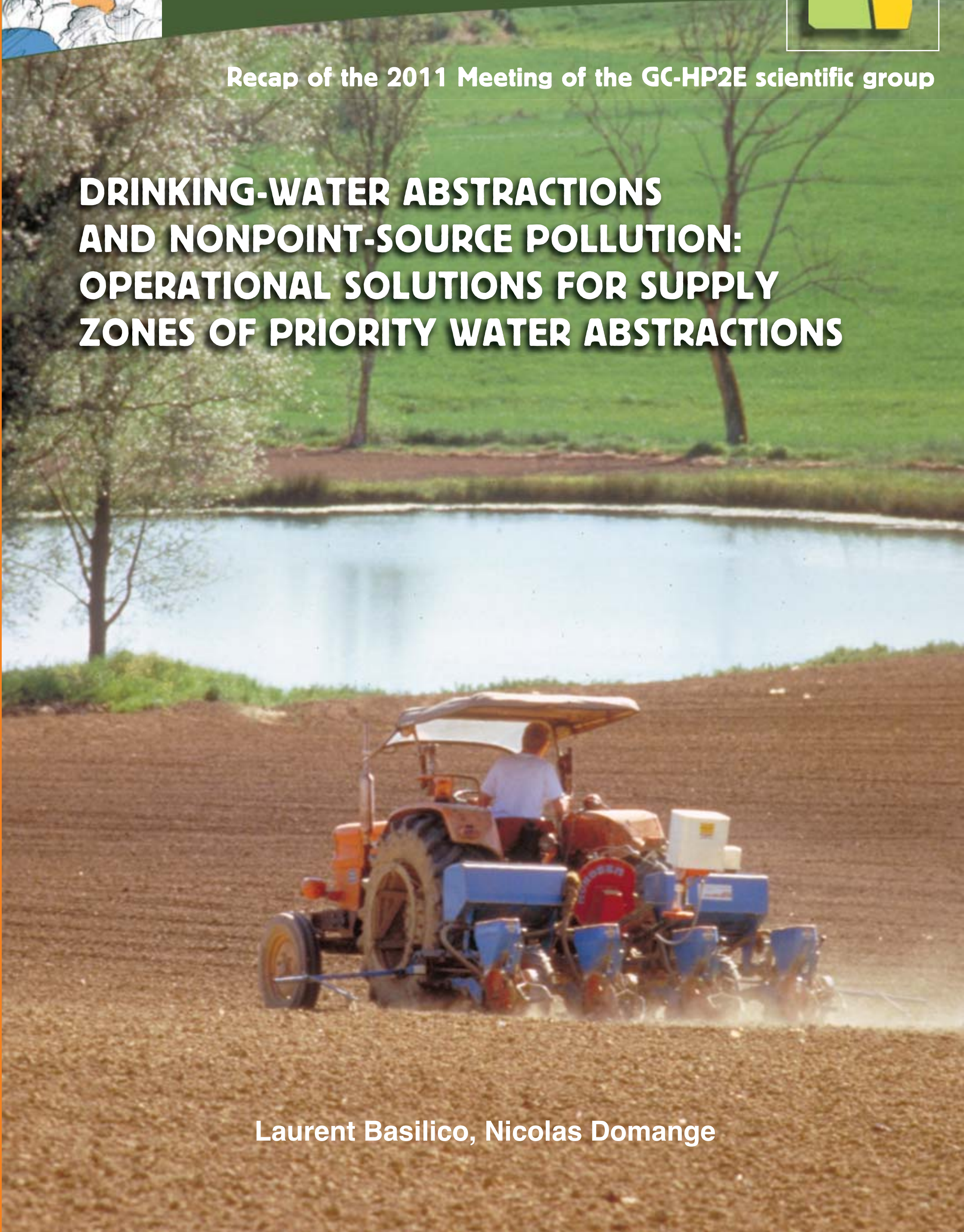
ONEMA Meetings

Recap of the 2011 Meeting of the GC-HP2E scientific group

DRINKING-WATER ABSTRACTIONS AND NONPOINT-SOURCE POLLUTION: OPERATIONAL SOLUTIONS FOR SUPPLY ZONES OF PRIORITY WATER ABSTRACTIONS



Laurent Basilico, Nicolas Domange

DRINKING-WATER ABSTRACTIONS AND NONPOINT-SOURCE POLLUTION: OPERATIONAL SOLUTIONS FOR SUPPLY ZONES OF PRIORITY WATER ABSTRACTIONS

Drinking-water abstractions and nonpoint-source pollution

Operational solutions for supply zones of priority water abstractions

Recap of the 2011 Meeting of the GC-HP2E scientific group

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The 2011 Meeting of the "Large-scale farming offering high economic and environmental performance" (GC-HP2E) scientific group on the topic of "Protecting abstraction supply zones from nonpoint-source pollution" was organised in conjunction with the National agency for water and aquatic environments (Onema), a member of the scientific group, on 3 February 2011 at AgroParisTech in Paris.

This recapitulation and its shorter version are available at (https://colloque.inra.fr/gchp2e_rencontres2011) and at (www.onema.fr/IMG/EV/cat7a.html).

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Foreword

Both drinking water and agriculture are essential to modern life. Protecting water abstractions from the nonpoint-source pollution released by farming activities is a crucial challenge for our societies.

On the European level, commitments to achieve effective levels of water quality by 2015 were made in the Water framework directive (WFD), voted in 2000. This pro-active policy led to the designation, in France, of approximately 500 "priority" abstractions requiring special protective procedures. These new regulations have accelerated and reconfigured long-standing efforts in favour of abstractions because there is now a deadline for effective implementation.

More than ever, the new goals require coordinated efforts on the part of the various stakeholders who find themselves in highly diverse local situations. Many questions remain. How can we assess the effectiveness of past projects for water quality in abstractions? What are the best legal and economic conditions to implement the available technical solutions? With the above questions in mind, how can we best mobilise and assist local stakeholders? And what R&D work needs to be done?

The 2011 GC-HP2E meeting on 3 February 2011 in Paris brought together approximately 200 participants, including the agricultural and institutional sectors, representatives of local governments, industrial companies and scientists, to discuss these complex issues. Organised to encourage dialogue and feedback on projects, the meeting contributed to launching the necessary discussions on the national level in view of producing operational solutions for the problems involved in protecting abstractions. This document recapitulates the projects presented, the viewpoints and the scientific contributions made during the meeting.

GC-HP2E scientific group

Following the Grenelle environmental meetings, INRA, a number of technical institutes working on large-scale farming (Arvalis, CETIOM, ITB, ITL, UNIP), APCA and Onema set up a scientific group to develop production systems targeting high economic and environmental performance levels.

A number of other entities joined the group later, namely GNIS, FNAMS, DGER-MAAP, AgroParisTech, Coop de France, Nouricia, ACTA, ITAB, FNA, InVivo, Terrena, Axéréal, UIPP, FNE, Cemagref, Syngenta, Bayer S.A.S and UNIFA.

The goal of the scientific group is to jointly programme and launch R&D projects in nine main fields, namely 1) the observatory on production systems, practices and performance levels, 2) control over biogeochemical cycles, energy sums and the fate of pollutants, 3) control over bioaggressors and management of biodiversity, 4) innovation in plant varieties, 5) design, evaluation and experimentation of innovative crop systems, 6) indicators for sustainable management of agroecosystems, 7) decision-making determinants and processes, 8) insertion of crop systems in agri-business processes and 9) public policy and production systems.

French national agency for water and aquatic environments (Onema)

Onema is a public agency created by the 2006 Water law and launched in April 2007. It is the main technical organisation in France for knowledge on and monitoring of water status and for the ecology of aquatic environments. Its mission is to contribute to overall and sustainable management of water resources and aquatic ecosystems.

The Water framework directive (WFD) set ambitious goals for water quality, notably for the resources intended for drinking water. Similarly, the Grenelle environmental laws stipulated that the supply zones of 500 abstractions among the most threatened by nonpoint-source pollution must be protected by 2012.

To succeed in these difficult tasks, the Ecology and Agriculture ministries, Onema and the Water agencies have mobilised their forces with their research partners to create methods to assist in defining suitable measures to restore water quality. Onema was the initiator in the beginning of 2010 of a Technical group to protect abstractions from nonpoint-source pollution. The purpose of the group is to identify gaps in our knowledge and any R&D work required to improve preparation of action programmes incorporating technical and socio-economic aspects.

In addition, Onema funds and manages a number of operational research projects on protecting abstractions via its partnerships with French research organisations.

To encourage dissemination of information on projects to protect water from nonpoint-source pollution, Onema has made a particular effort to publicise the meeting between stakeholders in large-scale farming and water management.

Contents

A major health issue, an urgent regulatory problem

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Each day in France, over 18.5 million cubic metres of drinking water are drawn from over 33 000 abstractions spread throughout the country. Maintaining the quality of such a vital resource is an essential requirement for public health. It is particularly important to protect abstractions from contaminants, notably agricultural substances (nitrates and phytosanitary products), by setting up action plans for abstraction supply zones (ASZ). Over the past few years, these concerns have become a growing social issue and new regulations are now the driving force behind the reaction of public authorities. It should be noted that since the 1992 Water law, protection perimeters established by certified hydrogeologists are mandatory for all abstractions of water intended for human consumption. In addition to the protection perimeter directly around the abstraction borehole, there are also the inner and outer protection perimeters.

In the inner protection perimeter, i.e. the area surrounding the borehole and which generally varies from one to ten hectares, any dumping, activities and building are regulated and, if necessary, forbidden to ensure effective protection of the drinking water from accidental contact with polluting substances. Certain protective measures may be extended to the outer protection perimeter, which is not mandatory and the size of which can vary considerably.

Over 500 priority abstractions requiring immediate protection

The previous regulations were considerably reinforced by the WFD (water framework directive) in 2000, which created unprecedented EU-wide requirements concerning the protection of water resources, setting in particular the goal of reaching good chemical and ecological status of water bodies by 2015. The 2006 Law on water and aquatic environments created zones with environmental restrictions (article 21), whereby the prefects determine the areas requiring special protection and launch action plans based on input from local stakeholders. The creation of such zones is voluntary for a period of three years, but can then be imposed by the prefect if deemed necessary. Hailed as a pro-active regulatory tool, zones with environmental restrictions (ZER) have however raised a number of questions concerning their practical implementation as well as the necessary control and monitoring capabilities in local contexts often overshadowed by conflicts concerning water usage.

Following the 2009 Grenelle environmental law, the priority is now to address approximately 500 abstractions deemed particularly vulnerable given the population supplied, their irreplaceability and the level of nitrate and/or pesticide pollution. These priority abstractions must be effectively protected by 2012. It may be necessary to designate zones with environmental restrictions (ZER) to ensure that the expected results in terms of water quality are achieved rapidly. The new legal obligations have created, in parallel with the health issue, an urgent regulatory problem.

Protection of an abstraction may be broken down into three main steps, 1) delimiting the abstraction supply zone (ASZ) and the extent of its intrinsic vulnerability, 2) territorial diagnosis of pressures weighing on the zone and 3) collaborative formulation of the action plan.

The protection of priority abstractions would appear to be a straightforward matter (the prefects are in charge of implementing the action plans), but the reality in the field is in fact complex. The relation between the goal of 500 abstractions set by the law and the local geological and/or sociological situations is not always obvious and decisions to classify abstractions as “priority” sites were preceded by intense discussions. The studies on ASZ boundaries and vulnerabilities are now underway with support from the Water agencies. The procedure has turned out to be very difficult for very large ASZs. Finally, there are a number of cases where projects already underway, notably territorial action plans, must be re-evaluated, maintained and folded into the new procedure, without destroying the momentum achieved and the relations between stakeholders. For abstractions already covered by protective measures, it was suggested (Laurent Verdié, Adour-Garonne water agency, 2011 meeting) that any existing contractual situations be subjected to regional evaluations to determine whether they should be maintained or replaced by the ZER procedure.

Generally speaking, success in achieving WFD goals, for both priority abstractions and all the others, will require an immediate and unprecedented mobilisation of a vast array of stakeholders, including farmers, abstraction owners, the French State, the Chambers of agriculture and farming cooperatives, local governments, agronomists and suppliers of drinking water. To succeed, this mobilisation must be based on a shared analysis of existing local projects, a clear understanding of the make-or-break issues for each participant, a shared understanding of the available tools and technical solutions, and of the necessary knowledge and the corresponding R&D still required. It was with the above needs in mind that the 2011 meeting of the GC-HP2E scientific group was organised.

1

Experience feedback


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Over the last decades, numerous projects to protect water from nonpoint-source pollution have been undertaken throughout France by local governments, the Water agencies and regulatory agencies. In the 1990s, protection projects were often part of national programmes, for example the Ferti-Mieux (better fertilisation) certification programme run from 1991 to 2003 by ANDA (national association for agricultural development). However, an evaluation of these projects today reveals great diversity in the means and methods employed and in the results achieved. The Grenelle environmental agreement has made it necessary to coordinate efforts under tight deadlines and to draw lessons from past experience and present projects.

This first section will contribute to drawing those lessons using the data presented in a few of the reports made to the 2011 Meeting.

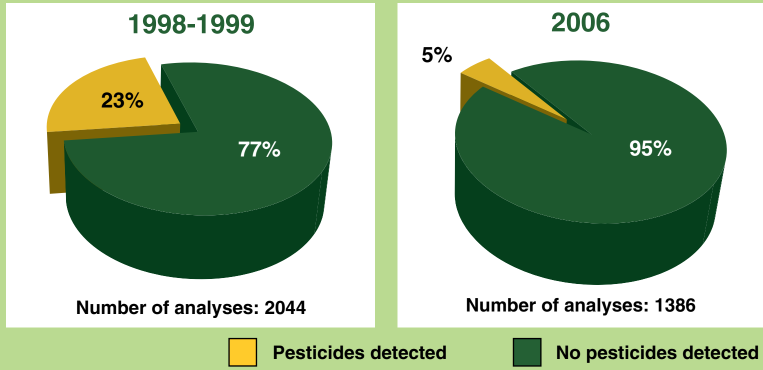
1.1 – Diagnosis and action programmes - the work by Arvalis in two river basins

A problem linked to ASZs is the protection of catchments from nonpoint-source pollution, which has been the topic of many agricultural action plans. Benoît Réal (Arvalis - Institut du végétal) presented two action plans that Arvalis has been managing since 1997 with various partners. In each case, a similar approach was adopted, first a spatial diagnosis on pollution sources and transfer, then preparation of action plans, followed by monitoring of indicators on water status and the progress made.

The Fontaine du Theil catchment, located north of Rennes in Brittany, measures 136 hectares and comprises 80 fields worked by 20 farmers, essentially corn, permanent pastures and straw cereals. A measurement station at the catchment exit quantified the presence of various herbicides in the river water at the start of the study. In 1998, all the sprayers used in the catchment were analysed and the farmers were subsequently trained in fine tuning their systems. Training sessions on weeding cereals and corn were also set up, with regular visits to the fields in the company of the farmers. Finally, the action plan also resulted in the creation of buffer zones (grass buffer strips, fallow land, wooded banks) and the exchange of critical fields between farmers in order to create permanent pastures. Hedgerows were restored and a dump was eliminated. Chemical treatments along the edges of fields and the stream were stopped and replaced with mechanical means, fields are now ploughed perpendicularly to the slope.

On the basis of 15 000 analyses between 1998 and 2006 at the catchment exit, the results showed a significant drop in the number of samples in which active ingredients could be quantified, from 23% in 1998-1999 to 5% in 2005-2006, as shown in figure 1. The threshold of 5 µg/litre for all substances combined was occasionally exceeded during the first two years, but not since 2000.

Figure 1. Number of pesticides detected at Fontaine du Theil (Benoît Réal, 2011).



Péron catchment, an effective action plan in a large catchment

The Péron catchment in the northern part of the Aisne department is much larger with 14 648 hectares, including 82% of useable farm land. A technician from the Cerena cooperative noted very high death rates for fish in the river and succeeded in launching the Agri Péron project in 2004 to turn the catchment into a model of good practices for controlling point-source and nonpoint-source pollution by phytosanitary products. The project, supported by Arvalis, Cerena and the Aisne Chamber of agriculture, with funding from the Seine-Normandy water agency and the departmental council, first diagnosed the pollutant-transfer modes and then provided the farmers with recommendations on spring crops, changes in phytosanitary products and development work.

In the spring of 2004, a test of water quality by the regional environmental agency detected 28 active substances that were transported directly via drains from the farm yards to the river after a storm. Efforts were therefore made on isolating the sprayer filling stations and work was carried out on 52 farm yards to that end. Three years later, the phytosanitary products detected in the river were not of agricultural origin.

At the same time, there was a problem of herbicides used in corn fields running off toward zones that infiltrated rapidly to the water table. This problem was reduced by creating buffer zones, hedgerows and rows of trees.

Extension to the entire Aisne department

The successful use of this method in a catchment led to the idea of expanding its implementation to a larger zone, i.e. the entire department. That is the goal of the Agriper'Aisne programme, now underway and involving all the agricultural stakeholders in the department, from the Chamber of agriculture to the entire collection and distribution sector. Following an Aquavallée® diagnosis, Arvalis-Institut du végétal and the Chamber of agriculture assessed transfer risks over the entire department. The zones identified as the most "at risk" represented 41% of the total useable farm land. The main transfer mechanisms are draining, runoff due to soil capping and the corresponding erosion. The diagnostic procedures for each farm were carried out by trained project managers from each of the participating organisations. The "diagnosticians" used a highly informative and didactic feedback technique thanks to the graphic field registers supplied by the farmers. The graphic agri-environmental diagnostic tool was the means to assess the risks not only of using phytosanitary products, but also of nitrates. It was used as well to evaluate their impact on biodiversity and in terms of energy use. In September 2010, over 300 farms had been diagnosed with financial support from the Seine-Normandy and the Artois-Picardie water agencies.

1.2 – Champagne Berrichonne (Cher department) - changes in use of nitrogen-based fertiliser

The Champagne Berrichonne region has for years been affected by high nitrate levels in abstractions, regularly above the 50 mg/litre threshold, and was ranked as "vulnerable" in 1992 according to the Nitrates directive. The Axéréal co-op (formerly Epis Centre), which provides technical advice and supplies 70% of the local farms, has spent the last 20 years trying to modify how nitrogen-based fertilisers are used, by setting up advisory services for volunteer farms.

From 1993 to 2003, the AZUR project, carried out in conjunction with the Chamber of agriculture using the Ferti-Mieux label, analysed the recorded work habits of farmers and compared them to measured nitrate levels. Over the first five years, the project resulted in a reduction in the initial treatment and in the development of split treatments. Starting in 1998, the availability of new calculation and management tools made it possible to pursue the efforts which resulted in a general and significant reduction in the doses applied. From 1998 to 2003, the average nitrogen level dropped from +70 to +50 kg N per hectare and per year.

In 2003, at the end of the AZUR project, the launch of the Epiclès® Invivo software used to calculate nitrogen-based fertiliser quantities, combined with the Farmstar®

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remote-sensing diagnostic tool, enabled Axéréal to continue and even reinforce recording of work habits and its advisory work. These tools are now extensively used in most catchments of the Champagne Berrichonne region.

Variable results for nitrate levels in abstractions

The efforts undertaken by the Axéréal co-op over almost 20 years have produced both qualitative and quantitative change in the work habits concerning nitrogen-based fertiliser among farmers in the Champagne Berrichonne region, however, they have not produced clear results throughout the region in terms of nitrate levels in water tables. Two examples provided by Jean-Marie Larcher (Axéréal, 2011 Meeting) illustrate the diversity of results.

In the Avord abstraction, at 25 metres below ground level, nitrate levels have steadily decreased since 1995. Whereas they frequently exceeded 80 mg/litre up until 1997, the measured levels have remained below 50 mg/litre since 2005.

The results are very different at the Porche 2 deep abstraction, 100 metres below ground level, in the priority abstraction supply zone (ASZ) for the city of Bourges. Following a decade of constant increases between 1990 and 2000, nitrate levels have since stabilised at between 65 and 70 mg/litre.

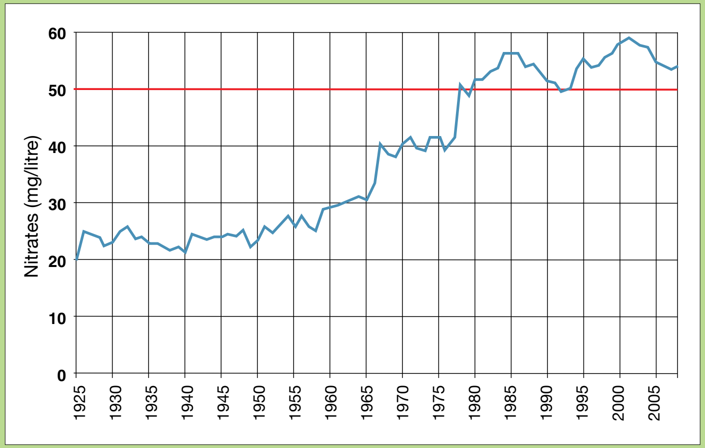
The two catchments are located in areas with typical soils for the Champagne Berrichonne region and comparable large-scale farming systems. Similar protection projects using similar means were implemented at both abstractions.

Though there is still some debate today, the major differences in the results achieved are clearly linked, at least in part, to the difference in the depth of the aquifers. A groundwater age-dating study run by LADES (Groundwater age-dating laboratory) for the Bourges Urban Area revealed a travel time of approximately ten years for water tables located at a depth of 100 metres.

1.3 – Eau de Paris - reducing inputs and developing organic agriculture

Half of the drinking water for the city of Paris (560 000 cubic metres/day) comes from the surface waters of the Seine and Marne rivers. The other half comes from highly vulnerable underground abstractions located in rural areas near the cities of Sens, Dreux, Fontainebleau and Provins. Since the 1960s, the quality has dropped, to different degrees, due to increases in nitrate and pesticide levels as shown in figure 2.

Figure 2. Average annual concentrations of nitrates at the Vicomté abstraction from 1925 to 2009. (Manon Zakeossian, 2011).



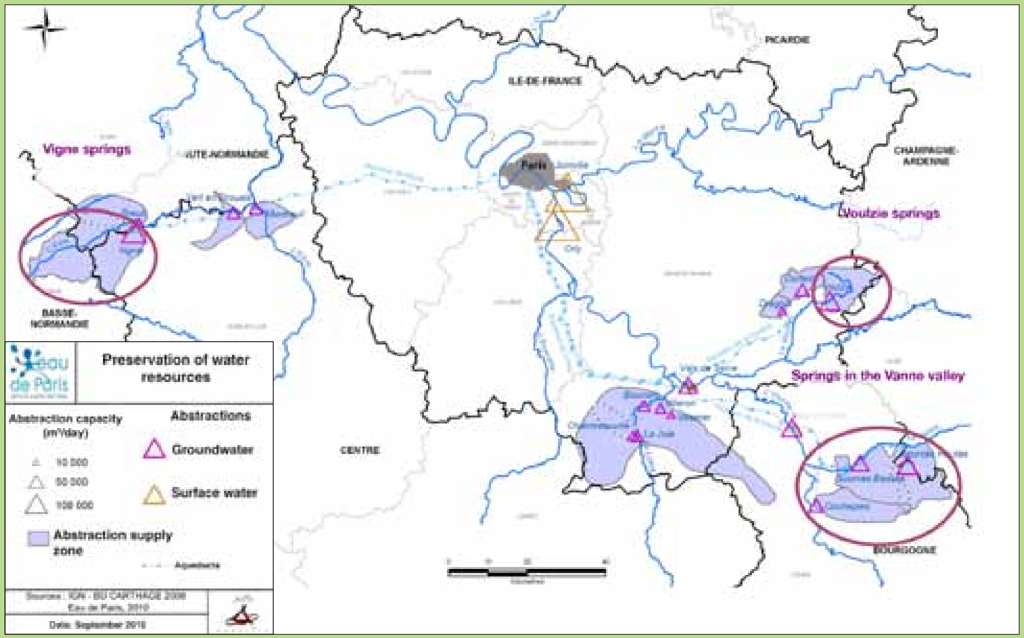
Immediately following the creation of these abstractions, major efforts were made to protect them, notably to limit the propagation of contamination causing infectious diseases. The well protection perimeters are very large and cover a total of 826 hectares. Caves and permeable sections of rivers were blocked off to limit the transfer of surface waters to aquifers. Initial projects with farmers were launched in the beginning of the 1990s. They include the Ferti-Mieux programme on the Voulzie river, the replacement of atrazine in the Dragon catchment and funding of fallow areas along rivers. Four groundwater treatment plants were built from 2004 to 2009, notably to treat atrazine and its metabolites.

These efforts produced insufficient results in terms of water quality. However, they did provide Eau de Paris, the Parisian municipal water service, with useful information for more ambitious projects in the framework of a strategy primarily targeting the transition to crop systems with low chemical input levels and notably organic agriculture, in parallel with the creation of landscaping work designed to reduce concentrations in water before it infiltrates the soil.

Since 2007, the municipal service (Manon Zakeossian, Eau de Paris, 2011 Meeting) has concentrated on three strategic ASZs, the Voulzie springs (Seine-et-Marne department), the Vigne springs (Eure-et-Loir) and the springs in the Vanne valley (Yonne et Aube) (see figure 3).

These catchments, where large-scale farming is prevalent, represent almost half of the total surface area of the ASZs involved in supplying water to Paris. To restore water quality, Eau de Paris focuses on technical advice, often provided by the Chambers of agriculture, agri-environmental measures (AEM) and land purchases.

Figure 3. The three strategic sites for Eau de Paris.



Progress in implementation, but results must still be evaluated

At the Voulzie abstraction, where the ASZ covers 11 000 hectares (90% useable farm land), the average nitrate level is 54 mg/litre. Atrazine (0.1 µg/l) and the metabolite desethylatrazine (DEA) (0.35 µg/l) are the two main pesticides continuously detected, with other phytosanitary products regularly exceeding thresholds during the periods when they are used. Winter large-scale crops dominate and 15% of the useable farm land is drained.

In order to progress toward integrated agricultural systems, AEMs targeting a 50% reduction in herbicides and a 40% reduction in other products were proposed for the entire catchment and other AEMs are in the planning stage, notably to promote change in fertilising techniques. Since 2007, the measures have been adopted by about 30 farmers representing a total of 3 900 hectares. A partnership was also launched with Cemagref to create artificial-wetland buffer zones (AWBZ) at the output of draining systems.

For the Vigne springs, where the situation is comparable, the same type of project resulted in 65 farmers signing up, which resulted in almost 700 hectares being turned over to or maintained as grasslands and a reduction in inputs for 2 900 hectares.

Finally, the project in the Vanne valley (46 800 hectares), managed by Sedarb (Bourgogne rural and agrobiological eco-development service and the Organic farmers group in the Yonne department, specifically targets organic farming with installations to limit runoff. An AEM to achieve those goals was proposed in 2010 and 11 farmers, representing 550 hectares, decided to convert to organic farming.

On the whole, the strategy adopted by Eau de Paris has met with limited, but nonetheless encouraging acceptance by farmers. On the other hand, the actual impact in terms of water quality must still be evaluated. The municipal service stresses the need to consider the project over the long term and notes the limitations imposed by the five-year contract periods of AEMs. The need for continuity must also overcome the future changes in the Common agricultural policy starting in 2013, which will require significant adaptation efforts from project managers.

Abstractions in lakes and eutrophication, the case of the Carcès lake

Phosphorous from human activities (wastewater, agriculture, industry) is one of the main drivers of algal proliferation in aquatic environments. Such proliferation has taken place for many years in Lake Carcès (Var department), the primary source of drinking water for the 400 000 inhabitants of Toulon and the surrounding area. In addition to a protection project undertaken by the departmental territorial and maritime agency, the Veolia group launched an evaluation of the lake in 2009 (Magali Dechesne, Veolia, 2011 Meeting). The evaluation used a diagnostic method developed by Cemagref to determine the trophic state of the lake and identify the potential sources of the phosphorous. Among those sources, soil erosion in the catchment, of which 10% consists of vineyards, would appear to be a significant source of nonpoint-source pollution, plus wastewater-treatment plants and agricultural co-ops. Four sampling campaigns in 2009 revealed that water quality in the lake is worrisome, but not critical. The bioavailability of the high quantities of phosphate compounds detected in lake sediment is low. Monitoring of phytoplankton revealed local proliferations of cyanobacteria, particularly during summer low-water periods, that risk blocking filters.

The initial diagnosis resulted in numerous recommendations on the hydraulic operation of installations, on maintaining a higher level in the lake and on a possible change in the position of the water intake.

But for long-term results, more precise understanding of phosphorous flows in the catchment will be necessary for preventive work to reduce the quantities arriving in the lake.

1.4 – Results in terms of water quality - keys to success and limiting factors

The feedback presented at the 2011 Meeting provides only a glimpse of the diverse projects undertaken over the past few years to protect abstractions. Though the increased involvement of the agricultural sector, local governments and water stakeholders is a positive factor, it must nonetheless be objectively analysed. The time and effort invested and the encouraging results achieved locally cannot mask the fact that progress is often partial, empirical and spatially limited, in short it is insufficient for the country as a whole.

It is necessary to pinpoint the insufficiencies and limiting factors of common methods that can be scaled up in order to effectively protect abstractions, notably given the tight deadlines set by the Grenelle environmental agreements. The projects presented during the 2011 Meeting and the following debates contributed to those efforts.

The availability of operational technical and scientific knowledge is of course of major importance for ASZ managers and stakeholders in fully understanding the phenomena involved. Prior to setting up action plans suited to each situation, it is indispensable to have the necessary tools to set the ASZ perimeter, i.e. assess vulnerabilities, identify pollution sources and causes as well as the corresponding farming practices, determine the potential for progress and, finally, propose suitable changes in practices and any necessary work. In view of mutualising investments and enabling large-scale operational implementation, there are currently great hopes that the methods devised will be highly transposable.

All of these goals are the topics of projects that have mobilised numerous, increasingly multi-disciplinary teams over the past few years. Some of those projects were presented during the meetings and are discussed in the second part of this recapitulation.

Work on technical solutions must of course take place in step with considerable training efforts to facilitate their use by the various groups that will implement those solutions, namely project managers, funding agencies, administrations, cooperatives and specifying entities, local governments and farmers.

Generally speaking, the capacity to mobilise all stakeholders in favour of an action plan was highlighted by all the participants at the 2011 Meeting as an essential condition for success. Prior to generating consensus for the proposed solutions, the diagnosis must be understood and approved by all concerned. The project leadership must ensure that a consistent message is transmitted by all the participants in the advisory system. This approach contributed to the success achieved in an ambitious project such as Agriper'Aisne (see page 14). The proposed solutions, including the restrictions on certain products, were validated by each person in the advisory system, from the technicians trained to carry out the diagnostic procedure up to the co-op presidents. Each farmer was also assisted by a single contact person.

The necessary assistance on the social level has been the topic of research programmes run in the field and is increasingly recognised by the various stakeholders ranging from the Chambers of agriculture to the distributors. It must exist on the local level, in the form of farm coordination groups in a given ASZ, and on the national level, where an example is the partnership agreement signed by the national Chamber of agriculture organisation and the federation of water companies. These issues are the topic of the third section in this document.

Another key factor frequently noted during the discussions was the need to maintain projects over time. The efforts made may require several years to improve the quality of water in abstractions, due notably to the long travel times to aquifers.

Once results have been achieved, they must be maintained over time. AEMs are an indispensable means to launch and accompany projects, but their contract duration is only five years. That may result in problems down the line when efforts must be maintained beyond the contract duration. They are an effective means to run projects, but are insufficient to ensure the overriding goal of long-term protection of water resources.

Finally, evaluations of the impact of action plans on the water quality of abstractions are often insufficient, or even absent, in which case the percentage of farmers adopting the measures is used to determine the success of the project. It is indispensable that evaluations be systematically included in projects to protect abstractions in order to assess their true effectiveness.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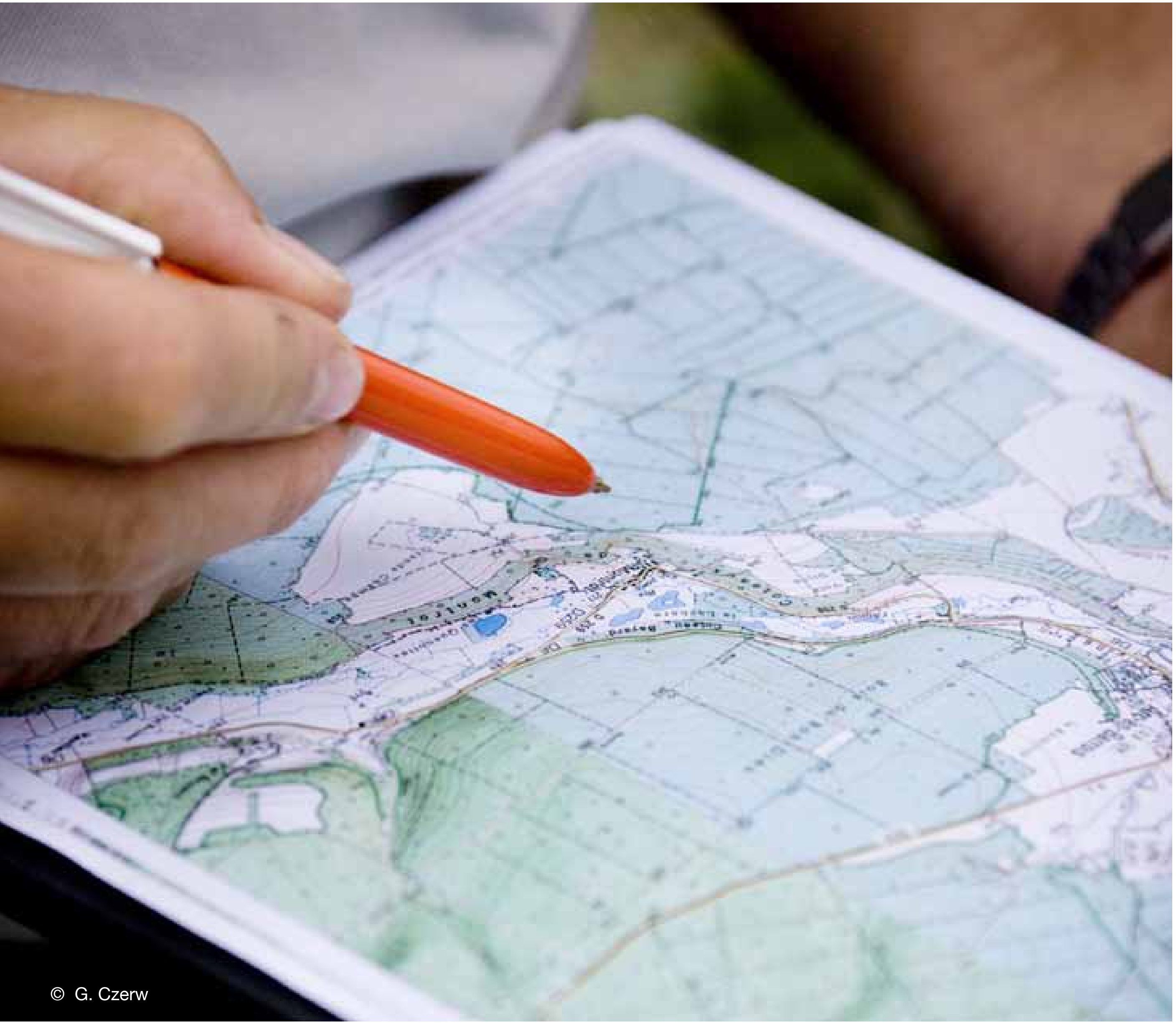
From diagnosis to operations: knowledge, tools and methods



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Over the past ten years, the issues raised by abstraction protection have been increasingly addressed by technical institutes, scientific labs and State agencies. The result has been a great deal of research on solutions, models and methods ranging from analysis of vulnerable areas in ASZs to modifications in agricultural practices and the reduction of transfers.

Paradoxically, these proactive efforts mean managers are now confronted with an array of tools. Which model is best to simulate transfers in a given ASZ? To what extent is a method used in one context relevant for a different context?

This second section, calling on the scientific and technical contributions made during the meeting, will not present a complete panorama of currently available or future tools and methods, however it does propose updated guidelines on technical concepts and operational solutions.

2.1 – Some hydrogeology to understand how ASZ perimeters are set

The term "abstraction supply zone" used in the legislation designates all land surfaces from which any water infiltrating or running off contributes to the water resources (aquifer or surface water) of the abstraction. ASZs can cover surfaces ranging from tens to thousands of hectares.

Practically speaking, the surfaces are determined by the topography, the type of soil (infiltrating or prone to runoff) and the underlying geological structure (impermeable formations, etc.). Precise mapping, an essential condition for effective protection measures, remains a complex task requiring a high level of hydrogeological know-how.

For groundwater abstractions, BRGM published in 2007 a methods guide titled "Setting boundaries for abstraction supply zones and mapping vulnerabilities to nonpoint-source pollution". The public report proposes a three-step method. The decisive first step concerns the hydrogeological study of the underground catchment, i.e. abstraction characteristics, data review and/or acquisition, an understanding of the aquifer system.

Selection of the ASZ delimiting method clearly depends on the type of aquifer. It is necessary to distinguish between continuous aquifers (water is contained in a porous structure), fractured aquifers (water flows through cracks in an impermeable structure) and karstic aquifers which are complex systems of more or less fractured zones, more or less saturated with water. The BRGM report presents in detail, for each type of aquifer, the methods used to delimit the part of the aquifer supplying a given abstraction. The goal is to identify the surface area likely to impact on the quality of the water in that part of the aquifer, in short the abstraction supply zone.

For surface-water abstractions, Cemagref is now preparing, at the request of the Ecology ministry, a guide on ASZ mapping and characterisation of vulnerability to nonpoint-source pollution by agricultural pesticides. The proposed method (Guy Le Henaff, Cemagref, 2011 Meeting) is based on a qualitative approach to water-transfer phenomena. The first step again consists of gathering and analysing existing data on the local pedology (soil conditions), hydrology and topography. In addition to using previous studies (notably for expropriation procedures), it may be necessary to acquire new data. It is particularly important to have in-depth knowledge on the hydric properties of soil, which determine hydric transfer to the abstraction. Precise data on ASZ limits are then obtained using a geographic information system.

In 2012, the two methods guides will be combined to form a single manual on both surface and underground abstractions, including evaluation methods for abstraction vulnerability.

2.2 – Understanding transfers and determining the zones most in need of work

Analysis of transfer risks, which vary from one field or zone to another, is an indispensable part of setting ASZ boundaries in view of protecting resources for drinking water from nonpoint-source pollution. The level of risk comprises two components, the intrinsic vulnerability of the ASZ (a function of its topographical and pedological characteristics) and any pressures weighing on it (land use and chemical inputs). The risk may be mitigated by the presence of landscape features (earth banks, hedgerows, grass buffer strips, etc.) that affect pollutant flows.

To be effective, economically realistic and remain compatible with competitive farming activities, action plans must be adapted to the level of risk in each area and target at least those surfaces where the transfer risks are the greatest.

Different types of transfer may contribute to the flow of chemical substances in an ASZ.

• Runoff, i.e. rainwater flowing over the soil picks up pollutants. Runoff types include Horton overland flow, over relatively impermeable surfaces when rainfall has exceeded infiltration capacity, runoff over saturated soil, when rain falls on soil already filled with water, and erosive runoff.

• Hypodermic flows resulting in subsurface transfers (below the soil surface but above the water table), of which agricultural draining is a particular type.

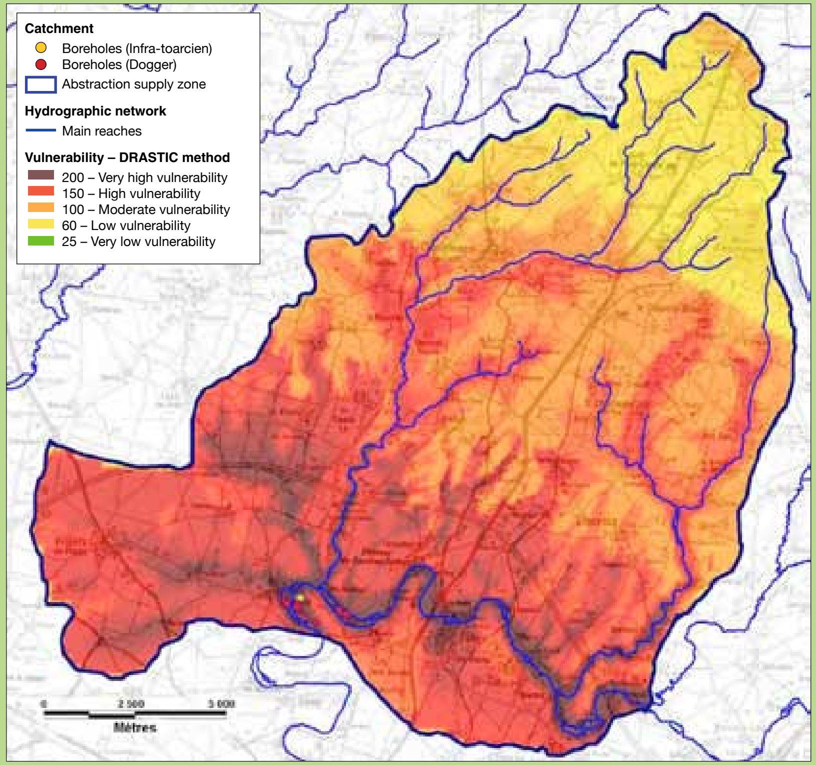
• Infiltration of rainwater in soil.

• Drift of sprayed chemical products.

Mapping of water vulnerabilities with respect to nonpoint-source pollution and transfer risks is thus a complex task requiring extensive know-how, notably in hydrogeology and agronomy. To meet the challenge, digital models have become the universal solution over the past 20 years, first for research and now increasingly for operational applications.

A method to prioritise zones for action based on modelling of each cadastral unit was presented during the 2011 Meeting (Thibaut Constant, InVivo, 2011 Meeting). This approach, which has drawn on work by INRA in the Bruyères-et-Montbérault catchment and the Beauce aquifer, was used by Union InVivo, in conjunction with the Footways and Safege engineering offices, in the Saint-Maxire ASZ, which comprises 12 boreholes for an annual production of 12 million cubic metres. Following a complete hydrogeological study, Safege mapped the intrinsic vulnerability of the catchment based on the strong assumption that transfer to the aquifer takes place exclusively through infiltration (figure 4).

Figure 4. Map of intrinsic vulnerability in the Saint-Maxire-Échiré ASZ (Deux-Sèvres department) (see the review by Thibaut

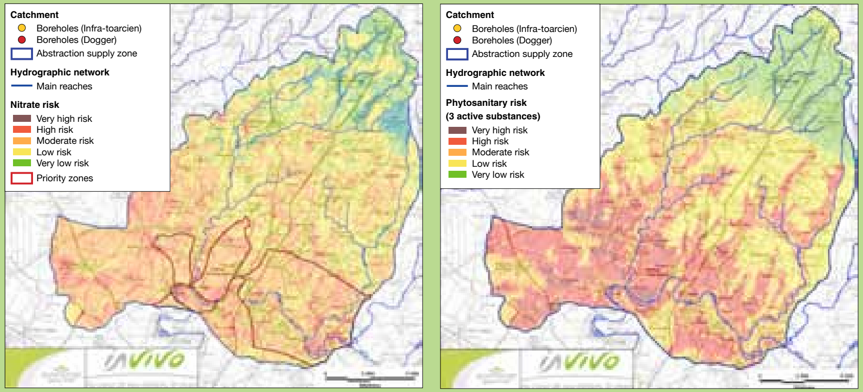


The studies on the risks of surface transfers were then carried out using two approaches targeting, respectively, nitrates and phytosanitary products, based on actual practices. The Footways company modelled, field by field, pesticide transfers based on 900 agri-environmental scenarios inventoried throughout the ASZ, distinguishing five soil types, five crops and 88 active substances. For nitrates, concentrations in runoff volumes were calculated for each field based on estimations provided by the decision-aid tool for the Epiclès fertilisation plan, using the average values calculated for the four years surveyed.

The risk maps for transfer to the abstraction were then obtained, for nitrates and pesticides, by merging the risk maps for surface transfers with the map of ASZ intrinsic vulnerability (figure 5).

This type of model based on cadastral units, which has the advantage of being easy to read by local stakeholders and directly related to farming practices, would appear to be particularly well suited to pedological situations characterised by vertical transfers.

Figure 5. Risk maps of nitrate and pesticide transfers with indication of priority zones, in the Saint-Maxire-Échiré ASZ (see the review by Thibaut Constant, 2011).



A different type of model consists of simulating pollutant flows using a distributed approach. An example is the TNT2 model developed by INRA to predict the effects of measures to reduce nonpoint-source nitric pollution in abstractions (Patrick Durand, UMR 1069, INRA-Agrocampus Ouest, 2011 Meeting). This model, which links a hydrological model with a simplified version of STICS (crop model with a time step of one day), has been used to date in a dozen catchments, notably in Brittany, to assist in developing systems with very low nitrogen leakage rates to water resources (Raimbault *et al.*, 2009). It was also used for the ex post evaluation of the BEP2 (Bretagne Eau Pure) regional programme to restore water quality (Durand *et al.*, 2006).

In the latter case, TNT2 showed that the drops in nitrate concentrations noted over the last decade were in fact the result of changes in farming practices (and not of the climate), but that the improvement was probably insufficient to rapidly restore water quality to the desired level.

This model currently requires highly qualified personnel, e.g. implementation in a new catchment takes 3 to 6 months by an engineer. The zones covered must be less than approximately 100 square kilometres in size and the model is certainly best suited to certain situations found in western France. These limitations, common to many modelling approaches, are obviously a major obstacle to effective protection of priority abstractions by 2012. For TNT2, a current goal is to make the model useable in larger catchments, notably by simplifying the entry of input parameters.

In general, a major goal currently is to develop integrated simulation tools suitable for operational use in the field. Some of the available solutions are presented in section 2.4 below.

Another major lacking in current models is that they rarely take into account the role played by landscape features (hedgerows, earth banks, etc.) and development work (buffer zones and grass buffer strips, etc.) in blocking pollutant transfer. Such features and work are, however, useful additional means to limit the impact on water resources and are discussed in the next section.

Finally, the availability of reliable data on farming practices, the input data for the models, is a persistent problem limiting wide-scale use of the models. Agricultural technicians can play an important role in solving this problem, notably by providing information on discrepancies between advised product use and effective use by farmers.

2.3 – Reducing transfers using cover crops, buffer zones and landscaping work

In addition to efforts to optimise use of fertilisers and phytosanitary products, work to protect abstractions can call on a wide range of tools to limit pollutant transfers, notably by creating buffer zones. They can be simple features of the landscape that serve as natural obstacles to substance transfers, e.g. earth banks, hedgerows, groves or lines of trees. The creation (or recreation) of such features can significantly limit risks for certain areas, as was shown by the action plan set up by Arvalis at Fontaine du Theil (see page 12).

Numerous studies have addressed more or less artificial buffer zones set up between the field and the receiving environment specifically to limit transfers. There are dry buffer zones, e.g. grass buffer strips, extensively discussed in CORPEN technical documents, and artificial-wetland buffer zones (AWBZ), the most promising for drained fields.

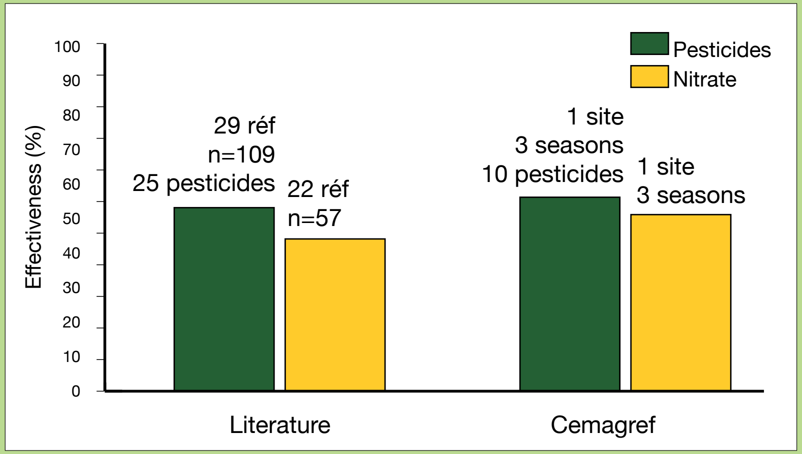
Set up at the output of a collector drain, an AWBZ serves a double function, nitrate assimilation by the plants and denitrification. Pesticide reductions are achieved, depending on the molecule, by photodegradation, hydrolysis, reduction-oxidation, adsorption on various substrates, etc.

Cemagref (Julien Tournebize, Cemagref, 2011 Meeting) reviewed 54 articles presenting results on the effectiveness of AWBZs, in addition to his own experimental results. It would appear (figure 6) that such zones can reduce the transfer of substances (nitrates and pesticides) to water resources by 50 % on average.

AWBZs are, of course, not useful in all situations. Cemagref, contacted by different site owners, carried out preliminary studies on setting them up in three ASZs, Rampillon, Léchelle and Vovelles, confronted with intensive agriculture and potential links between surface and groundwater.

At the Vovelles ASZ, 97% of groundwater comes from

Figure 6. Effectiveness of artificial-wetland buffer zones against pesticides and nitrates, a review of the literature and Cemagref experimental data (J. Tournebize, 2011).



infiltration, even though 8% of farm land is drained. Recommendations therefore address adaptation of work practices and changes in land use, without the installation of an AWBZ.

On the other hand, in the Rampillon and Léchelle ASZs, farm land is drained 100% and 13% respectively, and in both cases, all surface waters infiltrate.

In these two ASZs, following hydrological studies, it was decided to set up four AWBZs, in addition to changes in practices. As is often the case for this type of work, one of the difficulties concerned land ownership. In the Rampillon catchment, the owners were either public, the river board, or farmers. At the Voulzie springs in the Léchelle catchment, the zones were set up, where possible, on land owned by Eau de Paris.

In addition to buffer zones, there is another promising solution to limit pollutant transfers to water resources in areas with large-scale farming, i.e. plant covers between crop rotations. The capacity of cover crops to protect soil from erosion, improve its structure and fertility, and limit the escape of nitrates is well documented (Ritter *et al.*, 1998; Justes *et al.*, 1999). Plant covers are also a means, that varies depending on the type, to influence the retention, degradation and/or transport of applied herbicides (Reddy *et al.*, 1997; Sadeghi & Isensee, 1997).

The CIREPPE programme (cover crops to reduce pesticide losses), carried out by the Purpan engineering school and several research units from INRA, is currently studying this solution. The project is based on lab tests, experimental systems for quantitative results and the use of models to examine situations not tested experimentally. The goal for mid-2014 is to propose a decision-aid tool to select cover crops depending on the implemented crop system and to manage technical aspects.

2.4 – Integrated decision-aid tools for diagnosis and action

Though the development of digital agro-hydrogeological models has made it possible to gain more knowledge on pollutant transfers and optimise agricultural practices, their large-scale use remains complex and time consuming. There is consequently an increasing effort on the part of public authorities and research institutes to propose more integrated and operational tools to diagnose vulnerability, simulate corrective measures and evaluate the effectiveness of action plans (involving changes in crops, fertilisation techniques and phytosanitary use, letting land lie fallow, creating buffer zones, etc.).

That is the goal of the methods developed for pesticides by the Footways company, which are currently used in several ASZs in France, but also in catchments in Sweden, Slovenia and Greece.

The method (Igor Dubus, Footways, 2011 Meeting) includes a step to characterise the territory (weather, types of soil and crops). The system is designed for use on different spatial scales, from an ASZ to an entire country, and can adapt to the available data by making use of information on a farm, a set of fields or even part of a given field. A geographic information system is used to localise the zones exposed to transfer risks.

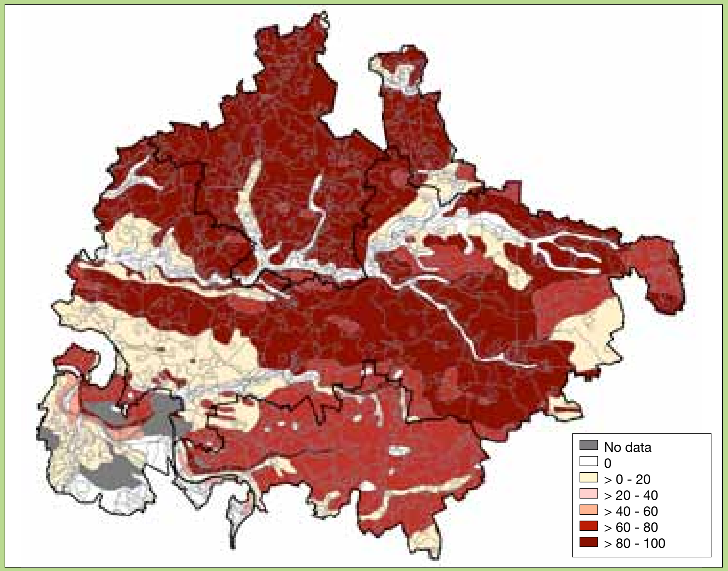
These data are then used to simulate product transfers, field by field, to water resources, using three separate models addressing, respectively, vertical flows, horizontal flows and spray drift. Models must also be capable of simulating the presence of certain features, e.g. hedgerows, grass buffer strips, etc.

The resulting data are reprocessed for use in an operational context. They are analysed, for each given situation, taking into account quality indicators for drinking water (the threshold concentrations are those set by regulations for each substance or the sum of substances) and indicators on the potential ecotoxicological effects for aquatic environments. Pressure indicators may also be used, e.g. the pesticide treatment frequency index.

For each application, the useful results are extracted and fed into decision-aid tools that can produce histograms, graphs, maps, etc. for water-quality managers and agricultural technicians.

Figure 7 shows a map produced for an ASZ.

Figure 7. Example of a map produced by Footways showing the potential for transfer of a given phytosanitary product to the groundwater in an ASZ. Pesticide indicators for sustainable agriculture (PITSA) show the frequency, in the percentage of days, of a given threshold being overrun by one or more active substances.



For nitrates, a decision-aid tool was developed by the International centre for research on water and the environment (CIRSEE) at Suez Environnement. Called NitrascopeTM, this simplified model tests the effectiveness of various preventive-measure scenarios in view of reducing nitrate concentrations in drinking-water abstractions (Julie Paille, Suez Environnement, 2011 Meeting).

For a given ASZ correctly characterised in the model (type of soil, crops, quantities of nitrogen fertiliser), the system uses historic concentration data at the abstraction to calibrate the model in order to produce a graph of nitrate concentrations and simulate various scenarios on land use and reductions in the use of nitrogen fertilisers. Generally speaking, the maps produced identify zones for priority action and assist in setting up appropriate action plans, in conjunction with the various local stakeholders. The maps are also a useful means of transmitting information.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Past uses of NitrascopeTM in four French ASZs (managed by the Lyonnaise des eaux company), confronted with very different hydrodynamic contexts, served to draw the attention of users to the importance of the quality of input data, a decisive factor for the reliability of results. It is essential to have precise piezometric data on the studied area and a good map of the non-saturated zone.

In parallel with these promising tools, a further, useful development concerns qualitative methods for rapid preliminary diagnostic procedures.

With that in mind, Terrena, Arvalis-Institut du végétal and Syngenta joined forces to design an evaluation tool to provide recommendations in support of the advice on herbicide use given by agricultural technicians to farmers (Lancelot Leroy, Terrena, 2011 Meeting).

This work, based on the recommendations of CORPEN, the Arvalis experimental system in Jaillère (Loire-Atlantique department) and the Aquaplaine® method, targets the risk of transfer to surface waters of phytosanitary products applied in the spring, in the pedological context of the Oudon river (essentially silt on schist). The tool was used in a part of the priority catchment.

The technicians taking part in the project received training on the status of the river, regulations and the available means of action. The evaluation tool determines risk levels for a given field, based on five data points:

- distance to water;
- presence or absence of a planted zone between the field and the river;
- slope of the field;
- risk of soil capping or compacting;
- useable water reserves of the field.

The results in turn determine the various solutions proposed, e.g. development work, improved farming practices or treatment periods, a change of products or alternative methods.

The tool turned out to be very useful because it is simple to use and was well received by the farmers. This first step encouraged the project partners to test the tool in other catchments and on a larger scale. Other integrated tools such as Footways were a means to check ex post the validity of the recommendations produced by the tool and, where necessary, to improve it.

Terrena, Arvalis and Syngenta will pursue their partnership to develop other evaluation tools adapted to different pedological contexts and uses of phytosanitary products. It should be noted, however, that all these integrated decision-aid tools have a common defect, i.e. very few evaluations have been carried out on their effectiveness in terms of the ex post quality of water.

3

Project acceptability and mobilisation of local stakeholders

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In addition to the scientific and technical challenges involved in protecting drinking-water abstractions, there are social aspects that are key factors to success. In an ASZ, even the best action plan will not produce results unless it is fully understood, adopted and supported by all stakeholders, down to the individual farmers who must implement it in the field. This aspect, stressed by all meeting participants, means that it is necessary to understand the problems confronting each stakeholder in a context of increased tension around water issues. It is also necessary to create the means and procedures for calm discussions to enable effective collaboration within the ASZ.

This third section will address these issues by examining changes in the relations between stakeholders, on both the local and national levels, given the urgent need to protect priority abstractions. An instructive project is presented, carried out by a group of stakeholders at the Harol (Vosges department) abstraction, highlighting the difficulties encountered and the identified keys to success. Finally, this third section presents the promising concept of agricultural socio-economic diagnostics, which was presented during the 2011 Meeting.

3.1 – Conflicting water uses and stakeholder positions on abstractions

Above and beyond the immediate issues of priority abstractions, the protection of abstractions in general brings to the fore tensions concerning water resources, whose vulnerability is a topic of increasing worry for public opinion. With the acknowledgement of anthropogenic impact on climate change, awareness of health and environmental issues has grown over the past decade in a context of increasing needs and intense competition between different uses of water.

This new situation has confronted the agricultural sector and water companies with unprecedented difficulties. Water boards are required to enforce applicable quality standards, but must also maintain acceptable water prices for the population, even more so when price increases are caused by the need to depollute the water. Farmers already face structural economic difficulties and are confronted with the change in society's attitude toward intensive agriculture, now under fire from all sides.

It would thus appear necessary to analyse the socio-economic consequences of current regulatory changes and determine the acceptability of the proposed measures for each stakeholder.

This work was done by a joint AgroParisTech and INRA-SADAPT research unit, with the Chamber of agriculture and the city of La Rochelle (for the ASZ in the Charente-Maritime department). This agricultural department has limited water resources that cannot be quickly restored. Since the drought of 1976, it has undergone profound change, i.e. reduced dairy, more cereals and corn, increased irrigation due to a simplified declaration procedure, at the same time that the urbanisation of the La Rochelle area has resulted in increased demand for drinking water. In this context, the Chamber of agriculture and the Rochelle water service (SELR) launched a partnership, under the guidance of State services for health, the environment and agriculture (ARS, DREAL, DRAAF) and the Water agencies, to push for improved water quality at the most affected abstractions.

The study (Luc Bossuet, AgroParisTech, 2011 Meeting) looked at the farmers involved in the Varaize, Fraise and Anaïs ASZs and at the positions of the Rochelle water service and the Chamber of agriculture. It was based on surveys of experts and local stakeholders, and filled out with sampling data on agricultural land (supplied by the local Chamber of agriculture) and analysis data on abstraction water (supplied by SELR).

The president of the Chamber of agriculture easily admits that farmers must make efforts to reduce pollution caused by farming activities, if only to restore the reputation of the profession that is highly contested locally.

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He notes, however, that farmers were encouraged to intensify the activities that are now criticised and that it would be possible to modify the irrigation system by switching to crops requiring less water. That opinion is welcomed by the SELR engineer. But the latter questions the role of the product distributors (co-ops and merchants) who gain from over-consumption of inputs.

And the farmers? The study revealed the different attitudes of farmers with respect to the proposed AEMs, which can be grouped into three types of reactions. A majority adopt a “wait and see” attitude. In the absence of any legal obligations and any real social recognition for participation, they prefer not to change their habits and to observe the results and techniques employed by those participating in the project.

For others, AEMs are nonsensical because their priority is to control their production using known techniques and to maintain income in a context of fluctuating costs. Their opposition is not only economic, a virtually unspoken opinion is that feeding the planet is the priority.

Finally, the last group comprises the farmers that have opted for organic or “integrated” agriculture and, unsurprisingly, are open to the proposed AEMs.

Toward a new distribution of roles

The results of this local study are representative of numerous places elsewhere in France. In spite of increasing institutional initiatives, the proposed modifications have trouble gaining traction with most farmers and produce little real impact in the field. One of the main causes for the reticence, as noted in section 1.4, is the absence of long-term measures and suitable funding.

In spite of the above, the clear change in mindset concerning health issues related to the protection of drinking water on the part of departmental, agricultural and management entities should be welcomed as a necessary condition for success.

This new awareness has resulted in a new distribution of roles, similar to the partnership between the Chamber of agriculture and SELR, mentioned above. The presentation of the Federation of agricultural distributors (FNA) by Sébastien Picardat (FNA, 2011 Meeting) is a sign of the times. Often accused in the past of encouraging overconsumption of inputs, the distributors today see themselves in a role of providing responsible advice and recommendations, fully taking into account the need to protect abstractions.

On the national level, the change in roles resulted in the signature, on 29 November 2009, of a partnership agreement between the federation of water companies (FP2E) and the national Chamber of agriculture organisation (APCA) (Laura Blasquez, Veolia, 2011 Meeting). The goal of this unprecedented partnership is to initiate dialogue and cooperation between water and agricultural professionals, who until then had communicated very little. To that end, a study was carried out on ten abstractions located in all of the major river basins and managed by four different companies, Veolia Eau, Saur, Lyonnaise des eaux and Sogedo. The purpose was to identify the favourable factors, but also the obstacles to setting up the projects proposed by the partners on the selected sites, through discussions with local stakeholders, i.e. installation owners (towns, water boards, etc.), the water companies and the departmental Chambers of agriculture.

Following discussions and validation by all the participants, a list of 21 recommendations for “good partnership practices” was drawn up, covering the entire abstraction-protection process. The recommendations may be found at www.fp2e.org and www.apca.chambagri.fr. APCA and FP2E identified as the main way forward the establishment of contracts between the main technical and financial players involved in protecting water resources.

To ensure the perennity of solutions, it would appear necessary to revise certain conditions of the aid currently proposed. A second way to lever solutions would be to develop sources of income in the ASZs offering farmers new perspectives, e.g. short-rotation coppice, hemp, hay, local markets, mass catering, etc.

This partnership will, of course, be pursued. The two professions have agreed to launch long-term efforts in the economic, environmental and sociological fields. The priority will be given to local projects on a contractual basis, rather than creating new regulations.

3.2 – The interesting Harol project to coordinate stakeholders at a priority ASZ

The abstraction at the Rochotte spring is part of the drinking-water supply for the inhabitants of Harol, a village in the Vosges mountains. Located in the upper section of the Saône river basin, in a farming area (mixed crop, livestock), the abstraction has persistent nitrates levels near the 50 mg/litre threshold, thus making it a priority. The study to set the ASZ perimeter is now being carried out by an engineering firm, under contract from the "institutional" steering committee. According to current estimates, the ASZ should not exceed 100 hectares and the inner protection perimeter will be 55 hectares in size.

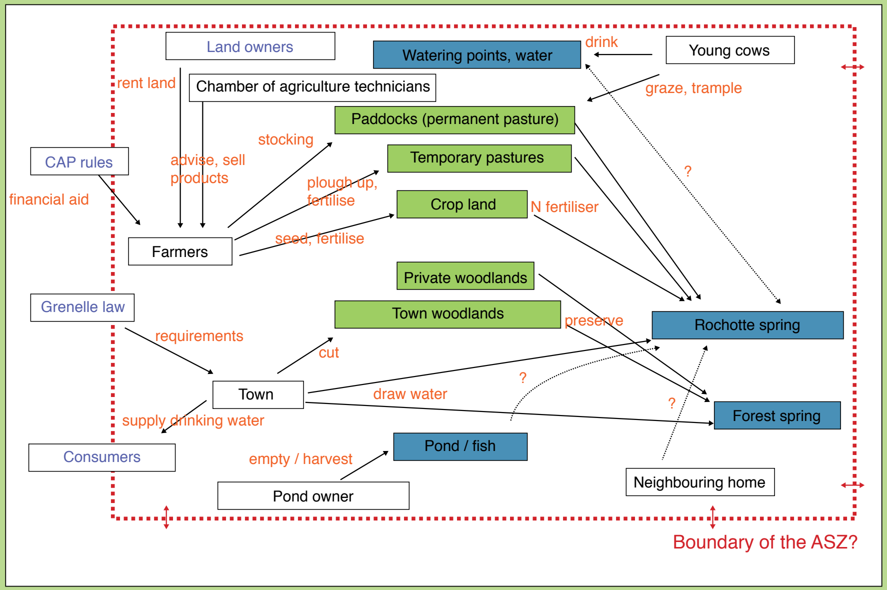
The unanticipated announcement concerning priority status placed the town in a difficult situation made all the more complex by the fact that it is located near the watershed and is part of a group of towns that depends on a different basin for water treatment. Given this special context, a group comprising primarily the local stakeholders, including the farmers and the town, was created in 2009 by the INRA Agrosystèmes Territoires Ressources research unit and the sustainable-development department of the Vosges Chamber of agriculture. The double goal is to do research and to collectively create a coordination group for farming activities around the ASZ.

Its first major step was to propose a shared view of the territory in the form of a diagram showing local interactions (see figure 8).

The diagram highlighted the role of indirect actors (co-op technicians, suppliers, land owners) who until now have not been included in the discussions of the local stakeholders nor in those of the steering committee. It also revealed the complexity of the relations between crop systems and work habits, on the one hand, and environmental impacts, on the other, and thus served as a basis of discussion on how to enhance understanding of that complexity. The group decided to characterise soil types and monitor the quality of nearby springs.

Finally, it also showed the importance of the ASZ boundaries which determine the number of farmers

Figure 8. Interactions between actors and resources at Harol (F. Barataud, 2011).



involved and the impact of the adopted measures on their farms.

The research team analysed the impact using two indicators, 1) the "% of concerned farm" (Benoît *et al.*, 1997), i.e. the ratio of a farmer's land in the ASZ to the total farm, and 2) the "% of ASZ", i.e. the ratio of a farmer's land in the ASZ to the total ASZ.

The novel approach at Harol will be pursued, on the basis of the existing discussions, with the formulation of scenarios for territorial reorganisation and an evaluation of the scenarios' impact on water quality.

3.3 – Agricultural socio-economic diagnostic procedures

The example of the Harol abstraction, presented above, illustrates the importance of taking local social realities into account for the success of efforts to protect abstractions. Though the initial steps, i.e. delimiting the basin, determining its intrinsic vulnerability and the pressures weighing, essentially bring scientific and technical means into play, that is not the case when the time comes to define the action plan. The success of this step, the most difficult, depends on proposing measures that are effective in terms of water quality and applicable, i.e. adapted to the local context. To that end, it is necessary to learn about the economic, social and political relations in the given area.

With that in mind, the Seine-Normandy water agency AESN (Anne-Louise Guilmain, 2011 Meeting), developed an agricultural socio-economic diagnostic procedure that, ideally, should be carried out between the intrinsic vulnerability/pressures assessment and the drafting of the action plan. The agency commissioned a study by the Ecodécision et Agristem consultants to draft a "good-practices" memento for diagnostic procedures and it has already been used for an initial test case in an area with large-scale farming.

The study recommended that the diagnostic procedure comprise the following steps:

- initial meeting with the steering committee to ensure a smooth transition from the previous phases of the abstraction-protection procedure;
- start-up meeting with already identified stakeholders and farmers, with a presentation of the procedure and of its time line by the project manager;
- interviews with farmers and other stakeholders, e.g. local companies, advisory entities, management services, State services, natural parks, etc.;
- analysis of data and of relations between stakeholders;
- proposals for ways forward, intended to enhance discussions while defining the action plan;
- feedback meeting and presentation of the progress made possible by the study;
- continuation of the abstraction-protection procedure.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The study commissioned by AESN also identified key factors to the success of the procedure. First, the call for tenders must highlight the diagnostic procedure and set clear goals approved by all. In selecting the company to run the procedure, special importance should be placed on its know-how in the fields of agronomy and "sustainable", integrated or organic agriculture. Once it has been launched, true involvement by the abstraction owner is indispensable to ensure awareness of the issues and the development of a collective effort. Finally, acceptance of the conclusions by each stakeholder is facilitated by prior agreement on the initial goals, regular progress reports in meetings with the steering committee, a meeting to present the project to the public and, generally speaking, consistent efforts to communicate on the project.

The socio-economic diagnostic procedure, which met with great interest during the 2011 Meeting, is now used by AESN in its ASZ-protection procedure. Though the agency does not impose a diagnosis before granting financial aid, it does strongly encourage its inclusion in the overall procedure. A diagnosis is, however, costly and cannot be applied in an identical manner in each catchment. But it can constitute a useful means to untangle difficult situations.


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Conclusion

The large number of participants at the 2011 Meeting of the GC-HP2E scientific group shows the importance placed on the issues surrounding the protection of abstractions, in the agricultural sector and among local governments and water companies. People need information, but above all operational solutions in order to meet the imminent deadlines set for priority ASZs.

The diversity and the quality of the viewpoints expressed in no less than 27 contributions, by scientists, managers and technical institutes, should be welcomed as a clear signal that society as a whole has mobilised to address this issue. However, we must now go further and subject past and present projects to critical analysis. The debates during the 2011 Meeting are a contribution to that end.

For each feedback, research programme or project presented, the keys to success as well as the obstacles were identified. The transposability of the methods used, an understanding of those methods by all concerned, the perennity of projects and the systematic evaluation of results in terms of water quality would all appear to be essential conditions in meeting current challenges.

Technically speaking, the complexity of substance transfers in an ASZ has made digital modelling one of the main tools used to diagnose pressures weighing on territories. But existing models often suffer from relatively difficult use in operational contexts, from uncertainty on where and how they can be applied and from defects that are difficult to detect for non-experts.

Though an ideal model does not exist, the 2011 Meeting identified a few integrated and operational tools capable of diagnosing vulnerability, simulating corrective measures (changes in crops and work habits, letting land lie fallow, creating buffer zones, etc.) and evaluating the effectiveness of action plans.

The definition of action plans to protect abstractions cannot be limited to technical aspects. To produce results, the plans must be understood, accepted and supported by all stakeholders. Taking local, social realities into account in the decision-making process is a key factor to success. A number of possibilities requiring further development and promising tools to that end were proposed in the previous section.

In addition to the technical and social aspects, ASZ protection from nonpoint-source pollution requires the use of suitable economic instruments, a further necessary condition for acceptance of projects by the stakeholders in the field. Though this essential aspect was mentioned incidentally by a number of speakers, no specific proposals were made during the 2011 Meeting.

That observation reveals a major line of work required for the upcoming deadlines.

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