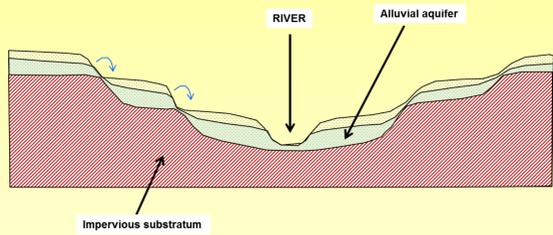


Managing groundwater extraction for irrigation in Tarn-et-Garonne (France)

M. Bardeau.^{(1)*}, P. Le Cointe ⁽²⁾

In France, in one of the watershed districts from the European Water Framework Directive, the Adour-Garonne basin, alluvial aquifers make for strategic water resources thanks to their high productivity, their accessibility and their low providing costs.

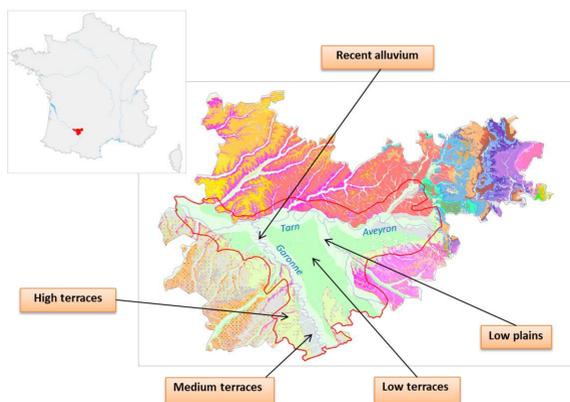
1 These aquifers are closely linked to the rivers and support their low flows.



In Tarn-et-Garonne, alluvial aquifers are highly exploited for agricultural irrigation. Since several decades, lower rainfall has led to more severe low flows, which create conflicts of use.

Historic :

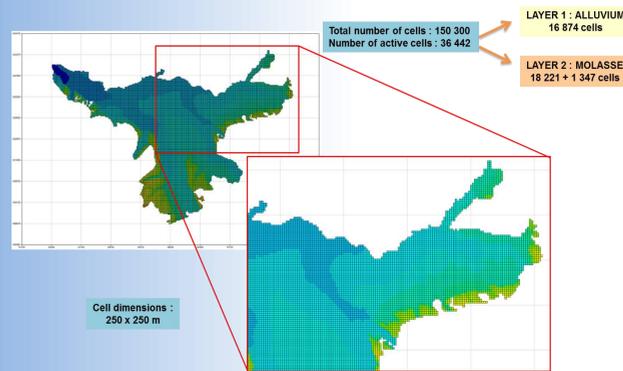
In 1995, the BRGM was asked to build a hydrodynamic model of the alluvial aquifer in Tarn-et-Garonne. 940 km² divided in 5 alluvial terraces crossed by 3 main rivers (Garonne, Tarn and Aveyron) were modeled with MARTHE (BRGM software).



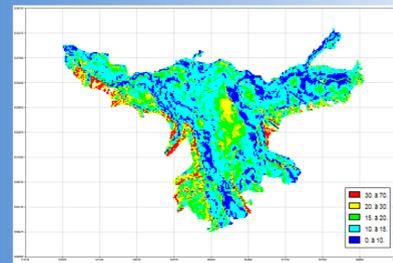
The first model ran in steady state on a 1x1 km grid. The study area was divided in several spatial units and a simplified groundwater extraction management tool with EXCEL was developed. From 1997, DDT has used this tool to manage groundwater extraction for irrigation in each spatial unit. In 2007, the model has been updated to run in transient state with a refined mesh (250x250 m).

2 The last and new model

In 2016, a second update has been launched: the model now has two layers and 36,500 cells; it simulates the water level and flow of 41 rivers in a 20-year span and takes into account 750 agricultural pumping wells.



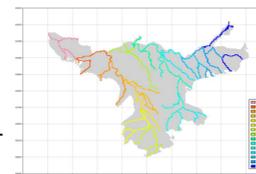
Creation of a geological model



Thickness of alluvium (m)

Construction of the input dataset

- ✓ **Geo-tracking** of agricultural pumping wells. Limit: Hard to assess the pumping flows time distribution.
- ✓ Calculation of **groundwater recharge**: coupling with a rainfall-runoff model (GARDENIA, BRGM). Limit: few data on soil characteristics.



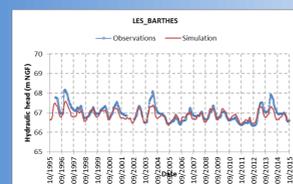
Simulated rivers

Construction of a **dense dynamic river system** – 41 rivers (Manning-Strickler law). Simulations of upstream flows with GARDENIA for 23 rivers.

Simulation of groundwater and river levels and river flows :

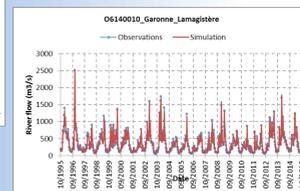
- ✓ Time-step : **Decade (10 days)**,
- ✓ Period **October 1995 to September 2015** (20 years), that is to say 720 time-steps

Validation and water balances

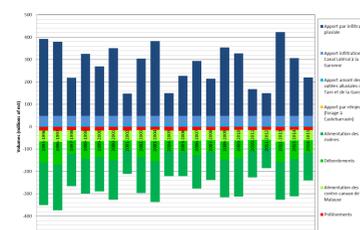


Example of validation for river flows

Example of validation for a piezometer

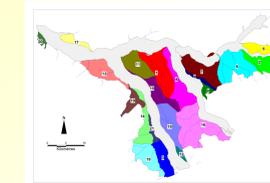


Contribution of different components in the water balance



3 Development of model : creation of a groundwater agricultural extraction management tool

- Goal : Provide organizations responsible for the management of water resources a tool to know actual available groundwater volumes each year and adjust authorized pumping volumes accordingly.
- Methodology :
 - ✓ The alluvial aquifer was cut into 21 hydrogeological compartments, based on geological, hydrogeological and water management criteria.

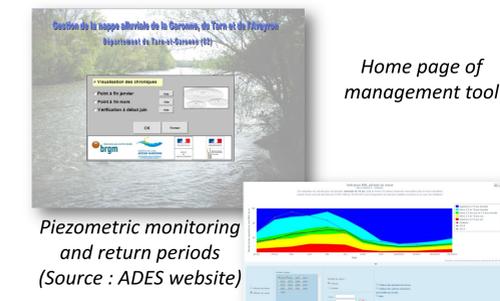


21 hydrogeological compartments

- ✓ The model was then used to calculate the available volumes.
 - 8 climate scenarii ranging from minimum to maximum groundwater recharge ever observed (since 1949) were created.
 - These groundwater recharge scenarii were modeled to estimate, in each compartment, the available volume for each climate scenario.

✓ **Excel management tool:**

- Visualization of the piezometric monitoring in selected wells and computation of the return period of the current water level.
- The tool can be used at 3 different periods (late January, late March and early June) based on management needs and climatic knowledge of the ongoing year.
- For each period, the available groundwater volumes are compared to the requested pumping volumes. If needed, a reduction coefficient is enforced.



Home page of management tool

Piezometric monitoring and return periods (Source : ADES website)



Comparison of available volumes to requested ones

4 CONCLUSIONS

The updated management tool integrates the Allowed Pumping Volume and Unique Authorization Over Several Years notions and the new French legislation with water management driven by "Organismes Uniques" based on watersheds rather than administrative breakdown. A participative forecasting study, combining the scientific approach with the farmers' and the territorial actors' point of view, was also carried out to model the quantitative management of groundwater resources in France around 2020-2035.

(1) m.bardeau@brgm.fr

(2) p.lecointe@brgm.fr