Groundwater and the groundwater daughter directive

Key features and potential impact on the downstream petroleum industry

The Groundwater Directive (GWD) is a daughter directive of the Water Framework Directive (WFD) and has the potential to significantly affect downstream petroleum operations. It is currently undergoing its second reading in the EU parliament and gives rise to very heated debates between MEPs, the Commission and stakeholders who will be subject to its provisions.

One key issue in this debate is whether or not all groundwater should be managed under drinking water quality standards. The science of hydrogeology teaches us that water interacts with the surrounding geological structures. By implication, achieving drinking water quality in all cases is not feasible from either a technical or an economic perspective. This is not only because of remediation issues but also because, in some locations, the volumetric yield will not be high enough to justify the economics. As a result, one should not manage all groundwaters in the same way. It is important for decision makers to be well informed of the scientific and economic aspects of groundwater if they are to create a pragmatic Directive that Member States can implement and industry can comply with technically and economically.

The WFD seeks to establish a consolidated and sustainable approach to water management throughout the European Community and it will ultimately result in the progressive repeal of a substantial number of existing Directives concerned with water.

The main objectives of the WFD are:

- Provision of a secure supply of drinking water in sufficient quantity and with sufficient reliability.
- Provision of water resources of sufficient quality and quantity to meet economic (e.g. industry, agriculture) and recreational requirements.
- Provision of water resources in appropriate quality and quantity to protect and sustain, in all but exceptional cases, the good ecological state and functioning of the aquatic environment.
- Assurance that water is managed so as to prevent or reduce the adverse impact of floods and minimise the impact of droughts.

The WFD requires Member States to achieve 'good chemical and ecological status' for surface waters and groundwaters by 2015. Where surface waters are concerned, good chemical status is defined as compliance with all the Environmental Quality Standards (EQS) established for chemical substances at the European level.

Within the WFD, there are 'daughter' or sub-directives that more specifically define quality standards, monitoring and other issues not dealt with directly in the WFD. The GWD will specifically:

- clarify the definition of groundwater bodies;
- set criteria for defining good chemical status within groundwater bodies;
- set criteria for defining significant and sustained upward trends in contaminant concentrations; and
- define the starting point for trend reversal.

The GWD will also require integration with several other Directives (Nitrates, Landfill, Soil, etc.), which address issues that are environmentally interrelated. As these Directives are developed and implemented, industry can expect that the WFD and GWD will require them to devote more resources to groundwater protection and remediation than they have done in the past. Historically, the focus for contaminated land has primarily been on human health, rather than water quality *per se*. The new focus on the ecological status will increase the attention that regulators pay to groundwater quality at those sites close to water bodies, and industry can expect to have to do more in order to demonstrate compliance with the WFD by 2015.

Basics

It is important to be aware of the basic principles of groundwater hydrology and the hydrologic cycle to

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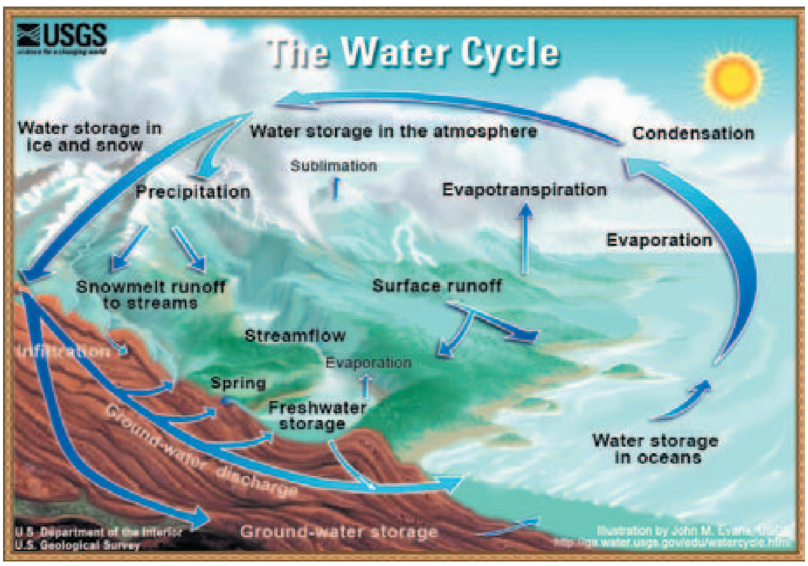
properly understand the complexity of the topic. Groundwater is not a stand-alone entity, but part of an integrated natural cycle involving interaction between surface water (note: many surface waters are an outcrop of groundwater), vegetation, soil, and other natural components; and these in turn have an impact upon groundwater. As water evaporates from the earth's surface, the vapour collects in the atmosphere and eventually makes its way back to earth as precipitation. This precipitation then percolates through the soil surface and ends up in a saturation zone through gravity, and then flows terrestrially where it discharges into surface waters or is used for anthropogenic purposes (drinking water, industry, agriculture, etc.). The process is continuous and Figure 1 shows this cycle in more detail. While the principle is simple, individual processes and interactions can be complex.

Along with this cycle, hydrogeology has a critical part to play. As an example of how complex hydrogeology can be, consider the differences between The Netherlands and Austria. Underlying each area is a completely different set of rock and soil that dictates how groundwater is collected and stored. In The Netherlands groundwater tables can be very close to the surface lying less than a meter below ground. In the Austrian Alps, groundwater may not be found until 50 meters deep or more. What happens then, when one goes deeper into the earth and finds not one but several aquifers that are stratified in different layers and at different depths? Figure 2 illustrates a simplified cross sectional view of this stratification.

Figure 1
The water cycle is a continuous process. For further information see: http://ga.water.usgs.gov/edu/watercycle.html



Each aquifer will have varying characteristics that could make one suitable for drinking water supply and the other one unsuitable. This is often a direct result of a water body's mineral concentrations, recharge rate (weeks, years, centuries or millennia), usage and flow characteristics. Some of these groundwater bodies are confined and will have very different attributes due to naturally protective barriers, for example clay or impervious rock, as compared to unconfined aquifers that are closer to the surface.

Additionally, the concentration of organic materials and minerals will often vary within the same aquifer. Due to different hydrogeology, it is possible to find a low concentration of a naturally occurring substance at one point and a very high concentration of the same substance some distance away. This is, for example, often the case with iron, one location requiring its removal prior to household use and another not. Such differing iron concentrations are by no means the exception, rendering a standardised approach to groundwater regulation quite impractical because hydrogeology makes all of the difference!

Risk-based approach

Due to the complexities that surround the management of Groundwater, it is CONCAWE's recommendation to use a risk-based approach implemented at Member State level. At the heart of the process is the three-pillar concept of the source-pathway-receptor relationship. Simply put, this concept states that, for a risk to exist, there must be a source of potential harm, it must have a pathway to the receptor and a receptor must have an exposure. If one of these pillars does not exist, then there is no risk. Figure 3 illustrates this relationship in more detail.

The model is underpinned by the notion that no two risks are equal and each must be managed individually. The risk management methods for two groundwater

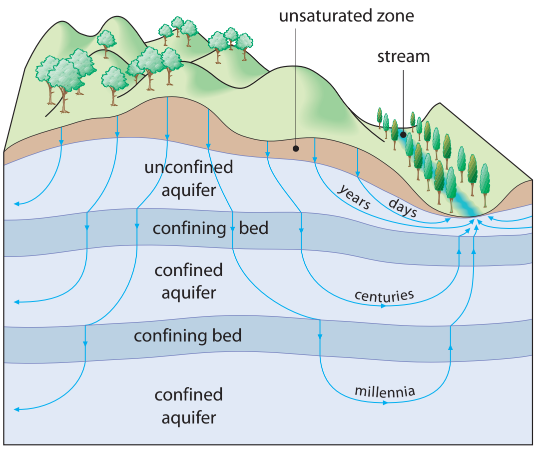


Figure 2
The stratification of aquifers at different depths

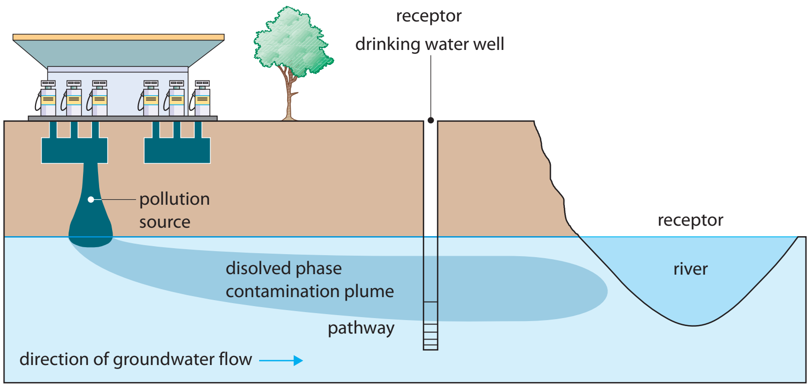


Figure 3
Soil and groundwater contamination: for a potential risk to exist there must be at least one complete source-pathway receptor linkage

bodies that have the same concentration of a substance may be quite different depending upon the location. Natural attenuation[1] is a viable approach to managing the risks associated with groundwater contamination but is affected by the surrounding hydrogeology. Parameters such as biodegradation, dilution and sorption, all of which contribute to natural attenuation of groundwater contamination plumes, vary by location and these processes dictate whether or not a substance degrades before it impacts a receptor. Therefore the surrounding hydrogeology and site specific characteristics will dictate a particular course of action.

Another key strength of this approach is that it enables the regulators and the site owners to identify and prioritise high risk sites. A 'one-size-fits-all' approach would call for action at all sites regardless of risk potential, leading to the danger of focusing on low risk sites while leaving higher risk locations unmanaged. This would allow real risks to actually increase and get worse over time.

Access to a polluted groundwater body located in a rural area might not be a problem and decontamination could be a feasible solution. Alternatively, it may be more economically and technically feasible to block the pathway to a receptor to provide effective protection against adverse effects. The situation may be very different in an urban landscape where decontamination might be infeasible due to the impossibility to access the water body. The preferred solution could be to protect the receptor by providing an alternative water supply and allow natural bioremediation to attenuate the contaminants over time.

If all locations are treated in the same way, there is a chance that the method used in one instance may over-protect or under-protect a receptor in another. This is why each location must be viewed independently of others and managed according to its specific characteristics and risk potential.

CONCAWE activities

To further support our risk-based methodology CONCAWE began a project in 2005 to review the petroleum industry's potential risk to groundwater across the EU-25. The project entails gathering and integrating digital data around petroleum sites and mapping this against aquifer type and their vulnerability to contamination. This is a risk assessment process that starts at a high

[1] *The naturally occurring chemical and biological processes that gradually renders a substance harmless*

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level to help manage multiple assets located in areas with varying geographic and hydrogeologic characteristics. The idea here is to first determine the risk potential for each location. Some sites have a higher risk potential than others but the risk only becomes real if there is a source of contamination, a pathway and an unacceptable impact at a receptor (or potential to cause unacceptable impact if no action is taken).

With this risk-based approach mindset, CONCAWE developed a risk criteria matrix to help categorise risk potential for petrol filling stations. In the environmental sensitivity criteria table below (Table 1), a Category 1 site is within a drinking water Source Protection Zone (SPZ) and carries a high risk potential from a leak at an underground storage tank. Conversely, at a site in Category 5 there would be no risk since there is no potential to impact drinking water, and therefore no receptor. This requires completely different approaches of how a regulator should view a site and its risk, as well as how the industry manages risk mitigation measures.

The specific case of the Czech Republic is described below. Figure 4 maps petrol stations against the groundwater and source protection zone data provided by the Member State, where the dots are sites and the colours indicate the category into which they fall.

Of the 1756 sites mapped against groundwater data, none are in Category 1 and only 17 fall within 100 meters of a source protection zone. Overall, there are few sites with high risk potential in the Czech Republic. This information is powerful because it provides a guide to initially focus activities on the most important locations (the 17 high risk sites in Category 2) and then move to the lower-risk sites in a methodical approach instead of trying to manage all 1756 sites in the same manner. This is more beneficial for the regulators, the industry and the public alike because effective action can then be taken in locations where it is warranted.

With regards to data capture and analysis, there are still hurdles to overcome. The major issue CONCAWE is dealing with is lack of consistent data across the EU. There are several reasons for this. Firstly not all Member States have information in digital form that will make it easy to map or study, precluding all EU-25 countries from being reviewed at this time. Secondly, much of the data is not collated on a country-wide basis and is often held by provincial government bodies in different formats. In several countries studied thus far, it has created visible gaps where one part of the country is analysed and other regions are left blank, making overall analysis difficult. We have also encountered several situations where the data are available in digital format, but the data holders have either requested an exorbitant price for the data or have flatly refused to provide data for our study. This is in no one's interest, since the data will be used to help identify possible risks to groundwater from petroleum sites and act as a first step at managing those risks.

For the above reasons, we currently have incomplete data for some countries and will only be able to identify

Table 1 Environmental sensitivity: provisional risk criteria

Groundwater category	Category 1	Category 2	Category 3	Category 4	Category 5
Principal criterion	SPZ1	Within 100 m of SPZ1	Other SPZ (2, 3 and 4)	Any other condition over minor aquifer	Non-aquifer, and not in SPZ

Groundwater sensitivity in the Czech Republic

Locations of petrol filling stations identified by environmental sensitivity

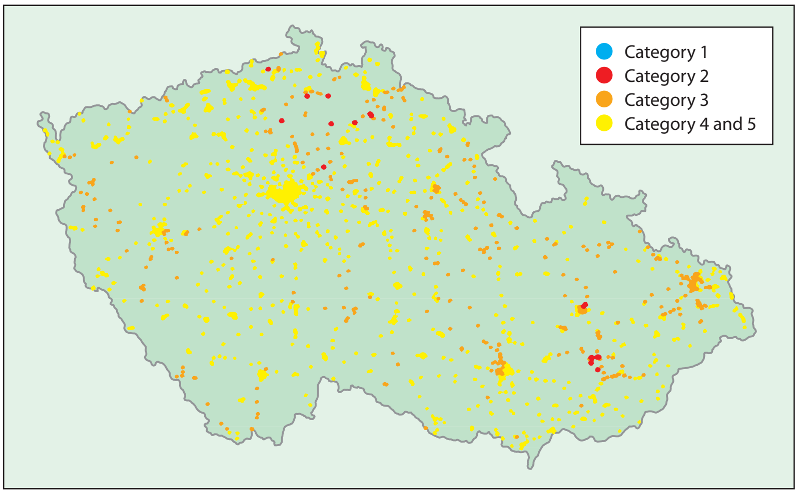

Figure 4

The locations of petrol filling stations were mapped against groundwater and source protection zone data throughout the Czech Republic; the dots are sites and the colours indicate the categories into which they fall.

Table 2 Provisional groundwater sensitivity of retail filling stations in the Czech Republic

Groundwater category	Category 1	Category 2	Category 3	Category 4	Category 5
Number of sites in each category	0	17	426	622	691

site-by-site risk as the data become available, in the required format, and at a reasonable cost. To compound the difficulty, countries do not use the same scale when they provide data, which prevents country-by-country comparisons. Therefore, an overall EU picture is currently not attainable and may not be in the near future.

Conclusion

CONCAWE strongly believes that groundwater should not be treated with a 'one-size-fits-all' approach. As illustrated above, creating EU-wide standards, methods and management practices for groundwater is neither pragmatic nor economically viable, and may lead to technically unachievable requirements due to hydrogeological variations and other issues. The lack of consistent data among Member States would, in any case, preclude an EU-level approach.

The recommended way forward is for a risk-based methodology that can be implemented by Member States according to their particular circumstances.

More information can be obtained at the following websites:

www.europa.eu.int/comm/environment/water/water-framework/groundwater.html

www.nicole.org

www.usgs.gov