substances, rejections and waste - study of the effects on health and the ecosystems related to the industrial activities except ionizing radiations - detailed study of the risks related to the sites and potentially polluted grounds - third expertise of impact studies, etc.
- Risks of the ground and the underground: Evaluation of the risks related to the gas emanations from the ground - evaluation of the risks of movement of ground - contribution to the development of Plans of Prevention of the Natural Risks (PPRN) and Mining (PPRM) - sounding and monitoring of the risks of the under ground. Etc.
- Certification: Certification of materials (Directives ATEX, CEM...) - physicochemical properties of the products, etc.
- Measurements and monitoring: expertise covers chemical pollution and technological hazards as a whole (explosion, fire, air, water and soil pollution), except nuclear hazards - Pollutant control monitoring - Identification of pollution sources - Verification of models - Certification of measuring equipment

In addition the following agencies provide technical support to the inspectorates of the Ministry of environment:

- The French Agency for Environment and Energy Management (ADEME),
- The Water Agencies, the National Water Data Network (RNDE),
- The Geological and Mining Research Office (BRGM),
- The National Institute for Agronomic Research (INRA) and
- The French Institute for Research on Marine Resource Use (IFREMER).

2 Principles of Environmental Management

2.1 Plans, Policies and Programmes

On monitoring or inspection, the Directorate prepares a National Yearly Action Plan based on thematic priorities. In 2000, for example, it addressed such issues as heavy metals, Seveso II sites and waste incinerators. These are identified initially by way of communication with both inspectors and with other interested parties, including industry, and the resulting plan is subjected to further wide consultation before it is issued. This plan is promulgated formally by way of an Administrative Circular to the Prefect of each Department and is published on the Ministry website. In addition, the Directorate has defined about 1800 priority installations in the whole of France, on the basis of their emission levels or high levels of risk. It has set rules requiring management of their regulation by the DRIRE at Regional level, as opposed to Department level, and their inspection at least once per year. The results of DRIRE regulatory activities on these 1800 or so priority installations are published in a high level annual report. More detailed Regional reports are also published.

The key policy principles behind the French environmental inspection system are:

1) Broad coverage of all types of installations that can represent a significant environmental risk: industries, farming, waste, incinerators, etc.;
2) Self declaration requirement by the operator before it start operation;
3) Progressive tightness of control rules depending on risks: no declaration of harmless activities, declaration (notification) for installation representing lesser risks, authorisation (permitting) for all installation representing significant risks;
4) Pollution and risk prevention taking into account all environmental aspects : water, air, land, noise, health, risk etc.;
5) Integrated risk assessment and mitigation approach: risk analysis & safety report is part of the permitting process;
6) Early information to the public by the state and the operator to anyone within a risk-exposed area

The Directorate for Pollution and Risk Prevention has since 2001 developed a major, new Efficiency Programme by the DRIREs whose objectives are to improve the collective efficiency of French inspections and to explain better the inspection activity to the population. This programme addressed the following topics: - Organisation, - Monitoring/National follow-up, - Methodology and know-how, - Training/Certification of Inspectors, - Information Systems, - Communication, - International Involvement.

The Ministry also started in 2004 an enhanced programme of modernization for the DRIREs. Under this new programme, the Minister fixes each year priorities for action, objectives and targets regarding the inspection of the classified installations. The priorities for 2004 addressed to the prefects included two topics: the plan air quality and the national plan for health and environment.

2.2 Environmental legislation

The French regulations below summarise the key laws and decrees that transpose major EC environmental directives

For Horizontal legislation: Directive 85/337/EEC amended by 97/11/EC, 2003/35/EC and 2003/87/EC Assessment of the effects of certain public and private projects on the environment – EIA.
The Decree 77-1141 of October 12, 1977 transposed the EC Directives on EIA.

Pollution control and risk management: Directive 96/61/EC amended by 2003/35/EC and 2003/87/EC Integrated pollution prevention and control – IPPC, Directive 96/82/EC Control of major accidents hazards involving dangerous substances – SEVESO II, Directive 99/13/EC Limitation of emissions of volatile organic compounds due to use of
The environmental code of 76-663 of July 19, 1976 relating to the installations classified for the environmental protection Decree of application of the law of July 19, 1976 relating to the installations classified for the environmental protection n°77-1133 of September 21, 1977; Circular DPPR/SEI n° 00-317 of June 19, 2000 relative at the requests of authorization presented at the title of the legislation on the classified installations; Decree n° 2001-146 of 12 February 2001 modifying the decree n° 77-1133.

Water quality: Directive 76/464/EEC amended by 91/692/EEC Pollution caused by certain dangerous substances discharged into the aquatic environment, Directive 80/68/EEC amended by 91/692/EEC Protection of groundwater against pollution caused by certain dangerous substances, Directive 91/271/EEC Urban wastewater treatment and Water Framework Directive 2000/60/EC.
The Water law of 1992 included all requirements of the EC directives related to surface and ground water pollution. The role of the river basin fro water management were established in 1964 and buttressed by the 1992 Water Law. Flood prevention plans were introduced in 2003.

Waste: Waste Framework Directive 75/442/EC amended by 91/156/EEC, Directive 91/689/EEC amended by 94/31/EC Hazardous waste, Directive 99/31/EC Landfill of waste.
The Arrêté of 25 January 1991 transposes the Waste Framework Directive; The Circulaires of 24 February 1997 and of 26 August 1998 transpose the incineration of hazardous wastes directive.

Air pollution: Directive 2000/76/EC Incineration of waste, Directive 88/609/EEC amended by 2001/80/EC Limitation of emission of certain pollutants into the air from large combustion plans.
The law on the air and the rational use of the energy of December 30, 1996 plus additional amendment of the regulation on classified installations helped France make progress in reducing emissions of most conventional pollutants, heavy metals and organic compounds in line with relevant Air pollution control EC directives.

2.3 Introduction to Structures for Practical Implementation

The inspection law of 1976 and its amendment divide the classified installations to be inspected and controlled into three tiers:

- Not classified installations;

- Classified Installations subjected to declaration: simplified file to give to the prefecture which delivers in return a receipt of declaration;
- Classified Installations subjected to authorization: a more complete file, with a description of the project (plans), an impact study, a study of dangers, a note of hygiene and safety and a non technical summary.

According to the law a classified installation "…presents dangers or disadvantages either to the convenience of the vicinity, or for health, safety and the public health, or for agriculture, or for the environment and nature conservancy, or for the conservation of the sites and monuments". This definition includes a very broad field of activities (industrial activities, commercial or services potentially polluting) which are all defined precisely in the nomenclature of the law which lists activities and which defines a threshold from which an installation is to be considered classified.

The authorization is granted by the representative of the State (the prefect) in the department in which the installation is to be established after examination by the competent inspectorate and a public investigation. The decree of authorization is necessary for the start-up of any dangerous installation.

The authorised installations are inspected periodically and sanctions can be applied if the conditions of exploitation and operation set into the authorisation are not strictly respected.

3. The Environmental Management Cycle

In general, the prescriptive nature of French Laws, Decrees, Arrêtés, Circulars, etc. is such that they already provide much of the procedural guidance and instructions necessary for consistent conduct of environmental regulatory activities. Nevertheless, the Ministry's Efficiency Programme commits to definition of common methodologies for dealing with permit applications, on-site inspections and associated enforcement activities, and a range documents is publicly available by way of the Internet. In addition, the DRIRE has a substantial number of written internal procedures and instructions designed to supplement those provided by legal instruments and Ministry documents. Every inspector is issued with a handbook containing all essential procedural guidance and supporting information. This includes a copy of the Ministry's Mission or Charter and a copy of the MCEI recommendation.

As regards determining, issuing and reviewing permits, the Decree of 1977 sets out the requirements for submission of an application for authorisation of a classified installation. These requirements are further developed in subsequent decrees. Advice to operators on how to make an application is given on the DRIRE website and further detail is available in a separate Ministry circular. A standard model permit developed by the DRIREs for installations requiring authorisation, including Seveso II installations, is available on the Internet. Legal guidance on the standards to be applied in determining applications for particular types of installations is also on the Internet.

A national Arrêté of July 2000 describes the information requirements and the procedure for 10-year review of IPPC installation permits. In the case of old plants, the 10 years is counted from the date of the last public inquiry associated with substantial permit modification.

The revoking of a permit can be construed in the French law as either suspension of plant operation or complete withdrawal of the permit. The procedures are described in legislation. The Prefect of the relevant Department implements suspension but withdrawal requires the authority of the Minister.

The scheduling and planning of inspections are carried out broadly according to the MCEI Recommendation. High level plans and priorities are produced nationally and are publicly available. These are elaborated at local level using the extensive database of information on sites and installations under DRIRE control.

Arrangements are in place for coordination of inspection activities with other relevant inspecting authorities, in particular the DDSV and the worker safety authority. The written procedures include arrangements for conducting in-depth inspections and for progressing related enforcement actions. These include arrangements for reporting on inspections and, in particular, an excellent pro-forma for inspection reports.

In regard to criminal prosecution specifically, there is national guidance on when to submit a prosecution report, and local instructions are produced by each DRIRE on how a proposal for prosecution should be undertaken. The decision on whether to submit a prosecution report is made on a case-by-case basis, but it is estimated that only about 15% of prosecution reports lead to actual prosecutions.

Although there is a good system for tracking the progress of prosecution reports there did not appear to be a well-developed system for reviewing the outcome of such submissions or for learning any lessons for their preparation and submission.

As regards public information, public inquiries are held in the cases of all authorisations and the proceedings are published in appropriate newspapers. Permits are publicly available on request, as are inspection reports after the Prefect has agreed those matters or actions that fall within his or her powers. Each DRIRE publish new permits and non-compliance information on the internet.

In addition, each DRIRE hosts a Permanent Secretariat for the Prevention of Industrial Pollution (SPPPI) whose role is to provide information to the public, NGOs, elected officials, etc. It is funded equally by the DRIRE, the Local Municipalities and Industry.

As regards dealing with accidents, all Seveso II sites and some other hazardous sites have detailed emergency plans. The key players are the Fire Service and the Security Services, operating under the authority of the Prefect. The DRIRE has an emergency response procedure, in the form of a checklist of questions and actions provided by the Ministry and available on the Internet. In practice the DRIRE sees its main role as organising a review of the lessons to be learnt from any accident and modifying the permit to prevent recurrence. The ministry also maintains a database of incidents and accidents on Internet.

3.1 Notification and permitting

All classified installations are subjected either to an authorization arrangement (permitting) or to a mode of declaration (notification) according to a classification which covers either substances (substances/preparations, poisons, combustive, explosive, flammable, combustible,

corrosive, radioactive & others) or types of activities (activities agricultural and animal, agro-alimentary, textiles, leathers and skins, wood, paper, paperboard, printing works, materials, ores and metals, chemicals & rubber, waste and others).

3.1.1 Installation subject to notification

The following information has to be submitted for a classified installation subjects to a notification:

- A plan of situation of the land register,
- An overall plan at scale 1/200,
- Information on the nature and the volume of the activities envisaged,
- Precise information on the mode and the conditions of use, evacuation, purification of waste water and emissions of any nature, as well as waste disposal,
- Precise information on the provisions to be followed in the event of disaster.

The prefect delivers a receipt of the declaration, after checking the conformity of the documentation with prevailing regulations. The prefect transmits copy of the declaration to the mayor who must publicly display it a full month in the town hall.
The finality of the declaration procedure is directed firstly towards prevention, and, in particular: i) compliance with all relevant regulations; ii) modification of operating conditions; iii) tracing in case of transfer of installation to another site; iv) establishment of adequate periodic control.

A declared installation can be suspended if: i) the declared installation has not started producing three years after declaration; ii) the declared installation ceases to produce for more than two years; iii) the declared installation definitively suspends its activities
When an owner shuts down definitively a declared installation, it should notify the prefect of the closing date at least one month in advance. The notification should indicate the actions taken for closure and if relevant site remediation.

3.1.2 Installation subject to authorisation by decree

The overarching conditions for obtaining a decree of authorization of exploitation for a classified installation include the following:

1. The authorization can be granted only if the disadvantages generated by the installations can be prevented by measurements which the prefectural decree specifies.
2. The delivery of the authorization can be subordinated in particular to: i) the distance of the dwellings, buildings usually occupied by thirds, establishments receiving of the public, rivers, transportation routes, etc. ii) the technical and financial capabilities of the applicant.

The owner of a classified installation is required at any time during operation to comply with all the relevant regulations and the requirement of the decree of authorisation. A public inquiry belongs to the authorisation procedure.

The file to be submitted for authorisation should include a number of documents as follows:

A. Basic documentation

1. The request for authorization.
This request in 7 copies reflects the qualities of the applicant (legal form, technical and financial capabilities, financial guarantee), the project location, the nature and the volume of the activities considered, the manufacturing processes to be applied, the substances to be used,

the products to be created or manufactured. If necessary, the applicant can compile in one copy under separate cover information considered trade secret. This copy can then be separated from the file submitted to investigation, review and consultations.

2. The maps and cartographic documents
These documents should reflect in adequate details: i) the location of the projected installation; ii) the access to the projected installation including the neighbouring grounds; iii) maps on the scale 1/2 500 indicating all the buildings or their functions, railroad, public highways, water points, channels and river, etc.; iv) drawings of projected installation, buildings and the layout of the sewers, up to 35 meters at least of the installation, on scale at least 1/200.

3. The risk assessment study
The study has the aim of documenting the dangers related to the installations and the risks which they can cause for the environment and the safety of the populations. It also describes the measures taken to mitigate these risks. It finally specifies the backup facilities available to fight the possible effects of a disaster. A non technical summary of this study should allow easy understanding by the public.
4. A note of conformity.
This note justifies the conformity of the projected installation with the entire legal and regulatory requirement relating to health, hygiene and safety of employees.

5. The certificate of the building permit.
The request for authorization has to be accompanied with the justification of the building permit

B. Complementary documentation
1. External assessment of specific elements of the file
The prefect can require at the expenses of the applicant, the production of an external assessment and review of particular sensitive elements to be developed by an expert selected by the administration.

2. The certificate of property
For any request for opening of quarry or installations for the storage of waste, a certificate of property or a transfer of rights for exploitation by the owners, must be provided.

The assessment of an application for authorisation follows the following steps:

A. Review by administrative inspectors
When the file is considered to be complete by the prefect, it is transmitted to the relevant inspectorate (DRIRE, etc.) for review and recommendations.

B. Opinion of the town council
The town council of the commune where the installation is projected (and the neighbouring communes if relevant for the public consultation) has to deliver an opinion on the projected installation. These opinions must be expressed at the latest fifteen days after the closure of the public consultation.

C. Public Inquiry
Members of the public have two opportunities to participate in the permitting process. The first is by way a public hearing on the application prior to formulation of the permit by the DRIRE inspector. The second, prior to its signing and issue by the Prefect, is by way of petition to the Department Health and Safety Committee that advises him or her. The application is advertised in newspapers and in notices within a specified radius of the site in question, the size of the radius depending on the nature of the site in question. The public hearing procedure lasts one month during which time the proposals are presented in Town Halls and the public is invited to make comments.

In this context, it was noted that permits for short-term trials may be developed without reference to a public hearing. There are time limits specified for the various stages of the permitting procedure but, in practice, these can readily be extended with the approval of the Prefect, and it takes an average of nine months for a decision on an application to be reached.

In general, once a permit has been decided there is no time limit on the period of its validity. For IPPC permits, however, there is a requirement to review permits at least every ten years. Seveso II safety cases are reviewed every five years.

D. Parallel consultation of various administrative services
From the date of the public inquiry, the file is also communicated to all the administrative services concerned which have 45 days to decide. These include the departmental directions of equipment (D.D.E.), agriculture and forest (D.D.A.F), medical and social administration (D.D.A.S.S.), the interdepartmental service of defence and civil protection (S.I.D.P.C.), the departmental service of fire protection (S.D.I.S.), the regional directorate of environment (D.I.R.EN.), and if it is necessary, the departments of the factory inspectorate etc.. The file is also transmitted to the committee of hygiene, health and safety of the company concerned, if there is one.

E. Complementary consultations
For the installations of storage of waste, the impact study is subject to the opinion of the local commission of information and monitoring when it exists. In the communes producing classified wines, the institute of national labels of origin has also to be consulted. In the case of a quarry, the minister of agriculture is then also necessary.

F. Issuance of the authorisation
The prefect takes then a decision as a “decree of authorization” to exploit or a decree of refusal, this last having to be justified. The decree of authorization is published by the prefect and thus fixes the conditions of operation and monitoring of the installation.

3.2 Control and Enforcement

The regional inspector of each DRIRE is charged, under the authority of the prefect of department with the organization of the inspection, control and enforcement of the classified installations.

The inspectors of the classified installations are technical experts appointed by the prefect on proposal of the DRIRE and depending from:

- The DRIRE themselves
- The departmental direction of equipment (D.D.E.)
- Veterinary services of the departmental direction of agriculture and forest (D.D.A.F) or
- The departmental direction of the medical and social businesses (D.D.A.S.S.)

The prefect can also appoint on proposal of a DRIRE and under certain conditions, technical experts belonging to other services of the State. In Paris and in the neighbouring departments, the technical experts of the prefecture of police can be appointed.

The professionals in charge of the inspection, control and enforcement are sworn in and have professional secrecy obligations. They can visit the installations subject to their monitoring at their convenience.

Enforcement in case of non compliance
Enforcement measures towards non-complying plants in France cover three levels. In the first step, called “mise en demeure”, the prefect fixes a date by which the plant must comply with its operating permit. If this date is exceeded, the second level of the enforcement procedure is applied. In this second step, called “procédure de consignation”, the operator has to pay the monies necessary to bring the plant into compliance into the public treasury. When compliance is achieved or the plant closed, the money is repaid to the operator.

The third level of administrative sanction is the suspension of the installation until it is in compliance. In addition, if criminal sanction is considered appropriate, a prosecution report may be submitted to the Public Prosecutor.

The line of communication from inspectorate to the Public Prosecutor does not go through the Prefect.

When a classified installation is found to be exploited without having subject itself to a declaration or an authorisation, the prefect can force the owner to regularize the situation. The prefect can suspend the operation of the installation by decree until it regularizes its situation. If the owner of an installation does not comply within given delay, the prefect can order the suspension or the closing of the installation.

Accident or incident
The owner of an installation is responsible to declare as soon as possible to the relevant inspectorate any accident or incident that may have occurred because of the operation of the installation and that are likely to cause dangers or inconvenience.

The prefect can prescribe, by decree, after opinion of the qualified advisory departmental commission, an evaluation and the implementation of mitigation measures to avoid recurrence.

The prefect can also decide that the restart of an installation temporarily out of use in consequence of a fire, an explosion or any other accident, needs to be subordinated to a new authorization.

If it appears that a classified installation present new dangers or an unknown risk following a declaration of accident or incident, the minister can order the suspension of its exploitation during the time necessary to the implementation of the measures to eliminate or mitigate the risk.

Not classified installation
If the exploitation of an installation not included in the nomenclature of the classified installations presents any danger, the prefect, after opinion of the mayor and the qualified advisory departmental commission, can force the owner to take measures adequate to eliminate the danger.

Closure of classified installation
In the event of a failure to comply with the relevant regulations and/or the authorisation requirements the prefect can order the closure of the installation.

Any classified installation presenting risks that can not be managed by the regulation or a decree of authorisation can be ordered to close by a decree of the Council of State after consultation of the higher council of the classified installations.

As an example in 2001 the DRIRE Nord Pas-de-Calais issued the following administrative sanctions;

- 344 Notices to comply;
- 14 Guarantees of funds for work on improvements or remediation;
- 18 Suspensions of operation;
- 0 Closure orders.

In addition, 68 prosecution reports were submitted to the Public Prosecutor. Each DRIRE has an effective database for tracking the progress and outcome of these submissions and full details are available to staff by way of the Intranet.

3.3 Appeal and jurisdictional recourse

There are various arrangements for appeal against the conditions in a permit. A company has two months from the time of issue in which to appeal against permit conditions. All other parties who can prove an interest in the permit, including NGOs, have four years to appeal against permit conditions, or one year in the case of permits for public institutions.

The consideration of an appeal is initially by the DRIRE itself. This is then followed sequentially, as necessary, by an Administrative Tribunal, Administrative Appeal Court and Counsel of State.

Recourse by a classified installation are possible toward administrative jurisdiction as well as legal jurisdiction

The decisions taken by the administration regarding a classified installation can be appealed to administrative jurisdictions within the framework of dispute resolution as envisaged in article 14 of the amended law of July 19, 1976. The judge has wide capacities. He can in particular modify the regulations of the authorization of exploitation.

Legal jurisdiction can also become active. Civil courts can condemn the owners of a classified installation to compensation for injury caused to third parties under the conditions of prevailing French common civil right.

The French courts can also inflict penal sanctions to owner of a classified installation: these can be fines (up to 300,000 Euro) and/or jail terms (up to 2 years, in the event of repetition), at the request of the public prosecutor which can receive the complaints of private individuals. French penal jurisdictions can prohibit the use of an installation exploited without authorization and to require the mitigation of pollution caused by a classified installation. Penal jurisdictions are also in charge to prohibit an installation to operate temporarily, if this installation is in infringement with a relevant regulation or do not respect the operative requirement contained in its decree of authorisation.

3.4 Monitoring

3.4.1 Air Quality

The monitoring of the quality of the air began in France more than twenty years. It was deeply reinforced after the adoption of the framework directive of September 27, 1996 on the quality of the air and the transposing French law on the air and the rational use of the energy of December 30, 1996.

The French system of monitoring of the quality of the air rests on four principal actors:

- The Environment Ministry through the DPPR and the DRIREs. It is the authority which works out the policies of monitoring of the quality of the air to be implemented and draft regional plan for air quality monitoring. It is the central point of the French system for air quality management and monitoring.
- The Agency of the environment and the control of energy (ADEME). In the sector of the quality of the air, ADEME ensures a general mission of technical coordination as well as management of the government stocks intended for acquisition of equipment of measurement for the inspection networks.
- The Approved Associations of Monitoring of the Quality of Air (AASQA). With a number of 40, these associations have a park of about 2 000 analyzers and trucks laboratories equipped for measurement of pollutants and the weather parameters.
- The Central Laboratory of monitoring of the quality of the air. Structure of support technical near the whole of the device of monitoring.

The monitoring is carried out, on behalf of the State, by approved Associations of monitoring of the quality of the air. In 2001, 40 associations AASQA manage the means of monitoring air quality with the technical support of ADEME. Each association is directed by a board of directors which includes representatives of the State, local communities (city, department or area), industrialists of the zone of competence of association and associations of consumers and environmental protection. The 55 metropolitan agglomerations of more than 100 000 inhabitants have a monitoring of quality of the air by fixed stations.

Monitoring relates essentially to the EU Directives on Air quality that fixed the levels of concentration not to be exceeded for SO2, CO, O3, NO2, Pb, PM10, benzene. Measurements are carried out by means of analyzers gathered in measuring sites which deliver data every fifteen minutes. These measures are supplemented by other techniques (truck laboratory, passive tube with diffusion...) and by modelling in order to have representative information for the entire territory.

3.4.2 Water Quality.

River basin agencies are in France in charge of monitoring receiving water quality. The national surface water network includes six basin agencies acting under the general supervision of the Ministry of Environment with each agency managing a national basin network (RNB).

As a general principle, sampling frequencies, lists of water components to be analyzed and analytical methods to be used are directly determined by the subsequent users of data. RNB purpose is to provide a set of reliable data related to French inland surface waters. RNB does not constitute the total of measured and available data, since many other organizations perform water composition measurements; nevertheless, it aims at being the permanent reference in the field.

Presently, RNB is co-ordinated at the state level and operated at basin agency level. State co-ordination involves the following tasks: i) checking the application (in each basin) of the national rules, specific problems may, however, be addressed differently by the agencies, ensuring laboratory inter-calibration and approval; ii) cooperation with AFNOR (the French National Standardisation Body) for periodical improvement of analytical methods and standardization of new methods; iii) Providing data on public requests at national level..

Typically a RNB programme would cover 1100 sampling sites, 946 of which are sampled yearly. The minimum annual sampling frequency permitted for these sites is eight samples per year. At each sampling site general physical and chemical variables such as pH, conductivity, organic pollution indicators, nutrients and specific ions are measured. At selected sites metals and organic micro-pollutants are also measured.

3.5 Environmental Reporting

Environmental reporting is done in France by the French Institute for the Environment (IFEN). It was established by Decree no. 91-1177 of November 18 1991. It is a public administrative body under the authority of the French Ministry of Environment and constitutes its statistical department (under Ministerial Order of December 22 1993).

IFEN undertakes and coordinates the collection, processing and dissemination of statistics and data on the environment as well as on natural and technological risks. It helps to define and harmonise methodologies used to gather environmental data for the purpose of general knowledge.

IFEN conducts studies and reports on the state of the environment and trends, the economic and social dimensions of the environment and is devising a system of sustainable development indicators.

IFEN is also the focal point of the European Environment Agency (EEA) based in Copenhagen (Denmark). It is involved in the work undertaken by international organisations (EUROSTAT, OECD and the UN) and in bilateral cooperation programmes.

Located in Orléans, IFEN receives guidance from three bodies: the Board comprising 23 members, the Scientific Council (15 members) and the Users' Committee (15 members). Working closely with the relevant national and international institutions, particularly the EEA, IFEN's task is to produce and disseminate scientific and statistical documents and information in the following areas: Land use and natural resources - Land cover and landscapes - The state of fauna, flora, terrestrial and marine ecosystems - Protection of coastal and mountain areas and other protected or sensitive areas - Water quality and pollutant discharges - Air quality and pollutant emissions - Soil quality - Waste management – Noise - Urban environment - The release of chemicals and the resulting impacts on the environment - Natural and technological risks - Public opinion and behaviour concerning the environment.

In order to carry out its responsibilities as a national monitoring body and to disseminate reference data on the environment, IFEN is actively involved in several networks:

- the network set up and run by the Ministry of Environment that brings together the main bodies producing environmental data at national and regional levels
- the public statistics system bringing together the National Institute for Statistics and Economic Studies (INSEE) and the statistics departments of the different Ministries of the Government
- the network set up and run by the European Environment Agency

IFEN is a core element of the national system of environmental administration. It is part of the network supporting the Ministry of Environment, made up of the main departments and bodies that produce and use data: Regional Environment Offices (DIREN), Regional Offices for Industry, Research and Environment (DRIRE), the French Agency for Environment and Energy Management (ADEME), the Water Agencies, the National Water Data Network (RNDE), the National Coast and Lakeshore Conservation Agency (CELRL), National Parks, the National Fisheries Council (CSP), the National Institute for Industry, Environment and Risks (INERIS), the National Hunting Office (ONC),the National Forestry Office (ONF), the National Natural History Museum (MNHN), the Geological and Mining Research Office (BRGM), the National Institute for Agronomic Research (INRA) and the French Institute for Research on Marine Resource Use (IFREMER).

3.6 Workload and Staffing of the Management System

In 2002, there are, in the whole of France, about 64 600 sites containing installations subject to authorisation and about 450,000 sites with installations subject to declaration. Of the sites with installations subject to authorisation, about 6,000 (<10%) contain at least one installation categorised as an IPPC installation under Annex 1 of the IPPC Directive, and 1,150 contain installations subject to the Seveso II Directive. The Regional DRIREs each maintain a database of sites in their region that contain classified installations subject to authorisation. These are merged into a national database twice yearly. The Prefects are each required to maintain a record of declarations from sites in their Department. There is currently no national database for the 450,000 sites subject to declaration.

A typical regional DRIRE would perhaps be responsible for control of about 2000 sites containing installations classified as requiring authorisation. These would include about 325 sites containing at least one IPPC installation, and therefore subject to the additional requirement for permit review within 10 years. This number excludes those IPPC installations in the Region that are related to agricultural activities and are regulated by the DDSV.

The average rate of inspection for all sites with installations requiring authorisation is about once in four years. For those sites with installations classified nationally as "priority" installations the frequency of inspections is at least once per year.

The Ministry produces an annual, national plan identifying a number of themes for priority action, which is then developed into a regional implementation strategy. This is used as the basis for inspectors work plans and allocation of resources. In some regions, the DRIRE allocates specific periods of time for inspections, for the purpose of work planning. Others prefer an objective-based approach in which the number of inspections to be carried out per year is specified in the work plans of individual inspectors. A similar approach is preferred for the activities of producing a permit, maintaining it and undertaking any related enforcement action. This approach is preferred because the national resource of environmental inspectors is already allocated between Regional DRIREs on the basis of levels of industrialisation in the Regions and an attempt to share fairly the workload on inspectors. Collectively, the 55 inspectors of a typical DRIRE would handle about 150 new permits and 300 permit modifications in a year and the site inspectors, individually, carry out 15-20 inspections per year on average.

A DRIRE prioritises its resources, against four main tasks, i.e. implementing legislation, permitting, inspection and complaint investigation. Often complaints are given a low priority but liaison committees associated with individual, contentious sites, including landfill sites, have been set up to facilitate discussion between industry and neighbours. The State levies charges for issue of new permits and modifications requiring a public inquiry. It also makes an associated annual subsistence charge. The charge for a permit or modification is typically €2,000. Annual subsistence charges are based on plant complexity. A large chemical plant would typically be charged about €30,000 and a small, simple plant €300. The cost of discharge sampling and monitoring required by a permit is borne directly by the relevant operator.

In regard to inspection activity, the ratio of inspector time on installations to time in the office is determined by the need for preparation for inspection and for follow-up activity. Typically, one day on site requires one day of preparation and two days for follow-up activities, giving a ratio of 1:3 for time on site to time in the office for inspection purposes. The ratio of time spent on planned, routine inspection to time on non-routine inspection is determined by the incidence of complaints or accidents. As described above, no specific allocation of time is made for these activities in the development of objective-based work plans but historic, national data indicate that the ratio of time on routine inspections to time on non-routine inspections is typically about 8:1.

The DRIREs in France are counting approximately 300 people including 800 engineers and 500 technicians. Figure 4 reflects the staffing of French inspectorates in 2003. The need for reinforcement of manpower in the DRIRE was raised by the Court of Auditors in 96, and was confirmed by the mission for inspection carried out following the catastrophe of AZF in Toulouse in 2001. 150 additional jobs for the inspection of the classified installations were then created over the 2002-2003 period. The government decided to continue the enhancement of the manpower for inspection over the period 2004-2007. In 2004, 50 new positions were created and 50 additional are envisaged.

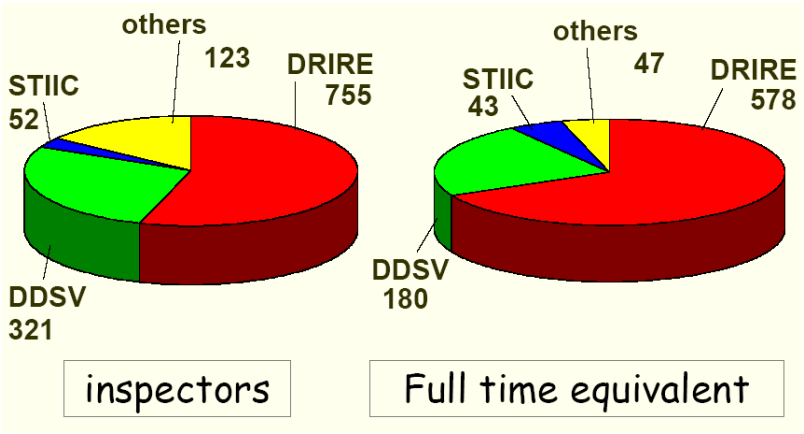


Figure 4: Staffing of French Inspectorates in 2003

By taking account of these new positions, the manpower of the inspection in the DRIREs carried to the governmental budget of the DPPR is around 1120 professionals in technical and administrative fields Twenty five additional positions have been entered in the budget of 2005.

A typical regional DRIRE will have a total staff complement of around 250 Full Time Equivalents (FTEs). Those concerned with prevention of industrial pollution and risks on classified installations, 55 FTE may be technical staff, categorised within the French Civil Service system as Engineers or Technicians, and **20** FTE may be administrative staff.

The Regional Director is usually supported by 4 Heads of Functional Divisions, the Heads of a General Secretariat and of a Communication Service, and by 4 Heads of Groups of Sub-Divisions. The Division Heads are based in the Regional office and are supported by teams of inspectors, each responsible for advising on a specialist topic. Site inspectors are allocated individual portfolios of sites and are based in Sub-Divisions, which are aligned with local administrative boundaries and which, for management purposes, are grouped under a local Head of Group.

Prevention of industrial pollution and risks on classified installations is the responsibility of the Environment Division. The Head of Division is supported by around 10 specialist inspectors (responsible for air, water, contaminated land, etc.) and their administrative staff. This team is the link to the Directorate for Prevention of Pollution and Risks in the Ministry, and to the Planning Authorities. It also provides specialist media-based technical advice to site inspectors, who operate on an integrated basis in the Sub-divisions. There may be around 25 Sub-divisions out of total of 40 in the region wholly dedicated to prevention of pollution and risk from classified installations.

Site inspectors are generalists and work on an integrated basis, with responsibility for all the activities of permitting, inspection and enforcement, under the authority of the regional division. They have access to specialist support from the Regional office as required. However, the system is flexible enough to allow individual inspectors to have a portfolio of responsibilities that takes advantage of any individual specialist experience and that may extend beyond the boundaries of his or her Subdivision.

Two important rules apply in the DRIRE generally. The first is that inspectors do not mix regulatory and advisory functions, in order to avoid conflict of interest. The second is that

those with environmental regulatory responsibilities must devote at least 50% of their time to these activities in order to maintain their levels of competence.

4. Conclusions

France has a vast, coherent body of environmental legislation and management system that is consistent with the principle of subsidiarity. The Environmental Charter approved in 2004 is to be incorporated into the Constitution. The 2000 Environment Code provided an opportunity to clarify France's environmental legislation, which has both influenced and been influenced by EU environment law (e.g. as concerns integrated pollution prevention and control for France's 68 000 classified installations). The new law on risk permits better economic assessment of natural and technological risk in spatial planning. Environmental policy implementation is carried out through a balanced package of instruments including regulation, economic instruments, planning and voluntary approaches. Enforcement of environmental regulations has benefited from a strengthened inspection system. A wide range of economic instruments is used. Charges for water services and waste management, and some other economic instruments, are used effectively. Several environmental taxes (as part of the general tax on polluting activities) were created. New instruments, such as trading in greenhouse gas emission permits, are being developed. Planning tools (e.g. state-regional contractual plans, climate plan, health and environment plan) and the system of land use planning play their part. Better institutional integration of economic concerns within environmental policies has been made possible by remarkable progress on economic studies and environmental assessments within the Ministry of Ecology and Sustainable Development. Environmental protection expenditure has risen to 1.9% of GDP and total environment-related expenditure (including water services and material recycling and recovery) to 2.8% of GDP. There is no indication that environmental action has affected the competitiveness of the French economy as a whole.