

Countrywide Groundwater Protection

Towards Sustainable Development

Special Report

Summary and Conclusions

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1 Groundwater Protection as an Element of Water Protection Policy

1.* Water management deals with all types of water, i.e., all types of surface water (whether flowing or not) and groundwater. In doing so, it deals with all aquatic (eco)systems and their functional interrelationships. Aquatic (eco)systems are complex, dynamic systems whose functions are determined by climatic conditions, by the hydrological cycle in general, by run-off characteristics, by the structure of aquatic environments, by exchanges between surface waters and groundwater etc.

2.* Water protection policy attempts to deal holistically with waters in the narrow sense, their peripheral areas, their immediate environment and the functional interrelationships that obtain between the waters and this environment, and the interactions between surface waters and groundwater. Its objectives are:

- protection of surface and coastal waters as a basis for life and as natural habitats,
- protection of groundwater as a natural resource, and
- sustainable use of water resources for the supply of water to the population, agriculture, industry and commerce, and for recreation and fishing.

The significance of groundwater in the overall balance of nature and the consequences of its degradation are often underestimated. Groundwater protection policy has to take into account the various special characteristics of groundwater and its occurrences. The soils and rock that overlie groundwater do not always protect it from anthropogenic influences and when they do their capacity to do so is not unlimited, and the consequences of these influences often go unnoticed until rather late. The causes and extent of groundwater degradation are often also very difficult to determine. Abiotic and microbial conversion processes in groundwater generally take place over much longer periods of time than in surface water. Remediation of groundwater degradation is often difficult, lengthy, generally costly and often not very effective. Moreover, groundwater can spread contaminants over large areas. Remediation is more difficult, the less is known about the hydraulic interactions within a particular groundwater occurrence, between various aquifers, and between aquifers and surface waters.

3.* In order to point out and emphasize the special measures that need to be taken in certain areas of groundwater protection, the German Environmental Council gives prominence to these areas in the following although it is well aware that water protection policy must take a holistic approach. Water protection regulations have, in actual fact, always emphasized that groundwater is an important resource, but this emphasis is not reflected in everyday policy practice. Groundwater protection is a long-term task that does not catch much public attention. Quick successes of the sort that have, for example, been attained by environmental measures aimed at improving the quality of surface waters are not to be had with respect to groundwater.

2 Sustainable Development and Groundwater Protection

4.* The theoretical concept of countrywide groundwater protection is intrinsic to the concept of sustainable development. Countrywide groundwater protection involves, above all, safeguarding groundwater quality as well as managing groundwater volumes.

That groundwater should be "of a natural quality" is a well-recognized environmental quality objective. This objective needs to be qualified, however, because groundwater, at least in near-surface aquifers, has been anthropogenically influenced practically everywhere as a result of the long-term and manifold effects of land use. The German Environmental Council thus proposes a different objective, namely that "groundwater should suffer as little anthropogenic impact as possible". This means that further anthropogenic impacts should be avoided to the greatest extent possible. The Federal Water Resources Management Act (Article 34; degradation proscription) and the *Länder* laws are largely already in line with this precautionary objective, which is based on the precautionary principle.

Implementing countrywide groundwater protection is widely recognized as an environmental action objective. In practice, however, groundwater protection is based primarily on water use criteria: that is, it is limited primarily to designating the catchment areas used for the extraction of drinking water as protected areas in order to prevent land uses that would endanger the water supply. Outside of these water protection areas, adequate protection of the groundwater is, in the opinion of the German Environmental Council, not ensured. The German Environmental Council thus emphatically calls for the consistent application of the principle of countrywide precautionary groundwater protection.

5.* The justification for this call is that there is insufficient knowledge of the manifold cause-and-effect relationships that obtain in the water balance of a particular landscape. Strategic approaches to groundwater protection should take those relationships which are known into account:

- Complex interactions take place between surface waters and groundwater. There is often an exchange of water between surface waters and groundwater occurrences.
- The composition of water is highly dependent on the soil and rock strata that overlie groundwater, and on the processes that take place in these strata. The uses to which these strata are subjected strongly influence the groundwater recharge rate and the capacity of soils to filter out contaminants.
- Aquifers are often interconnected hydrogeologically over large areas, and thus it is often difficult to map particular groundwater occurrences.
- Groundwater fulfills essential ecological functions in the natural balance of a landscape. It is in itself an essential habitat and an important environmental compartment. Many habitats are directly dependent on groundwater and only tolerate fluctuations in the water table or in the composition of groundwater when they remain within a certain range.

6.* Soil protection policy has paid far too little attention to protecting soils on a precautionary and countrywide basis, and thus effective countrywide groundwater

protection has not been ensured. Most processes that take place in soils are directly dependent on the water content of the soils and the speed at which water percolates downwards through the soils. New studies of the percolation speed and transport of solutes and particulates in soils have shown that the effects of processes in soils and the ability of soils to protect groundwater from contamination have often been misjudged. As long as active, precautionary soil protection is neglected, groundwater remediation measures will always be necessary.

The German Environmental Council is of the opinion that it is imperative that the Federal Soil Protection Act should be used to establish uniform minimum substance level criteria for ensuring countrywide soil protection, thus also ensuring countrywide groundwater protection. The extent to which the various substance levels that are prescribed by administrative regulations – levels when testing, levels requiring that corrective measures be taken and levels for implementing precautionary measures – will even begin to be able to meet the requirements of such minimum criteria remains to be seen. If, in the near future, further deficits in the implementation of this act and the administrative regulations, especially as concerns groundwater protection, should become apparent, then the Federal Soil Protection Act will have to be revised immediately.

7.* Measures aimed at bringing about groundwater protection on a countrywide basis should primarily be designed to prevent or reduce impacts on the overlying soil and rock strata and on groundwater itself in order to prevent water, especially groundwater, as is often the case, from spreading contaminants over wide areas.

3 Areas of Action Requiring Greater Attention

8.* The Water Resources Management Act stipulates that groundwater, with its essential functions in maintaining the balance of nature, is to be protected on a countrywide basis (Article 1 of the Water Resources Management Act). Special protection is to be provided by designating water supply catchment areas as protected areas. In spite of the demanding nature of this approach, groundwater occurrences and catchment areas are nevertheless often damaged by contaminants in soils and groundwater and by intervention into the structure of the environment. In examining various studies the German Environmental Council has ascertained that certain problems have been misjudged, or at least underestimated. Too little attention is taken of the fact that ecosystems that function properly can compensate for anthropogenic impacts and are thus still capable of providing water for drinking water purposes without this water having to be treated. Diffuse inputs, however, pose a special problem with regard to both beneficial water use and the maintenance of ecological functions. Present monitoring systems and protection efforts take into account diffuse inputs of nitrogen compounds and active agents in plant treatment chemicals (inputs which are primarily attributable to agriculture) but do not take into account inputs of secondary atmospheric pollutants (e.g., halogenated carboxylic acids, nitrophenols and methylnitrophenols, which are attributable to vehicle emissions) or of active agents in pharmaceuticals.

A further problem is the release of substances due to changes in land use. Present monitoring systems and protection efforts are not geared to deal with such types of problems. Even though the Water Resources Management Act stipulates that groundwater is to be

protected on a countrywide basis, protection is often not ensured outside of drinking water protection areas.

- **9.*** There are different reasons for the current deficits in groundwater protection:
- Precautionary measures are often only half-hearted.
- Short-term economic interests are given priority, whereas ecological necessities are often given little or absolutely no priority.
- Knowledge of the dangers posed by inputs into soils and groundwater and by intervention into the structure of the environment, and of effects that such inputs or intervention have on the magnitude of groundwater resources and on the composition of groundwater, are insufficient. The complex interactions that obtain between aquifers and the overlying soil and rock strata have not been studied sufficiently.
- Environmental policy objectives have not always been adequately implemented. There is also a lack of uniform databases and of implementation methods that are basically uniform throughout all the *Länder*, which have the jurisdiction over water protection.

10.* Using situation analysis the German Environmental Council has identified the following areas of action requiring greater attention if groundwater protection is to be implemented on a countrywide basis:

- Groundwater protection must, to a greater extent, include protecting the functions of groundwater in the balance of nature as stipulated in the Water Resources Management Act. Current water protection policy lacks a holistic approach that would not only take into account current water use interests and all measures which negatively affect water balance, but that would also take into account the protection of ecological functions in the balance of a landscape. This means that when assessing the productivity of cultivated/settled areas, not only the yield derived from the area but also the extent to which ecological functions in the area have been impaired must be taken into account.
- In order to protect groundwater on a countrywide basis, an attempt must be made to ensure that land use throughout a particular area is appropriate to that area and is thus groundwater-friendly, but currently there is a lack, for the most part, of such an approach. The requirements for protecting groundwater on a countrywide basis apply to settled areas with their numerous and small-scale land uses as well as to the large areas used for agriculture and silviculture, areas whose use regime is fragmentary and, moreover, almost impossible to monitor. Approaches to resolving the problems of groundwater-friendly land use pay far too little attention to geological and soil conditions, historical uses, and changes in use or restrictions of use in particular areas.
- Point source and linear source inputs stemming from contaminated sites, leaky sewers etc. as well as non-point source inputs of nitrates and the active agents in plant treatment chemicals, continue to pose urgent problems for groundwater protection. In addition, in the opinion of the German Environmental Council, nonpoint source inputs, especially inputs of secondary atmospheric pollutants, which

occur over wide areas, and inputs of the active agents in pharmaceuticals, which occur more locally, pose an ever-increasing threat to groundwater. Inputs stemming from the release of substances used in construction materials also pose a threat to groundwater.

- The amount of groundwater resources that can be extracted in a particular area and thus the potential extent to which groundwater extraction rights to provide drinking and raw water can be granted for that area can be estimated only very roughly. The data collected with respect to water catchment and water supply are currently collected according to formal, generally administrative criteria and are thus collected per jurisdictional area or per natural area, such as per the drainage basin of larger rivers. There is no consistent attempt to relate the amounts of groundwater that can be extracted to appropriate "groundwater units" (see below), and thus there is no appropriate basis upon which to base important water extraction decisions and plans.
- Inputs of contaminants often make it difficult to use near-surface groundwater occurrences; water supply facilities have often had to be closed because of excessive contamination. When this happens with the drinking water supply, neighboring groundwater occurrences, deeper groundwater storeys, or long-distance supply systems are used instead. In the future, switching from polluted groundwater occurrences to other, better water resources should be coupled with a requirement to remediate the polluted occurrences.
- In spite of technological advances, water treatment technology is obviously not able to cope with certain substances, which demonstrates the limits of water treatment processes. The only way to counter the need to use ever more advanced and costly technologies in water treatment facilities is to implement precautionary groundwater protection on a countrywide basis, thus preventing further degradation of water quality.
- Currently, there is a lack of nationally uniform administrative procedures in the area of groundwater protection. Since the water authorities in the *Länder* have jurisdiction in matters of groundwater protection, setting up a water management administration at the federal level is not possible. Insofar as the jurisdictional area of administrative units is not coterminous with groundwater occurrences, neighboring units will have to cooperate with one another. The predominantly quantitative orientation of water management policy should also be changed such that it also ensures and monitors water quality to a greater extent.

4 Implementing the Principle of Countrywide Groundwater Protection

11.* The degree to which groundwater occurrences are threatened by contaminant inputs and physical and structural intervention depends on the conditions in a particular area (soil and subsoil properties) and on the type, extent and duration of anthropogenic impacts (historical and current uses). The amount of groundwater resources that can be extracted in a particular area also depends on the area in question, since recharge rates vary from area to area and the extraction of water can potentially effect relatively small areas (such as groundwater-dependent ecosystems), depending on the properties of the groundwater body in that area.

Accordingly, countrywide groundwater protection does not require that protective efforts be the same everywhere, but that they be appropriate to a particular area, and that they all have the same environmental objective in mind. The German Environmental Council is of the opinion that a reference system that is based on spatial differentiation, i.e., that classifies groundwater occurrences by area and impact sensitivity, is necessary if groundwater protection is to be implemented countrywide while taking protection interests as well as water use interests into account.

12.* The German Environmental Council proposes implementing a uniform system that uses *Länder*-independent *groundwater units and sub-units* for assessing groundwater composition and estimating its sensitivity to contaminant inputs and structural interventions (see box below). This approach would establish groundwater units and groundwater sub-units that are determined using process-oriented criteria, and these units would replace currently designated groundwater landscapes and groundwater regions, which both have a *Länder*-specific character and are usually designated using the concept of natural regions.

Groundwater Units

Groundwater units and sub-units are areas in which similar hydrogeologic conditions and similar groundwater composition obtain. Unlike when using the concept of groundwater landscapes and groundwater regions, using the concept of groundwater units and groundwater sub-units allows deeper groundwater storeys to be also taken into account. This concept also takes into account all of the overlying soil and rock strata (the unsaturated zone, including soils), because they fulfill a crucially important function in protecting groundwater. By cross-referencing the impact sensitivity of overlying strata/groundwater units and groundwater sub-units as a complete system with current and historical patterns of land and water use in a particular area, current and potential threats to the groundwater quality can be ascertained (see Figure 1).

Groundwater units have the following characteristics:

- Designating groundwater units as such depends on the physical and hydrogeochemical processes that take place in aquifers.
- They initially refer only to groundwater whose composition has suffered as little anthropogenic impact as possible, without taking land-use-specific and water-use-specific impacts into account.
- They are independent of natural areas and administrative jurisdictional structures.

Potential geogenic groundwater composition is dependent on the chemical-physical, microbial and hydraulic interactions that take place between groundwater and aquifers. Knowledge of these interactions can be used to determine anthropogenic influences, especially inputs. Groundwater units thus provide a frame of reference for determining groundwater composition, or rather current concentrations of inputs in groundwater.

Whereas designating groundwater units provides a rough classification of groundwater occurrences, a greater degree of differentiation can be achieved by using sub-unit designations that are based on other factors relevant to groundwater composition and its monitoring.

By including overlying soil and rock in the definition of groundwater units, aquifers can be classified according to impact sensitivity. This classification can be used to establish objectives in

Figure 1

Schematic Representation of a Concept for Assessing the Impact Sensitivity of Groundwater Units

Anthropogenic Impacts

a) Diffuse inputs



Soil and Rock Cover / Groundwater Unit / Groundwater Sub-unit as a System



after HOFMANN and TEUTSCH; modified

protecting groundwater occurrences that are particularly sensitive and to implement measures to achieve these objectives. Measures need to be graded according to impact sensitivity levels.

Cross-referencing of data on the impact sensitivity of groundwater units with information about land use and thus with information about contaminant inputs can be used to determine current or potential threats to groundwater quality.

The system of groundwater units and groundwater sub-units as proposed by the German Environmental Council

- is independent of natural areas and administrative jurisdictional structures,
- allows the classification of groundwater occurrences according to different impact sensitivity by taking the protective function of their overlying soil and rock into account,
- is of great importance for Länder and regional planning and thus for environmentally friendly groundwater management as well as for land use planning (e.g., in designating particularly impact sensitive areas or when allowing the erection of facilities that could potentially endanger groundwater quality) and thus provides a basis for precautionary groundwater protection,
- make it possible to design and establish a uniform, groundwater-unit-appropriate, optimized monitoring system to monitor the success of preventative protection measures, to detect anthropogenically induced changes in groundwater composition early on and to initiate appropriate corrective measures.

Scenarios of natural flow, transport and reaction processes in groundwater units and groundwater sub-units can be constructed qualitatively.

This approach can be used countrywide. In order to obtain data that are representative and comparable, i.e., that have been collected on a uniform basis in all of the *Länder*, an optimized quality measurement network should be used to characterize groundwater occurrences and determine whether groundwater composition is potentially geogenic. Groundwater units thus provide a respective frame of reference for potentially geogenic groundwater composition or current concentration levels. Policy decisions with respect to groundwater protection measures (e.g., designation of priority [groundwater] areas) can be based on groundwater units.

13.* In the opinion of the German Environmental Council, planning instruments should be strengthened in order to prevent and regulate impacts engendered by under-takings requiring official planning approval (e.g., industrial parks) or other approval (e.g., businesses, farms, transport facilities, waste treatment plants and dumps, and by undertakings that pose a threat to the environment. This should be done in the areas of general regional planning and plan approval as well as in the area of water management planning by sectoral authorities (sectoral ministries, departments, agencies).

Official decisions concerning planning and the approval of individual plans that are of significance to water management (decisions concerning the size of settlements, the construction of transportation routes, approval of facilities in which substances are used that could affect water quality) should give priority to groundwater protection interests in areas that have been classified as priority areas. Whether individual plans that are of significance to water management are compatible with groundwater protection needs to be determined in accordance, in particular, with regional planning law (Article 4, Section 1 of the Regional Planning Act and Article 1, Section 4 of the Construction

Statutes, construction management must accommodate the objectives of regional planning; Article 15 of the Regional Planning Act, assessment in regional planning procedures). Approval regulations for facilities that could affect water quality should, in future, ensure the protection of priority areas by means other than merely technological means.

In addition, the following planning instruments which are standardized with respect to water management law should be used to protect groundwater: water management framework plans and management plans, sewage disposal plans and protected area designations. If land use were consistently site-appropriate, and if "good agricultural practice" were adhered to, then the only areas that would still need to be protected, in the opinion of the German Environmental Council, would be catchment areas in which water is extracted. Regionally important areas that are not used for water extraction would no longer have to be designated as protected areas in order to ensure the future quality of the water supply.

An important function of basic water management planning in the future will be to provide a countrywide overview of extant possible dangers for waters of all kinds, of endangered water-dependent ecosystems and of types of water use whose sustainability may be in jeopardy. Water management plans can be used to regulate the amount of water extracted as well as, possibly, to remediate areas damaged by groundwater level subsidence.

In addition to these plans, which are regulated by water management regulations, and these designations of protected areas, numerous sectoral plans, special plans and general plans have been developed in the course of planning at *Länder* and regional levels. These plans are used, among other things, to resolve local and regional problems and are also fundamentally appropriate for use in water protection. The plans that are especially interesting in this context are the more recent action plans, objective plans and sectoral plans, which, in their approach, are somewhat similar to framework plans and management plans, but which, because they are designed to deal with *Länder*-specific problems, have a different focus and set stricter ecological objectives.

Apart from regional master planning and sectoral water management planning, there are other types of environmentally related planning, such as landscape planning, that can be used for water protection; conversely, sectoral plans can be used in conjunction with environmental impact assessments.

14.* General qualitative groundwater protection is currently primarily regulated by the Water Resources Management Act and the water laws of the *Länder* as well as by other medium- and substance-related environmental laws. Analysis of the regulatory instruments has shown, however, that Germany's water laws, which tend to take a resource-oriented management approach, are not always capable of adequately limiting the numerous impacts on groundwater. Substance-related regulations, for example, should, in future, be better designed to prevent impacts on groundwater before they occur. Further, "good agricultural practice" needs to be concretized such that it is site-appropriate.

15.* The allocation of water extraction rights in Germany is subject to public use regulations (approval, licensing). The price mechanisms which determine the most

efficient uses of goods in the market are ineffective as concerns groundwater extraction. Most of the *Länder* now levy charges for water extraction, but the charges are not based on regional water scarcity. Incentives to switch to other water supply sources and thus to accept potentially higher treatment costs or transport costs are not provided.

Furthermore, contrary to the current practice of having to pay charges levied by the *Länder*, public water supply companies should have to pay the same charges as all water users. This is the only way to motivate water suppliers to compare the costs of extracting water locally with the cost of switching to other potential sources, and then to choose the cheaper of the two options. The efficient apportionment of a given supply of water can only be achieved by making everyone who uses water pay the same price. Making public water supply companies pay this price is also the prerequisite for ensuring that scarcity signals will be passed on to the end-users in the form of cost-covering charges in order to motivate them to modify their behavior appropriately.

Potential resistance to the designation of water protection areas generally stems from the fact that such areas are subject to higher protection requirements than areas that do not serve for water extraction and that thus the designation of such areas limits the economic development potential of a region (e.g., there is a loss of business tax revenue). By allowing the regions, rather than the *Länder*, to allocate water extraction rights, the regions with water protection areas could sell water extraction rights, which could make having areas designated as groundwater protection areas in a particular region economically attractive for that region.

By improving groundwater protection throughout the country, i.e., by implementing groundwater protection in a consistent manner on a countrywide basis, numerous regulations currently applying to groundwater protection areas would become superfluous. Such areas might still require more regulations than less protected areas, particularly because it would be in the interest of water supply companies to prevent, to the greatest extent possible, unpredictable inputs of pollutants and human pathogenic microorganisms from occurring in their extraction areas (e.g., by banning the transport of hazardous substances through these areas). Nevertheless, it would thus seem possible to thin out the regulations that apply to water protection areas; the regulations could be limited to protecting the interests of the water supply companies. When the application of additional regulations to water catchment areas, after implementing countrywide groundwater protection, unreasonably impinges upon private interests (e.g., on the interests of land owners), this would establish a right, on the part of those affected, to compensation that should be complied with by using revenue from the water extraction charges to make compensation payments.

16.* The groundwater protection strategy proposed here by the German Environmental Council only allows transfer payments intended as a financial incentive to stimulate additional environmental activities to be paid to a region within the framework of financial equalization if the region engages in environmental activities above and beyond those necessary to ensure countrywide groundwater protection and for which it cannot expect to be remunerated (e.g., for maintaining or rehabilitating cultural landscapes).

However, the consistent implementation of countrywide groundwater protection could engender considerable land and water use restrictions particularly in those regions in which the groundwater is characterized by high impact sensitivity. Transfers could be used to compensate these regions for such restrictions. Further, the implementation of countrywide groundwater protection could be improved in the regions by taking regional deficits in implementing legally prescribed objectives into account when allocating funds. This would provide communities with an additional incentive to actively work towards protecting groundwater.

17.* Achieving the objective that "groundwater should suffer as little anthropogenic impact as possible" will be a long-term task: reforming land use such that it is in line with this objective can only be achieved in the long term. Steps towards achieving this objective should be taken as soon as possible. The establishment of groundwater units can be effected by refining the concept of groundwater landscapes. By determining respective impact sensitivities and endangerment potentials, a direct basis with which to implement coordinated groundwater protection measures countrywide can be provided.

18.* Currently, there is a lack of nationally uniform administrative procedures in the area of groundwater protection, and establishing a water resources management administration at the federal level would not be possible, since the water authorities of the Länder have jurisdiction over groundwater protection matters. Thus the Länder are called upon to establish a spatially uninterrupted system of groundwater units throughout the country. When the areas in which the jurisdictional area of administrative units are not coincident with groundwater units, neighboring administrative units will have to cooperate with each other. In this case, the sectoral authorities should determine the usable amount of water resources, and the regions (associations of communes who may have jurisdiction over extensive groundwater units) would have the authority to grant water extraction rights that would be valid for a particular length of time. The region would thus become a supplier of groundwater extraction rights, and would be able to take regional measures to influence the quality of its groundwater (e.g., by protecting areas, and by working with polluters in order to do so). The regional authorities would be required to inform the head water authority of the rights granted. The head water authority would have the right to object ex post facto to the granting of such rights (licenses), and to revoke them if it is of the opinion that groundwater extraction could have an immediate or long-term negative impact on the ecological functions of the groundwater in the region. Thus the head water authority would be able to exercise control over whether water extraction is in line with protection objectives.

Competition between different water uses when there is a shortage of regional water resources can be dealt with by auctioning off water extraction rights. The prices for which the rights are sold in the bidding process reflect the scarcity of local groundwater.

The prevailing quantity-based orientation in water resources management needs to be augmented by a much greater concern for safeguarding and monitoring water quality. Apart from the traditional administrative tasks of granting approval and issuing licenses, the *Länder* administrations would have the extra task of cooperatively monitoring this "new type of water association".

19.* Countrywide groundwater protection with spatially differentiated degrees of protection requires detailed knowledge of the protective capacities of individual overlying strata. A great deal of further research will be necessary in order to

understand the complex interactions in soils and aquifers. In addition, it will be necessary to restructure current institutions, in line with the concept of groundwater units.