# Catchment Management Tools

## predicting the impact of changing catchment management practices in the Anglian region

by Frances Elwell

Water quality in both surface water and groundwater can be impacted by the way in which land is managed. In the Anglian region, trends of rising nitrate levels in groundwater have been evident for many years, and in surface waters, specific emerging pesticides, which are not removed by water treatment processes, are of concern. In both cases, the costs of treating raw water to remove these substances are high (and in some cases, prohibitive). The likelihood of needing to upgrade treatment, if no action is taken to reduce the substances at source, is increasing.

*Pesticides and fertilisers are typically applied to fields of arable crops to control species that inhabit crops, and to promote crop growth*
*Courtesy of Mott MacDonald*

Anglian Water, along with other UK water companies, is applying catchment management approaches as part of their strategy to improve raw water quality. While many water companies are focussing on implementing measures in the catchments during PR09, Anglian Water is also developing tools to predict the impact of catchment management measures. The use of these tools should allow a more targeted, and therefore more efficient, approach to the implementation of measures in the catchments.

Anglian Water's Catchment Management Strategy is being implemented between 2010 and 2015 through assessment of catchment management solutions for 20 (No.) sourceworks (13 (No.) surface water and 7 (No.) groundwater, which have been designated as at 'higher risk' of non-compliance with water quality standards for nitrates and/or pesticides. The Environment Agency is providing additional support for investigations at a further 34 (No.) groundwater sources, which have been identified to be at high risk, to ensure compliance with Article 7 of the Water Framework Directive.

Mott MacDonald is assisting Anglian Water to develop predictive tools for use at both groundwater and surface water sources. These tools comprise a suite of models which have been developed and implemented during a "pilot phase" for one groundwater and one surface water site. This modelling work contributes to Anglian Water's catchment management programme by identifying the potential benefits to surface and groundwater quality of various catchment management initiatives such as land use change.

Anglian Water require the models to be transparent (in terms of data inputs and models used), robust, defensible and accepted by the Environment Agency, Defra, Natural England and the Drinking Water Inspectorate (DWI). To promote transparency in the modelling approach, all data inputs to the models were obtained either from Anglian Water or from publicly available sources (although not necessarily without charge).

### Surface water

The surface water modelling focuses on pesticides. Concentrations of pesticide in raw water have become a cause for concern since techniques for measuring these substances were improved to allow measurement of concentrations at the limit set by the European Drinking Water Standards. In particular, metaldehyde and clopyralid are of concern, and are the focus of this work, because of the ineffectiveness of current treatment processes. For these pesticides, the concentrations measured in the drinking water are

sometimes greater than those allowed by the European Drinking Water Standards, and as such these pesticides are now defined in DWI Undertakings. The surface water modelling focuses on the pesticides metaldehyde (active ingredient in slug pellets, a molluscicide) and clopyralid (a weed killer or herbicide), both of which are defined in the DWI Undertakings for the Pilot Study area.

This Pilot Study used data for the catchments supplying the Pitsford sourceworks, which draws water from Pitsford Reservoir, to develop and calibrate the modelling tools.

The Pitsford Reservoir is fed from two catchments:

- The catchment to Duston Mill on the River Nene, from where water is pumped to the reservoir, and;
- The direct catchment to the reservoir.

These gently undulating catchments are located near Northampton. The pumped catchment (320km$^2$) is several times larger than the direct catchment (50km$^2$), but because of the constraints of pump capacity and licence conditions (particularly the minimum flow that must remain in the River Nene when pumping takes place), the relative contributions of the two catchments towards overall Pitsford inflow, are more evenly balanced.

Land use in the Pitsford catchments is predominantly arable, and the dominant crop type is wheat, followed by oil seed rape. Land use and land cover information was obtained from a variety of publicly available sources, and an innovative GIS technique was developed to combine these data sources.

Pesticide application data for the East of England was purchased from the Food and Environment Research Agency (FERA). Pesticide concentrations are measured by Anglian Water at five locations within the Pitsford catchments.

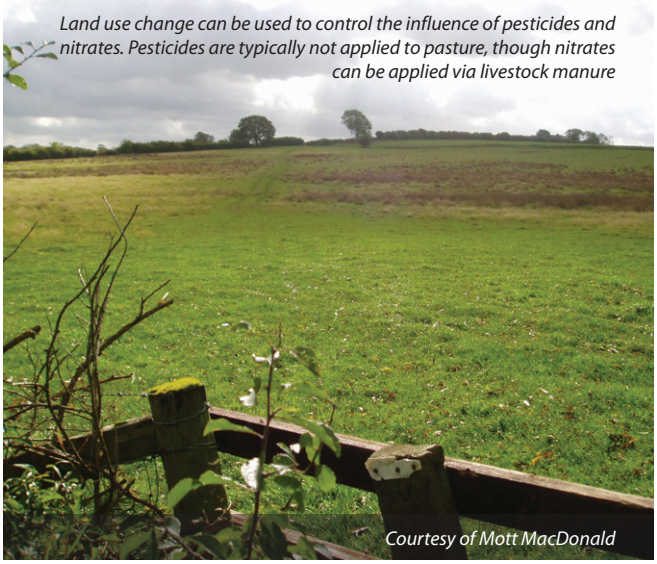
The Soil and Water Assessment Tool (SWAT) model was the tool selected for the pilot phase surface water modelling. This is a public domain model actively supported by the US Department of Agriculture's Agricultural Research Service (Texas, USA).

The models were calibrated using data from 2008 to 2010 and are being used to better understand the catchment response, to assess the impact of a number of land use scenarios and to investigate the areas of the catchment that were most influential on the water quality at the abstraction point.

## Groundwater

The groundwater modelling focuses on nitrates in groundwater, which in arable areas are thought to be strongly influenced by the application of nitrogen fertiliser. Use of nitrogen-rich fertilisers is thought to have begun in the post-war period; its use increased dramatically until the 1980s when application rates stabilised. As a result of the increased use in nitrogen application to land, concentrations of nitrate in groundwater have been rising steadily since the 1980s. In some places (including the Pilot Study site) they now exceed the drinking water standard of 50mg/l.

Determining the fate and transport of nitrogen in the subsurface requires a good understanding of the nitrogen cycle and groundwater flow. There is a complicated balance between these components, which is required to accurately simulate nitrate concentrations at abstraction locations. Nitrogen can exist in many different forms: atmospheric nitrogen, nitrate, nitrite, ammonia, urea and organic nitrogen. Chemical reactions controlled by bacteria and determined by soil conditions convert one form to another as part of the nitrogen cycle. In the oxygen-rich conditions in the soil, nitrates are the most common form of nitrogen to leach into groundwater.



*Land use change can be used to control the influence of pesticides and nitrates. Pesticides are typically not applied to pasture, though nitrates can be applied via livestock manure*

*Courtesy of Mott MacDonald*

Therefore, it is important to calculate the amount of nitrate that reaches the aquifer from all the different sources of nitrogen that are applied to the surface. These sources are dominated by fertiliser inputs but also include atmospheric nitrogen.

Nitrate that leaches from the base of the soil zone then travels through the unsaturated zone before it reaches the groundwater table and the saturated chalk.

Anglian Water's North Pickenham sourceworks was chosen for this pilot study due to its relative complexity in terms of geology and hydrogeology; it also has a relatively long nitrate record.

North Pickenham is located to the south east of Swaffham (Norfolk). There are three public water supply (PWS) groundwater abstraction boreholes to the north of the village. The River Wissey flows from the east to the south of the study area.

Three models were constructed to simulate the observed concentrations of nitrate at the North Pickenham boreholes:

- WAVE (Water and Agrochemicals in soil, crop and Vadose Environment) calculates the output of nitrate from the base of the soil zone;
- Modflow is used to determine the groundwater flow through the subsurface and into the abstraction boreholes;
- MT3D is used to calculate the movement of nitrate through the subsurface.

These models will be used to predict concentrations of nitrate at the abstraction borehole given a range of different land use scenarios.

## Conclusion

Mott MacDonald and Anglian Water have developed tools for modelling the transport of nitrates to groundwater and pesticides to surface water. These tools have been tested and calibrated for Anglian Water sourceworks catchments and are being used to test some simple land use change scenarios. The tools can be used to identify particular areas of the catchments on which Anglian Water should focus attention.

These tools will subsequently be used across the Anglian region to investigate catchment management approaches for a further 12 (No.) surface water sources and a further 6 (No.) groundwater sources.

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