

## **A COMPARATIVE EVALUATION OF SELECTED ASPECTS OF THE EU'S WATER FRAMEWORK DIRECTIVE VERSUS THE U.S. CLEAN WATER ACT**

By

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### ***Abstract***

Since its formal transition into national laws in December 2003, key elements of the European Union's Water Framework Directive (EU-WFD) have been and continue to be implemented by the member states. For this comparative evaluation with U.S.-based water-quality regulations, of particular interest was the recent (March 2007) milestone for design and execution of monitoring networks to complement existing information and data compiled in earlier (December 2004) environmental-assessment documents. The next EU-WFD key element being addressed involves development of river-basin management plans (draft, December 2008; final, December 2009) for all the identified river-basin districts. Also, this major policy seeks to provide standardization among the EU member countries for major river basins and other water bodies throughout Europe.

Key Words: water-quality management; Water Framework Directive; U.S. Clean Water Act; water-quality monitoring; river-basin plans/management; drinking source-water protection.

### ***General Approaches***

An assessment and evaluation of these and other key elements and milestones have been conducted during the 2007-2008 period (Steele, 2008); this effort has included relevant comparisons with U.S. water-quality management regulations (Clean Water Act with amendments, including source-water protection aspects). Extensive research was conducted, principally benefiting from numerous relevant websites addressing the technical, institutional, and economic aspects of water-quality management both in Europe and the U.S. The river-basin (watershed) basic framework is common to both the U.S. and EU regulatory processes in protection of water resources (Figure 1). Coincidentally, the webstream link for the European Water Conference 2007 held in Brussels, Belgium, during March 22-23, 2007, provided participants in attendance or linked by computer with a unique opportunity to learn about progress to date as well as ongoing challenges in striving to achieve EU-WFD objectives. This Conference was well organized and executed; criticisms and recommendations resulting from candid discussions of status of milestone objectives hopefully were considered - in particular, regarding the WFD's Common Implementation Strategy (CIS).

This comparative assessment focused on the following aspects:

- Basic water-quality management legislation (both for the EU and U.S.),
- Institutions and stakeholder identification and involvement,
- WFD-related technical tools, including examples from academia and with a special interest by major water-supply enterprises,
- Critical overview of monitoring-program efforts, and
- Demonstration of approaches and challenges of river-basin management plans, drawing from selected case studies for Germany, large international river basins, and Greece (Steele, 2008).



Source: [www.epa.gov/watershed/watershedtrain/watershedmgt](http://www.epa.gov/watershed/watershedtrain/watershedmgt)

Figure 1 – The Watershed Approach to Management

commonly applicable in Europe, especially in the case of EU member states.

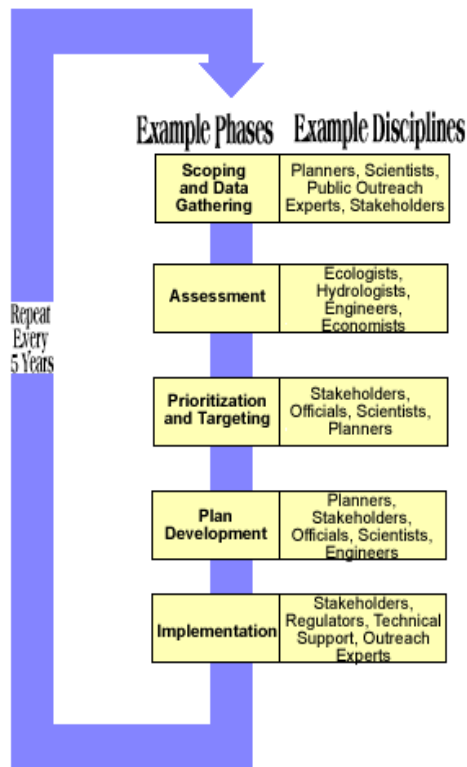
Three principles inherent in water-quality management (both EU and U.S. cases) have to be addressed and accepted:

- What constitutes “good” chemical and ecological status (Solimini and others, 2006),
- How “clean” is clean (an issue relevant to both the EU and USA), and
- What is in reality the “willingness (or ability)-to-pay” principle more

### ***Discussion – Concepts and Lessons Learned***

#### Overview

The basic water-resources planning components have long been recognized. What is rather new and innovative in this universal process are the specific targets, guidances and methods, decision-support tools (including models and linked database systems) offered or under development for river-basin practitioners. Caution is given, however, that currently some of the critical lessons learned from past experiences have not been sufficiently addressed.



Source: [www.epa.gov/watershed/watertrain/watershedmgmt](http://www.epa.gov/watershed/watertrain/watershedmgmt)

Figure 2 – River-Basin Management Planning

tools, such as those available in the U.S. (USEPA’s BASINS 4.0) and under development at FSU-Jena (JAMS-ILMS-RBIS; see discussion below and associated reference documents; more details are provided in Steele (2008)).

Regulatory Implementation

The original U.S. Clean Water Act of 1972 has been in effect more than 35 years. Its original mandate of “zero discharge” has been recognized as unattainable and economically unrealistic. This basic regulation has been modified over the years through various amendments and added regulations. Of specific interest are the additional regulations addressing source-water protection (water supplies) and wellhead protection for groundwater resources (Steele, 2008). The EU-WFD, on the other hand, has only fairly recently been enacted (2000), with a number of chronological milestones identified to phase implementation of the various aspects of this key law for water policy and water-resources protection (Frederiksen and Maenpaa, 2006). As such, this EU’s water policy could benefit from so-called “lessons learned” in the regulatory administration, management, and protection of this precious resource for human consumption, economic development, and natural habitat.

Selected key aspects of the EU-WFD articles are as follows:

1. Delineation of the river basins (Article 3, delegated for completion in 2003);

Focus topics for this discussion paper include, but may not be limited to:

- Regulatory implementation – describing the real intent of the laws or policy.
- Monitoring – too limited in water-quality variable coverage, need to add pharmaceuticals and personal-care products (PPCPs); included only a small fraction of historical monitoring sites (cost consideration and sustainability); frequency/scheduling is arbitrary and often insufficient to adequately assess current conditions, let alone long-term trends. How to deal with nondetects. Propose use of indicator variables or indices (weighted multiple variables).
- Modeling/management – the development of river-basin management plans is key, need to learn from each other and also from outside the EU (see U.S. and Canadian examples). Incorporate computer-based modeling and management

2. Development of monitoring programs (Article 8, for completion in 2006);
3. Development and public input on draft river-basin management plans (Article 14, due the end of 2008); and
4. Formal publication of the initial 'final' river-basin management plans (Article 13, due the end of 2009).

An important consideration of this latter component is the realization that river-basin management plans require intermittent review and updating (LAWA, 2002). Such near-term milestones in this case of the EU-WFD are to occur in the years 2015, 2021, and 2027.

### Monitoring Perspectives

For the various river basins, monitoring programs have been developed or otherwise modified to fulfill the requirements described in associated guidance documents on behalf of Article 8 of the EU-WFD. The bulk of these programs were published in documents during 2006. Now results of these monitoring programs are being presented. For purposes of this paper, selected results are described for the Rhine River (IKSR, 2007a; 2007b). This example is useful, because international cooperation is needed both in the network design and its implementation. IKSR (2007b) outlines the components of the water-chemistry aspects of the monitoring program for the 2007-2012 period. Some (but not all) of the EU-WFD-related water-quality monitoring sites are indicated in Figure 3. Presumably, this program then will be reviewed and modified intermittently, based upon monitoring goals and ability of the program to fulfill these goals. Selected results for the recent period 1990-2004 are summarized in ISKR (2007a). This latter document indicates water-quality variables (five in number) exceeding target limits, those variables (21) with reasonable attainment of these targets, and those (37) well within target limits (ISKR, 2007a, see Table 1). The time-series variability of these priority water-quality variables for the period of study also indicates both time trends and cases where a number of variables were not analyzed during the early part of the period (ISKR, 2007a). Time-series plots for streamflow and selected variables indicate cases of relatively greater concerns regarding target exceedances.

Besides the aspect of variable selection, the other two dimensions of monitoring programs address site selection and scheduling of sampling surveys and measurement frequencies. Some systematic guidance is offered via the EU-WFD. One criticism might be that too much standardization might be stipulated. Rather, monitoring components might be envisioned for purposes other than fixed-site (see example, Figure 3), regular-frequency monitoring strategies. In realizing that the EU-WFD monitoring network and program cannot fulfill all information needs, the various river-basin districts (RBDs) should encourage and use some professional judgment and flexibility in the implementation of monitoring programs. Moreover, the ecological/biological aspects for judging the attainment of good ecological status requires a completely distinct monitoring-program design strategy.



Source: [www.dk-rhein.de](http://www.dk-rhein.de)

Figure 3 – EU-WFD-Related Key Water-Quality Monitoring Sites, Rhine River Basin

A category of water-quality variables of recent and ongoing concern includes trace amounts of pharmaceuticals and personal-care substances found in water (Sacher and Stoks, 2003; AWWA, 2007; Donn and others, 2008). The growing scientific literature is indicating that such substances, even in minute quantities, may be harmful to aquatic life. Field studies to date have identified adverse impacts on aquatic species, including severe reproductive problems in many types of fish. A critical need is identified to formulate and implement epidemiological-monitoring studies with definitive human-health objectives for investigating possible linkages of observed illnesses or other adverse indicators with the presence and minute amounts of these substances in drinking water and other environmental media. Such studies need to be financially supported and to remain sustainable over the long term.

There occurs an antidegradation facet of both the EU-WFD and comparable CWA mandates in the U.S. generally regulated by individual states. Other contaminants now are being characterized in recent special-assessment programs (examples include MTBE, diglyme, additional pesticides, some of the pharmaceutical products, and X-ray media

residuals). In the case of the Rhine River, the IKSIR debate currently evolves around what criteria should be used to derive formal standards. Some missteps have occurred in the recent past regarding this process. Nonetheless, in the opinion of Europe's water-supply utilities, any degradation should not be allowed, regardless whether (or not) any given contaminant is toxic to aquatic life (Peter Stoks, RIWA, written commun., 3/26/08).

### Management Perspectives

The designation of RBDs required thoughtful and objective thinking by those involved in this aspect of the EU-WFD. Scale is an important aspect of water-resources management. The hydrologic-unit facet dominated this delineation of RBDs and rightfully so (USEPA, 1996). The larger river basins thereby involve several member states and multinational institutions. In contrast, watershed catchments can be too small for effective resource management. For example, the 13 former RBDs in Denmark were aggregated into four for purposes of the EU-WFD.

The preparation and publication of river-basin management plans constitute the key priority component of the EU-WFD. The EU-WFD (Articles 14 and 13) efforts currently are concentrating on preparation of draft and 'final' water-resources management plans, respectively. This work in progress, such as is occurring in the German State of Hessen (Dr. J.-G. Fritsche, HULG, written commun., 3/12/08), once completed will need to be adapted to the various parts of river basins within this political entity. Concurrent efforts are underway for the river-basin districts delineated throughout Europe. Undoubtedly, a progress-status evaluation by the EC will be useful after this key milestone at the end of year 2009 (see section below regarding *Recent Accomplishments – Status and Future Concerns*). Specifically, various guidances given through the EU-WFD's Common Implementation Strategy (CIS) as well as monitoring network design and evaluation provide useful information for document organization and development. The USEPA (2007; 2008) gives comparable guidance for U.S. watershed management.

In Europe, certain efforts are being promoted to return structural aspects of riverine systems back to more natural conditions. Although such goals may be attractive from an environmental standpoint, there may well be implications with regard to economic sustainability and water management from a water-supply perspective (IAWR, 2005). Given the common use of groundwater-resources and induced subsurface flows from streams for purification purposes, proposed engineered changes in channel morphology should not preclude the beneficial uses for obtaining drinking-water supplies by these means. Sediment transport in riverine systems creates problems in management of river-basin systems, from both physical and water-quality standpoints (Demayo and others, 1978; USEPA, 2004; Seidel and Mackenzie, *undated*).

### Drinking-Water (Water-Supply) Source Protection

Both the EU-WFD and US-CWA address this critical issue. In Europe, specific protection zones may be designated for drinking-water supplies. Newly defined zones are being areally more restricted, perhaps without sufficient contributing-area protection delineation or accompanying measures. In the U.S., source-water protection areas are explicitly delineated – both for surface-water supplies as well as for wellfields.

Within the EU, water-supply associations have been critical of lack of safeguards for drinking-water supplies within the EU-WFD (IAWR, 2004; 2005). Numerous substances adversely affecting drinking water are not required to be monitored; moreover, no incentives exist within the WFD to reduce their concentrations or to minimize their occurrence. A critical impasse inherent in this situation is the opinion that good chemical and ecological status (Solimini and others, 2006) may not be sufficiently protective in insuring safe drinking-water supplies.

Decision-Support Systems “Tools”

Decision-support systems provide water-management tools (BfG, 2000; ILMS, 2007). A range of water-resources decision-supporting and management tools continue to be developed at the University of Jena (Steele, 2008). This software toolset, being developed in the course of various national and international funded projects, is based on the following core components (Figure 2) [Notes: Acronyms are defined below]:

- A geo-relational database constitutes an underlying storage for all data relevant in environmental decision making processes (AIDIS),
- A user “front-end” information component for data management and analysis (RBIS),
- A software framework for the development and application of environmental simulation models (JAMS), and
- Various tools for deriving geo-information from remote-sensing data.

These several components are described in more detail in the following subsections.

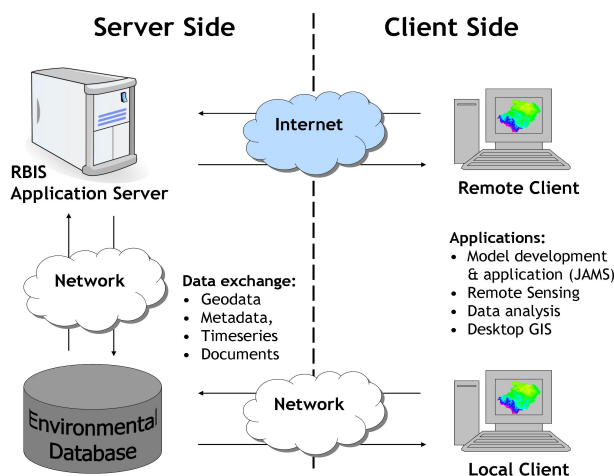


Figure 2 – ILMS Core Components

Geodata Management–Integrated environmental-resources research carried out by interdisciplinary research groups requires a comprehensive and holistic system analysis and process understanding. This in turn relies on powerful and effective data-management and information-sharing strategies to support researchers, but also decision makers based on best-available knowledge. Considerable work has been done regarding open-access database systems providing environmentally relevant geo- and time-series data to a broader research

community via the internet. Examples for these systems are Pangaea (<http://www.pangaea.de>), FAOSTAT (<http://faostat.fao.org>) and/or UNEP Grid (<http://www.grid.unep.ch>) that provide access to a huge variety of all kinds of geo-spatially related data. The literature review reveals that there are numerous attempts to organize and coordinate national, regional, and global geo-spatial data, but integrating diverse data and complex information into a structured object-relational information

system associated with a fully integrated meta-data set, GIS and statistical analysis capabilities as well as mapping features still may be problematic (PCGIAP, 1998; ANZLIC, 2000; Mansourian and others, 2006).

The River Basin Information System (RBIS) developed at the Department of Geoinformatics, Geohydrology and Modelling (DGHM) of the University of Jena addresses these deficits. This modular-structured application consists of a comprehensive and spatially enabled relational database – the Adaptive Integrated Data Information System (AIDIS, Flügel, 2007) – and an application server providing a web-based user “front-end” for easy data access. RBIS supports the management and analysis of different data types (e.g. time-series data and geodata) and belonging meta-information according to various standards (IS 19115, 2003) while providing flexible interfaces for reading and writing data, e.g. via Open Geospatial Consortium (OGC) compliant Web Feature or Web Coverage Services (<http://www.opengeospatial.org/standards>). Due to its flexible and modular database and application design, AIDIS can readily be tailored to meet emerging demands for new data types and relationships between them.

Environmental Modelling.—Current challenges in sustainable management of environmental systems have created demand for integrated, flexible and easy to use simulation models which are able to describe the interesting environmental processes (e. g. the quantitative and qualitative aspects of the hydrological cycle) with a sufficient degree of certainty. In addition, socio-economic and legislative objectives need to be considered to find the best solutions for such management problems. This introduces new problems, because each scientific discipline involved in the development of strategies for sustainable environmental management uses its own methods and tools for prognostic simulation of the regarded processes.

The basic principle of Integrated Water Resources Management (IWRM) in watershed management (GWP-TAC, 2000; Jain and Singh, 2003) is to use the landscape according to its capability and treat the land and water resources according to its needs for the sustainable development of the people living in a given river basin. The land that is being used beyond its capability results in adverse effects on the environment, such as soil degradation in form of erosion, salinization, and groundwater depletion. Remote sensing in conjunction with a geographical information system (GIS) has evolved as a powerful tool in watershed management (Dijk and Bos, 2001) and for modelling soil erosion (Flügel and Märker, 2003) and runoff generation (Krause, 2002; Flügel, 1995).

Large-scale water-resources systems with surface reservoirs have been simulated since early 1970s by various models. Two different, but somehow complementary approaches of surface-runoff modelling can be differentiated: (1) The hydraulic-oriented flow-routing models HEC-3 (HEC, 1972) and HEC-5 (HEC, 1979), developed by the U.S. Army Corps of Engineers (COE, 1987), basically simulate system operation in long-term periods and use reservoirs’ zoning to force withdrawals for downstream users. (2) The assessment of the hydrological process dynamics inherent within a river basin, is based on regional physical-based models, such as the well-tested PRMS model (Leavesley and others, 1983; Flügel, 1995) or the J2000 model (Krause, 2001; 2002). These models simulate the dynamics of runoff generation and groundwater recharge and are capable to also assess the solute input from diffuse sources (Bende and others, 1995).



Existing models which have been developed to fit the demands for a stronger integrative and multidisciplinary approach often are constrained to specific scales or purposes and thus can not easily be adapted to meet different challenges. Driven by the need for more flexibility in model development and application a number of environmental-simulation frameworks and architectures recently have been developed. Examples include: OMS (David and others, 2002), TIME (Rahman and others, 2003) or OpenMI (Gregersen and others, 2007). In order to enhance these systems with regard to their representation of the spatial and temporal domain, the Jena Adaptable Modelling System (JAMS) was developed at FSU-Jena's DGHM (Kralisch and Krause, 2006). JAMS is a JAVA-based framework that supports model developers in implementing environmental-process components in a modular fashion, while focusing more on flexibility during the development of new simulation components and less on easy integration of existing ones or on coupling of whole models. Due to their modular design, JAMS models can be easily adapted to implement further knowledge by exchanging single-process components with newly-implemented ones. One example is given by the JAMS/J2000-S model (Fink and others, 2007), that links the J2000 hydrological model (Krause, 2002) with a solute-transport model based on SWAT (Arnold and others, 1998).

The above description of FSU-Jena-related DSS-related investigations can be compared with components and examples using USEPA's BASINS and watershed-management internet tools (USEPA, 2007; 2008). In the U.S., there is some advantage in the coordination of database/GIS-modes and associated report products, especially related to the CWA's total maximum daily load (TMDL) assessments for individual watersheds (and river basins) throughout the U.S. The common base between this system and efforts supported through the EU-WFD is the need for reduction of contaminant loads and means for evaluating mitigation or remediation projects resulting in these reductions.

#### Water-Supply Protection

Are we using the appropriate technical and regulatory measurements to minimize the uncertainties underlying the goal of "safe" drinking-water supplies? Are the constituents included in judging safe water supply adequate (ARW, 2006)? Where are the priorities in developing long-term epidemiological (human-health) investigations for linking health and diseases with water, diet, or other aspects of the environment? These rhetorical but important questions may well apply to both European and U.S. situations.

A related issue to this beneficial use involves cases where water-quality standards under the EU-WFD are notably less stringent than earlier stipulated standards. In addition, attempts were made to propose additional variables for inclusion in the next revision of the WFD's so-called "daughter" Directive on Priority Substances. This effort has been heavily lobbied against, specifically by the wastewater entities concerned with the potential (probable) increased treatment costs. Whether these costs are incurred by them or instead are borne by the water-supply utilities becomes an institutional and political problem (Peter Stoks, RIWA, written commun., 3/26/08).

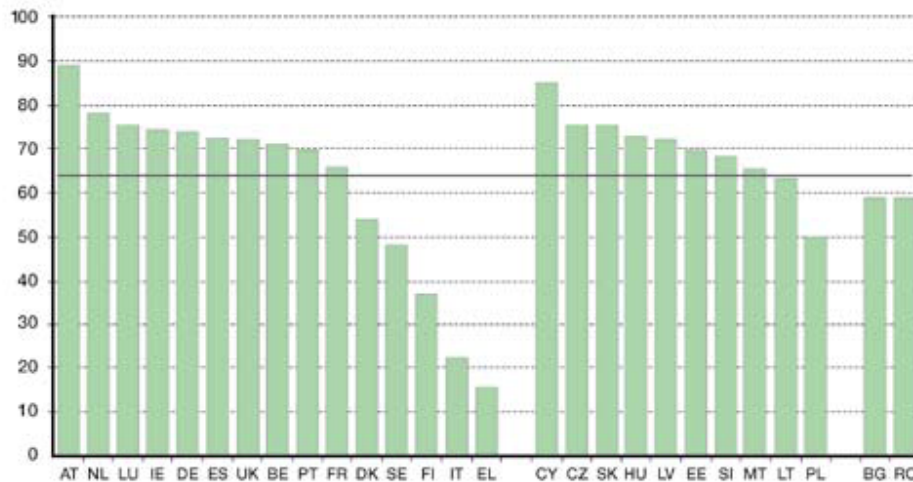
Coordination between reduction of nutrient loads from agricultural nonpoint sources and protection of drinking-water supplies (a high-priority link between agriculture and the EU-WFD) is demonstrated by a pilot project in Germany's Weser River basin. The so-called AGRUM model-network system (Cherlet, 2007; Ambros, 2006) appears to contain

components similar to those described above developed at the FSU-Jena and applied to smaller catchments in the State of Thuringia.

Infrastructure systems development along with issues of water pricing to cover both capital investment as well as operations-and-maintenance (O&M) costs is a critical component in the EU-WFD for water-supply utilities but is considered only indirectly in the U.S. regulations.

Recent Accomplishments – Status & Future Concerns

At the EC 2007 Water Conference (EC, 2007a; 2007b), the status and performance-indicator ranking results of progress/accomplishments to date were presented and discussed. Figure 5 provides the overview of conclusions regarding EU-WFD implementation, indicating which member states have done well (according to this indicator) and who have not. The original 15 EU member states were ranked separately (left-hand side of Figure 5), because they had more time to accomplish milestone objectives, compared to recently admitted member states.



Source: EC (2007a), EUWFD (2008)

Figure 5 – EU Member-State Performance-Indicator Ranking

Undoubtedly, some degree of subjectivity remains inherent in such ranking. However, countries indicated as having lower ranks hopefully will make note of this status and strive to improve their relative standings.

**Summary and Conclusions**

It is the judgment of this review (led by one outside the EU network) that the formulation and implementation of the EU-WFD has advanced the knowledge and understanding of these key aspects of regional and trans-boundary water management and policy. Its attempts at standardization and of coordination of watershed/river-basin management plans are noteworthy. Shortcomings and obstacles often occur, and compromise and consensus-building are noble keystones of this forward-thinking policy. Nonetheless, it still can benefit from “lessons” learned and being learned through implementation of recent and ongoing aspects of the earlier-promulgated Clean Water Act in the U.S.

Technology transfer and training aspects still represent needed high-priority activities; it is important how to instruct and how to make effective the multitude of technical guidance, methods, and tools in a manner understood to both technical experts and more important to laypersons interested in water resources and the environment in general.

Water-resources planning does not constitute a “one-time” effort. Rather, these regional basin management plans should be maintained as dynamic documents and add updates to basin characterization and be revised as conditions are modified and changes in physical or institutional factors occur over time. This facet remains inherent in the EU-WFD’s designated milestones for plan review and modification in years 2015, 2021, and 2027. Nonetheless, infrastructure investments understandably have an underlying concern that certain ‘stable’ management-framework conditions be maintained in the future.

Awareness of scale remains an important consideration to be kept in mind for both regional planning and water-resources management. Small catchments benefit from more detailed characterization with data and model applications. Large river basins on the other hand cannot sustain this level of detail and rather depend upon coordination and support through the numerous stakeholders involved.

This paper represents an obvious ‘leaning’ towards some of the databases and computer-software system tools that have potential application for use by water-resources managers and decision-makers. This serves primarily to indicate the direction of current research development in this area; it is recognized that other similar systems or components are available in the scientific community or are used by water-resources practitioners. Of greater importance to the overall implementation of water policy is the politically-driven leadership role in such areas as defining specifically ‘good status’ chemical and ecological goals as well as the source and allocation of financial resources in order to attain these goals.

A key noted deficiency in the EU-WFD is the continued regulatory gap in assuring safe drinking-water supplies. This use, identified as the highest beneficial use in the U.S. for source-water protection (both surface- and groundwater supplies) needs urgent supplemental regulations regarding sanitary (hygienic) and microbiological criteria. Another evaluation is needed on which contaminants are to be monitoring and reported in the water-supply sector.

In conclusion, a few additional (somewhat philosophical) comments are offered from this brief overview of regulatory and water-resources policy frameworks by the EU and U.S. These are oriented towards developing parts of world rarely benefiting from our perspectives, levels of technology, and basic hydrologic data and information:

1. First, we cannot always impose our Western interpretation of what constitutes “water management” without modification to other parts of the developing world. For example, the role of water law and administration is paramount. Without such guidance and acceptance, what is written on paper has little meaning.
2. Particularly, in parts of the world where water supplies of acceptable quality (generally, from the standpoint of human health), are limited or lacking, the role of scientific investigations and of technologies often are undermined by

- institutional/political conflicts (disputes) requiring resolution. Economics and sustainability play key roles in these processes.
3. What does integrated water-resources management (IWRM) truly mean? What inherent concepts and scientific applications to river-basin management plans are required and how do we gain acceptance of these?
  4. Finally, training and technology transfer are needed functions, but these often have to adapt to local conditions and to endure patience on the part of the providers.

### ***Acknowledgments***

Much of the background knowledge and basic information used herein was extracted from a block course developed first at the TU Darmstadt (2000-2001) and later modified and presented at the FSU-Jena (2001-2006). This background research was updated through an applied-research grant to the primary author through the Alexander von Humboldt-Stiftung; this financial support is hereby gratefully acknowledged. A useful water-management guidance document used in these courses was Heathcote (1998).

Further investigation and analysis for this assessment were completed during the spring of 2008 while again the first author visited the Friedrich-Schiller-University of Jena (FSU-Jena), Germany. It is anticipated that basic findings will be further refined or enhanced by future additional research efforts. In particular, the final initial series of river-basin management plans at the end of 2009 will constitute a key milestone phase of the EU-WFD's implementation. Thus, only results and findings to date are highlighted.

The authors appreciate the assistance of the following professional contacts and colleagues:

- Klaus Lindner, formerly with RheinEnergie (technical guidance and inputs);
- Peter Stoks, RIWA (The Netherlands) (technical guidance and inputs);
- Klaus Bongartz & Peter Krause, FSU-Jena (technical reviews); and
- Jörg Pechstädt, FSU-Jena (editing/assistance).

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