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River flow monitoring in summer

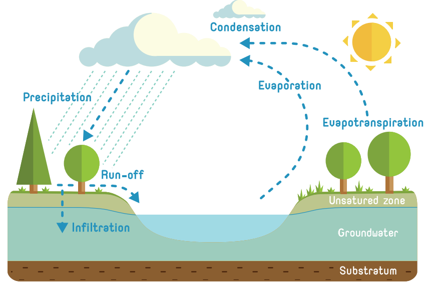
Water levels in rivers drop during the summer time, and the rivers can sometimes dry up altogether. This natural phenomenon called low-flow level is often accentuated by water needs such as drinking water supply, irrigation or watering parks & gardens, at a time when water resources are scarce[1]. How and when do these low-flow levels occur during the summer? Why should this be monitored and how? What variation can be observed over time? Field observations between 2012 and 2016 show that August 2012 and September 2016 were the months where the most rivers dried up, with significant variation across France.

Better understanding of how aquatic ecosystems behave

Low-flow levels[2] in a river are sometimes confused with seasonal low water levels[3], but it would be more accurate to describe them as a phenomenon that exacerbates seasonal low water levels[4]. Low-flow levels should be considered as a limited period in the year during which flow rates fall below a threshold value calculated statistically[5] for each river[6]. The severity of a low-flow level can either be described in terms of duration and intensity, or based on the water volumes that cannot be abstracted from the river.

As for any river flow, low flow results from a series of phenomena that convert and transfer water within the river catchment area. Unlike flash floods, which are fairly fast-moving and short-lived phenomena (lasting between a few hours and a few days), the dynamics that drive natural low flow episodes are much slower and result from hydro-meteorological phenomena that cause a drop in flow rates over several weeks or even months.

In metropolitan France, river flows drop mainly in the summer, with the lowest levels generally reached in late summer or early autumn (August-September). This is caused by various phenomena, including temperature rises, reduced groundwater inflow or abstraction (etc.), which lead to an increase in evapotranspiration.



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1. NOWAK C. & MICHON J., *Onde, un dispositif pour surveiller et comprendre l'assèchement des cours d'eau en été*, Onema, 2016
2. NICOLLE P., PERRIN C. & Al, *Prévoir les étiages, que peut-on attendre des modèles hydrologiques ?*, Onema, 2015
3. Low water refers to conditions in which the water level is at its lowest point over the year, as measured by depth or flow rate. During a low water or low-flow level period, the river fills only its low-water channel.
4. Dacharry, 1996
5. Based on sufficient quantities of data to ensure robust statistical analysis. The most commonly used statistical indicator is the lowest monthly flow rate for any given calendar year (known as QMNA in France). However, it is difficult to take account of all the complex factors relating to low flow with a single variable, whatever this variable may be.
6. Flow rate, high water and low water periods depend on local climate conditions (chiefly precipitation and temperature) and certain characteristics of their river catchment areas (e.g. steepness of slopes, nature of soils and underlying rock layers).

eaufrance
Public water information system

Higher temperatures may be combined with a seasonal decline in rainfall, resulting in smaller quantities of water available for runoff and streamflow. This leads to a drop (depletion) in groundwater and river levels, which can cause more significant low flow conditions, since they last longer. Some processes causing low-flow levels originate in previous seasons (e.g. low rainfall the previous winter, insufficient groundwater recharge) and these long-term causes explain why it is difficult to establish which factors determine the occurrence and severity of low-flow levels[7]. River water abstraction for various uses, such as irrigation, drinking water, power generation and industry, may also have significant consequences on flow rates.

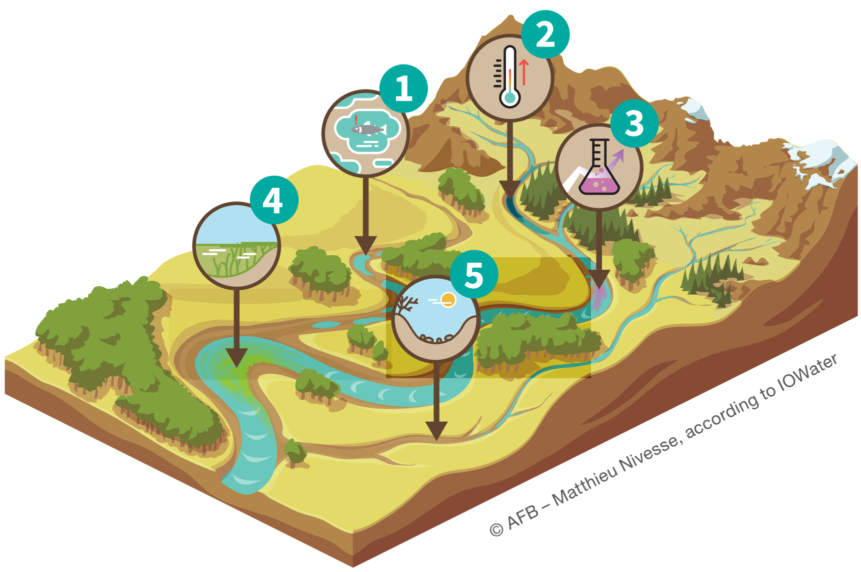
Water deficits cause more problems in small and medium-sized rivers located in upstream parts of catchment areas than in large rivers in the plains, because their small size mean they are more strongly dependent on hydro-climatic conditions (rainfall and temperature). Impacts are context-specific, but some of the main consequences on aquatic habitats and ecosystems are listed below:

1. river fragmentation (breaking of ecological continuity). The low water levels and lack of water may make some natural or man-made obstacles unpassable or remove water connections and thus restrict the travel of mobile organisms such as fish, interrupting their lifecycle at critical periods (e.g. migratory fish species);
2. temperature rises. The lower speed of the stream and the reduced depth of the water body mean that the river is more sensitive to sunlight. Higher temperatures can directly alter the physiology of some aquatic organisms and cause death in the event of significant heat stress[8]; biological equilibria may also be modified (eutrophication, development of cyanobacteria, increased virulence of certain pathogens);
3. changes in the physico-chemical quality of the water. A significant drop in flow rate can restrict the dilution and elimination of pollutants, thus increasing their concentration in some stretches of river[9];
4. changes of aquatic plant life. Low flow rates and higher temperatures can cause large-scale expansion of aquatic plants in the river bed. In extreme conditions, on the other hand (e.g. if the river dries up completely), vegetation may also be totally wiped out;
5. complete dry-out. In extreme deficit conditions, aquatic ecosystems dry out, killing aquatic organisms that have limited mobility such as young fish or some amphibians.

Better understanding of intermittent rivers

Some of France's rivers are intermittent, meaning that they stop flowing or dry up along some or all of their course at certain times of year. These rivers are less well understood than so-called "perennial rivers" and are mainly located in river basin heads. In order to identify them, Irstea[12] carried out a survey to characterize river typology[13] in 2011-2012, based on river flowrates and water levels[14], and extrapolating models to the whole French hydrographic network. Since the monitoring stations used were generally installed on perennial rivers, Irstea's analysis is now being supplemented by including flow observations from the Onde network (its network is well-represented higher up the river basin heads) in the initial models. This will provide further information on the existing river typologies, and should help specify which rivers are "intermittent".

It is vital to monitor these environments and changes to water resources in order to understand how they behave and to protect them. This is one of the roles of the French agency for biodiversity (AFB)[10] as technical coordinator of the French national water information system (SIE). The *national master plan for water data*[11] requires water-related data, including hydrology data, to be organised, produced, collected, stored and disseminated.



7. Delus, 2011.
8. The 2003 heatwave and related events caused the death of a significant number of eels, despite the fact that eels have one of the highest temperature tolerances of any French fish species (lethal temperature: 39°C).
9. This was observed during the 2003 drought and was a factor in disrupting migration (e.g. downstream migration of young alosa, upstream migration of salmon).
10. AFB was established by merging four pre-existing organisations working to protect biodiversity and the quality of marine, aquatic and botanical environments and protected natural areas: the French national agency for water and aquatic environments (Onema), the French agency for marine protected areas (AAMP), National Parks of France (PNF) and the Pole of resources and skills for nature (Aten).
11. Established by Order dated 26 July 2010 approving the French national master plan for water data.
12. French national research institute of science and technology for environment and agriculture.
13. DATRY T., SNELDER T., SAUQUET E., PELLA H., CATALOGNE C. & LAMOUROUX N., *Hydrologie des étiages : typologie des cours d'eau temporaires et cartographie nationale*, Irstea, 2012.
14. The specific stations used in this survey were the hydrometric monitoring stations.

Better water scarcity management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In addition to the impacts on aquatic ecosystems, low-flow levels have significant socio-economic consequences. In France, rivers are the main water supply source for many uses (irrigation, energy, industry, etc.), but are also used for transport and recreational activities. All water abstractions require a declaration or authorisation from the authorities[15]. During low flow periods, these uses are managed in two ways:

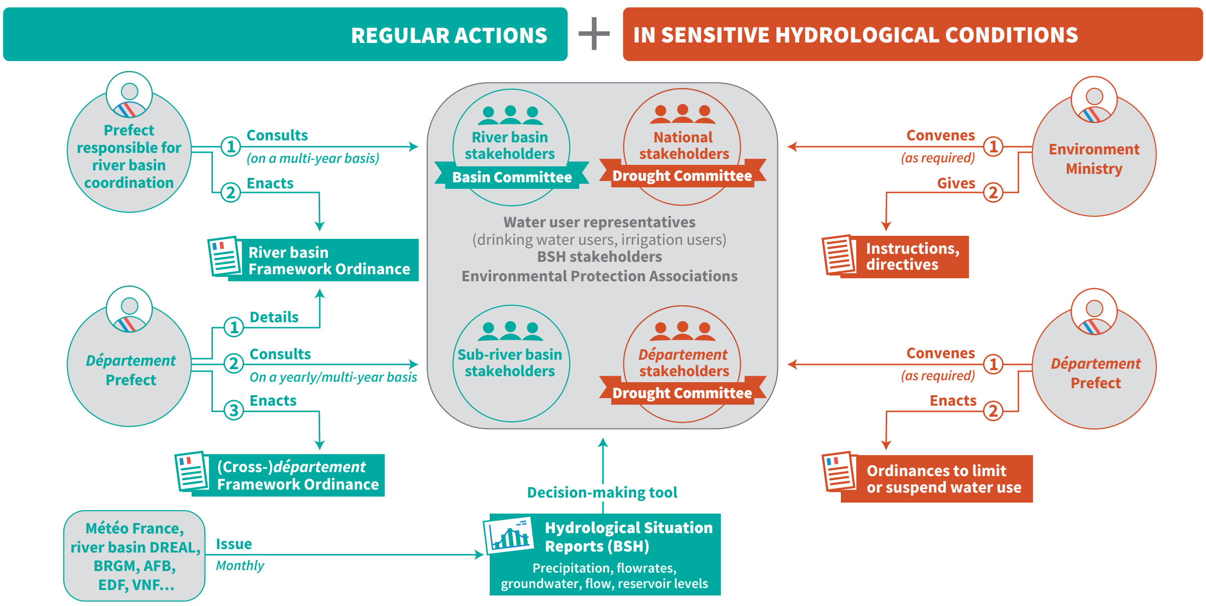
> a structural (or long-term) management strategy based on determining the volume of water that can be abstracted in each area and for each water use, according to the environmental capacity, to ensure that the aquatic ecosystems continue to behave correctly[16];

> an adaptive crisis management strategy: prefects can temporarily suspend water uses during exceptional episodes[17].

It is essential to monitor low-flow levels in order to improve water resource management and reduce the socio-economic and environmental impacts of periods of water scarcity.

The relevant stakeholders – representatives of the French Ministry of the Environment, prefects, public bodies, associations, water user representatives (such as EDF, the French waterways management body, industrial groups or irrigation users) – meet together locally and nationally on specific “Drought Committees”. These committees provide an opportunity to discuss and share information about hydrological conditions. They focus on the consequences of the situation on various water uses and aquatic ecosystems. The Water and Biodiversity Director from the Ministry of the Environment convenes the national committee whenever the hydrological conditions so require, and at least once a year at the end of the water cycle year, in order to review the past year.

When making decisions to restrict water uses, these committees use the *Hydrological Situation Report (BSH)*, which is produced through a collaboration between water data producers to monitor water resources across a given territory (region, river basin or nationwide) in quantitative terms.



15. Article R214-1 of the French Environmental Code.
16. Circular dated 30 June 2008.
17. Pursuant to Article L211-3 of the French Environmental Code, Prefects must enact a multiyear framework ordinance to plan any measures limiting water abstraction by different user groups. Annual water use limitation ordinances must refer to this framework ordinance.

A national observatory to monitor summer low-flow levels

In 2004, the Ministry of the Environment issued a *Drought Action Plan* to mitigate the consequences of hydro-climatic crises such as the 2003 drought and heatwave. The plan had three key focuses: planning for crises, improving crisis management (particularly by improving the way information is gathered and disseminated) and correcting water supply/demand imbalances

At this time, the Higher Council for Fishing (CSP), which had been responsible for monitoring aquatic ecosystems since its establishment in 1948, deployed a national dried out river observation network called "Roca" in order to supplement existing the information proposed to prefects for managing scarcity episodes (flowrates and piezometer measurements). In parallel, some regions, such as the Centre or Poitou-Charentes regions, established local river flow observation networks (called "RDOE") to monitor low-flow level phenomena and identify the river catchment areas that were most severely affected and log historical data in order to create crisis management tools.

In 2006, the French Law on water and aquatic environments[18] established the French national agency for water and aquatic environments (Onema), which was given national responsibility for studies, research and knowledge for monitoring the status of water resources and the ecological behaviour of aquatic environments. Onema therefore took over part of the role that the CSP had previously been playing. In particular, the initial experience from the Roca and RDOE networks (which varied in their effectiveness and usage in each *département*[19]) demonstrated the need to harmonise and improve practices, and especially to develop a new nationwide observatory to monitor low-flow levels, called "Onde".

Onde was first mentioned in a circular[20] on crisis management, and was introduced to definitively replace the Roca and RDOE systems nationwide in 2012. However, some of the exiting monitoring stations used by these former networks were included in the Onde network.

The observatory became one of the missions of the French agency for biodiversity (AFB)[21] when it came into existence on 1 January 2017, with two key objectives. Firstly, it forms a stable network of knowledge on summer low-flow levels:

> it provides information on the hydrological status (for a river or *département*) at a given time or station;

> it can also serve to characterise hydrological phenomena over time, using historical data logs;

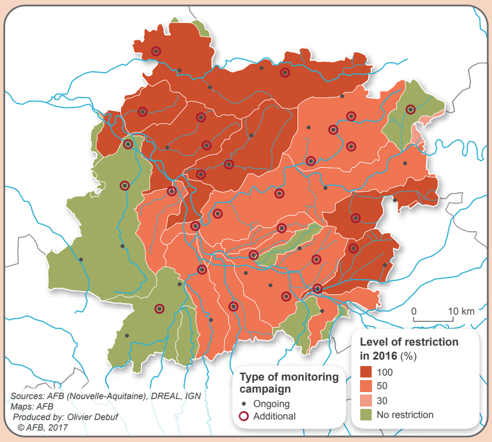
> in the longer term, the historical data logs will contribute to research efforts to help provide a better understanding of relations between groundwater supplies and rivers or links between hydrology and biology (in particular invertebrates and fish). In general, the data collected will help take into account the impacts of climate change on rivers.

The second function of the observatory is to help for anticipating and managing water crisis situations:

> it provides information that the authorities need in order to anticipate and manage water scarcity[22]: field prospection results are presented nationally and locally to drought committees. The threshold values at which water use restrictions are triggered may be determined based on these observations;

> it enhances existing environmental monitoring, providing additional information about areas that are often not equipped with more conventional monitoring stations (quantitative measurement performed according to a predefined protocol[23]).

Decision-making tools for local government organisations



Pursuant to Article L211-3 of the French Environmental Code, every year Prefects must enact a framework ordinance for each *département*[24] to plan any measures limiting water abstraction by different user groups[25]. This requires sound knowledge of the hydrological conditions of rivers at any moment.

In South-Western France, several cross-*département* ordinances (covering the Garonne, Tarn, Aveyron and Lot river sub-basins) or intra-*département* ordinances (Haute-Garonne and Lot-et-Garonne *départements*) explicitly use Onde data. It is the main tool used to understand the hydrological conditions of non-fed rivers (i.e. rivers that don't have an additional water source such as a spring or a groundwater contributions or tributaries to support their streamflow).

In the Lot-et-Garonne *département*, for example, the framework ordinance stipulates that water restriction orders may be based on the river flows observed using the Onde network. If 100% of observations (regardless of the monitoring type) within a river sub-basin[26] show 'low visible' flow, a 50% water restriction is applied. In 2016, 8 river sub-basins out of 24 in the Lot-et-Garonne *département* saw 50% water restrictions applied (and 6 had 100% restrictions).

18. Law 2006-1772 (LEMA) dated 30 December 2006.
19. *Département*: a French geographical and administrative territory, smaller than a region and larger than a municipality.
20. Circular dated 18 May 2011 on exceptional measures to limit or suspend water use during periods of drought.
21. On 1 January 2017, the French agency for marine protected areas (AAMP), the Pole of resources and skills for nature (Aten), the French national agency for water and aquatic environments (Onema) and National Parks of France (PNF) were merged to form the French agency for biodiversity (AFB).
22. Circular dated 18 May 2011 on exceptional measures to limit or suspend water use during periods of drought.
23. As per *Charte qualité de l'hydrométrie*, French Ministry of the Environment, 2017.
24. Cross-*département* Ordinances are sometimes enacted in some territories.
25. Any usage restriction orders issued during the year must refer to the framework order.
26. The relevant river sub-basins are listed in the *Framework ordinance for water management in periods of drought in the Lot-et-Garonne département*, Prefecture, 2015.

Additional evidence to support technical evaluations provided by AFB staff

One of the aims of the Onde network is to improve knowledge of the way rivers behave. Are low-flow levels a frequent and pronounced phenomenon? Do rivers have the capacity to support additional pressures? An improved understanding of these issues helps AFB staff provide evidence in support of the technical evaluations they issue to the local offices of the Ministry of the Environment.

For example, in 2015 in the Loiret *département*, about twenty applications to create substitution reservoirs[27] had been filed for two rivers, Puiseaux and Vernisson. These two tributaries of the Loing river are located in the most fragile part of the Beauce aquifer in terms of natural recharge. The applications included very little information on the reservoir filling capacities[28] and the impact of the planned abstractions on the rivers. The water volumes that could be abstracted from the river in winter periods to fill the reservoirs was calculated only using the monthly flowrates measured at the flow monitoring station[29], located at the main outlet of the river catchment area. These values were then extrapolated[30] to the two tributaries. However, Onde observations on the Puiseaux and Vernisson rivers and their own lateral tributaries, have been used used to analyse how sustainable these flows were and how well the environments might withstand any future water abstraction. The expertise of AFB staff and these additional observations led to a recommendation to move one water abstraction site in order to ensure that an adequate flow remained for the aquatic ecosystems, particularly in an area where the Southern damselfly (a protected species[31]) had been observed.

Two types of monitoring

The flow observation network covers the whole of France. The stations are chiefly located at river basin heads[32], in order to supplement current knowledge on the hydrological behaviour[33] of these ecosystems, since these areas had not been extensively monitored via existing systems. The aim is to monitor summer low-flow levels, both natural phenomena and those exacerbated by human activities. Two types of monitoring can be implemented with the Onde network:

> "ongoing" monitoring to provide a stable baseline of knowledge over time. The same protocol is used right across France for this type of regular monitoring, every month between May and September as near as possible to the 25th of each month (no more than 2 days either side);

> "additional" monitoring, which aims to contribute to managing sensitive situations. This protocol can be triggered at any time of year, across the entire network or a local area network at a frequency determined by local stakeholders (maximum weekly observations in the height of a crisis).

In the field, AFB staff visually assess the river flow level, using three main descriptors:

> "visible flow": water can be seen to be flowing continuously;

> "no visible flow": this means that water is present, maybe in the form of pools, but no streamflow can be seen;

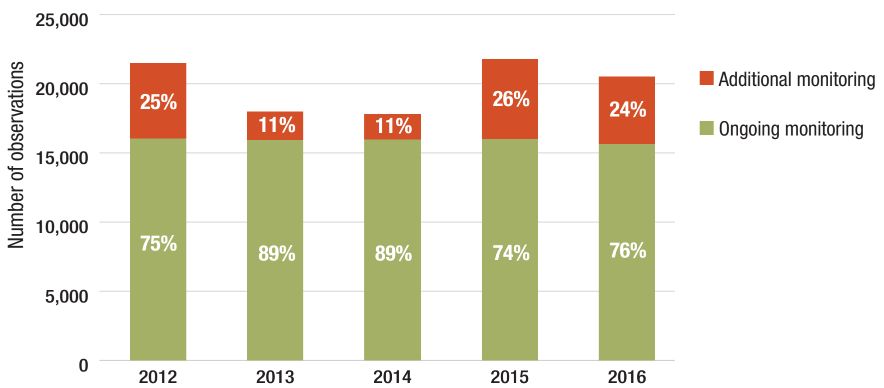
> "dried out": there is no water; it has evaporated or infiltrated into the ground.

One additional descriptor "observation not possible" can be used to report that the observer was unable to make an observation during the visit to the station due to exceptional conditions (e.g. impossible to reach the station).

Over the 2012-2016 period, 99,573 observations were made, of which 79,550 for ongoing monitoring and 20,023 for additional monitoring. This represents an average of 30 observations per station and 1,071 observations per *département*. The number of *départements* that implemented additional monitoring at least once over the course of a year varied year on year. 59 *départements* did so in 2012, 32 in 2013, 26 in 2014, 62 in 2015 and 53 in 2016. 11 *départements* implemented additional monitoring all of these years: Loire-Atlantique, Maine-et-Loire, Vendée and Charente-Maritime in Western France; Ariège, Lot, Lot-et-Garonne, Tarn-et-Garonne, Pyrénées-Atlantiques and Pyrénées-Orientales in South-Western France and Hautes-Alpes in South-Eastern France.

It should be recalled that additional monitoring is triggered as a joint decision by local stakeholders. Additional monitoring highlights the fact that stakeholders are concerned about hydrological conditions. However, the fact that it is not implemented does not necessary give an indication of whether the situation was critical or otherwise.

Proportion of observations per year by monitoring type



27. Man-made reservoirs that can be used to replace water volumes abstracted in low flow periods with volumes abstracted in other periods. Substitution reservoirs store water th [illegible] which would not endanger hydrological, biological and morphological balances.
28. Additional water resources that could feed into the reservoir (by volume).
29. Hydrometric monitoring stations, as per *Charte qualité de l'hydrométrie*, French Ministry of the Environment, 2017.
30. A flowrate value was associated with a value for part of the river catchment area (main drain flowrate was taken as a reference value); a rule of three (cross-multiplication) was then applied between the flow rate at point X and the part of the catchment area.
31. Articles L411-1 and following of the French Environmental Code and pursuant to Ministerial Ordinance dated 23 April 2007.
32. Upstream portion of river catchment areas and by extension the upstream section of rivers, which, in hilly areas in particular, are often less exposed to human pressures than the downstream parts (but still very fragile) and from this point of view are reference sections to be preserved.
33. Hydrological behaviour refers to all water flow pathways and processes within a river catchment area, involving water, soil, vegetation and the atmosphere.

Reading warning

For the purposes of interpretation, the results presented below should be considered in light of the scope of the observation protocol:

> river flow is only assessed visually; no field measurements are taken;

> in the annual national analysis, only observations from the ongoing monitoring programme are taken into account, between May and September throughout France;

> there are no Onde stations in the City of Paris, or in the Seine-Saint-Denis and Hauts-de-Seine *départements*, all of which are predominantly urban areas[34];

> due to short staffing, no campaigns have been carried out in the Eure-et-Loir *département* since 2014. In addition, in some months, observations were not carried out in some *départements* for exceptional reasons[35].

2012-2016: contrasts over time and across France

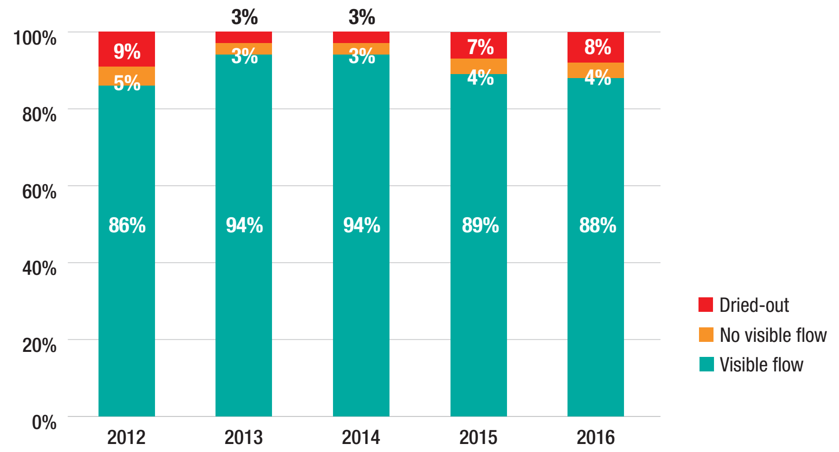
The use of a harmonised observation protocol right across France since 2012 means there is now a set of comparable data over a five-year period. These historical logs give an overview of the hydrological conditions throughout France and the variations observed over this period.

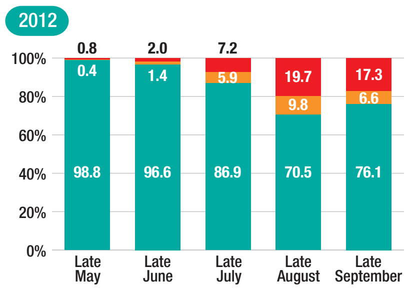
Between 2012 and 2016, the year with the most widespread occurrence of low-flow levels was 2012, when 14% of observations were "dried out" or "no visible flow". 2016 and 2015 were close behind with 12% and 11% such observations respectively. The impact was less severe in 2013 and 2014.

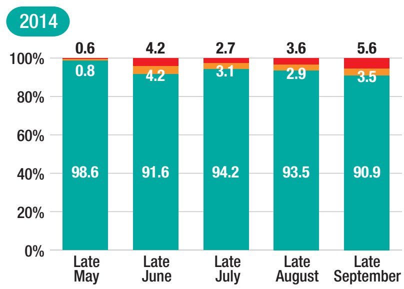
In interpreting these results, it should be remembered that river flow is highly influenced by rainfall conditions, temperature, water abstraction, river flow rates and connections with groundwater supplies.

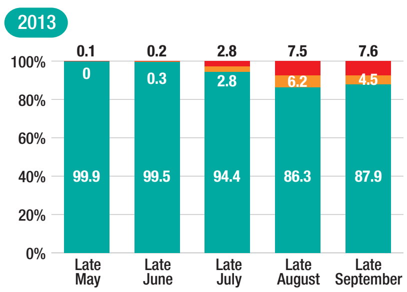
More specifically, in 2012, low flow was accentuated in late July and especially in late August, when 20% of observations listed "dried out" and 10% "no visible flow". The situation in late September showed slight improvement, but many areas remained affected; 24% of observations reported no visible flow. In 2012, May had been a rainy month and the early summer had been fairly cool across the whole country, very wet in the North, but with a rainfall deficit in the South-West and in Lorraine (Eastern France). August 2012 was then dry, hot and sunny[36].

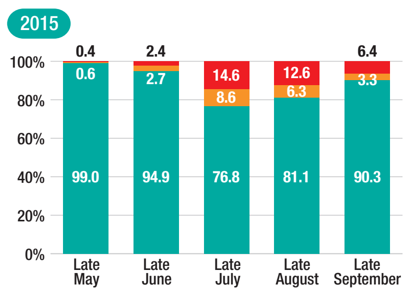
Proportion of observations of each flow condition per year (ongoing monitoring)

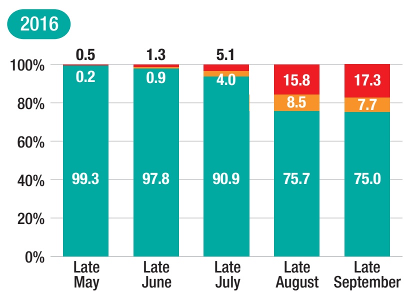












34. For the same reason, the other *départements* around Paris (94, 95, 91, 78) have only 2 to 11 stations. Charente-Maritime and Vienne are also special cases (with 113 and 130 observation stations respectively). These areas had made historic investments in this type of observation, with their local low water observation networks.
35. Missing observation data:
- 2012: Nièvre, Meuse, Seine-Maritime and Puy-de-Dôme (May), Nièvre (June), Morbihan, Sarthe and Nièvre (July), Hérault (September);
- 2013: Calvados and Pyrénées Orientales (May), Essonne and Val-de-Marne (June), Manche and Vendée (August), Corse du Sud, Haute-Corse, Eure, Finistère, Loire-Atlantique, Oise and Haut-Rhin (September);
- 2014: Loire Atlantique (May), Finistère and Hérault (July), Lot-et-Garonne (September);
- 2015: Aude and Seine-et-Marne (June), Tarn (September);
- 2016: Corse-du-Sud, Essonne, Haute-Corse, Indre, Landes, Val-de-Marne and Val d'Oise (May), Cher, Essonne, Manche, Val-de-Marne and Val-d'Oise (June), Essonne, Manche, Val-de-Marne and Val-d'Oise (July), Essonne, Val-de-Marne and Val-d'Oise (August), Essonne, Nord, Val-de-Marne and Val-d'Oise (September).
36. Source: Météo France

Although in 2013, the part of observations reporting "dried out" or "no visible flow" was lower than in 2012, the number of these observations also rose in late July and late August (up to 13%), before dropping off slightly in September. May 2013 was a very rainy and cold month, with little sunshine. This was followed by heavy rain and flooding in the South-West in June, a heatwave in July and stormy weather in August.

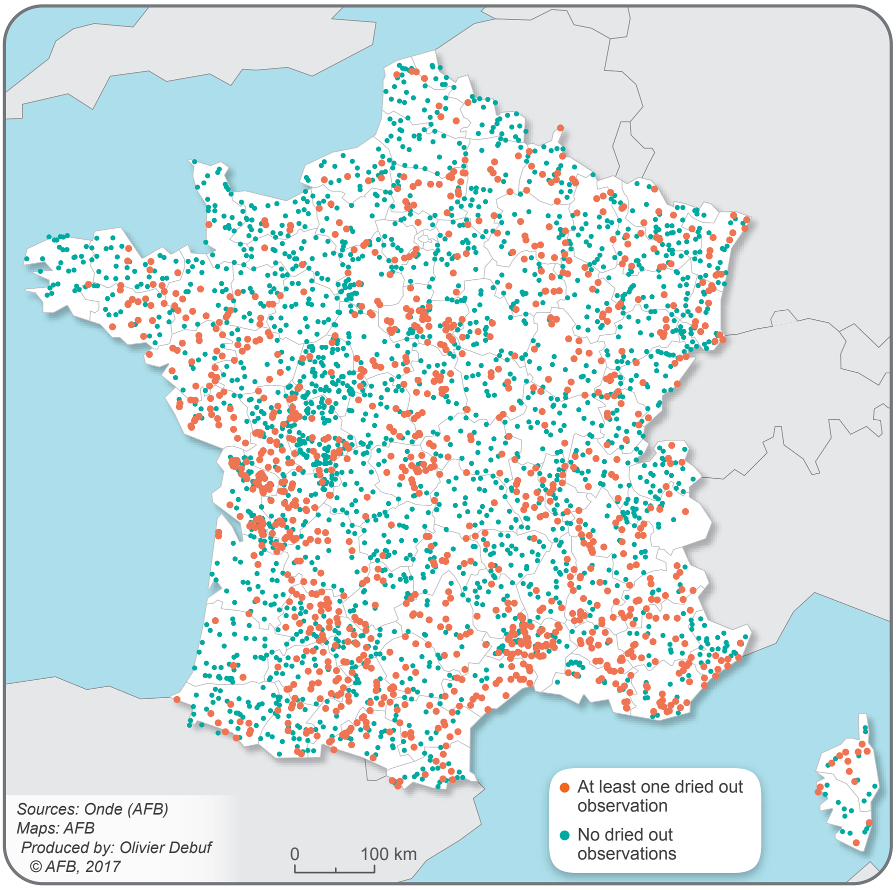
In 2014, conditions had already deteriorated by late June, when 4% of observations reported "dried out" and 4% "no visible flow". The situation improved somewhat in late July, but again by late September, 3% of observations reported "dried out" conditions and 6% "no visible flow". From April to June 2014, there had been a shortage of rainfall and record drought, particularly in North-Eastern France. This was followed by high total precipitation in July and August and intense rain storms in the Mediterranean region in the early autumn.

In 2015, the critical period came in late July, when 15% of observations reported "dried out" and 9% "no visible flow". These proportions started to fall in late August. Although some areas still reported deteriorated conditions in late September, many rivers had recovered a visible flow. There were rainfall shortages early in the year, then high temperatures and soil drought stretching from Limousin in central France to the North-Eastern region from May to July, with a heatwave in July. August 2015 was then cooler and much wetter across much of France (except the North-Est), with intense Mediterranean rainfall episodes in early autumn.

Finally, in 2016, conditions deteriorated month by month, culminating in 16% "dried out" in late August and 17% in late September. Rainfall had been higher than average for most of the country over the first six months of the year, with exceptional rains leading to flooding in Northern France in late May/early June. There was then an unusually late heatwave at the end of August. Other key features were record low rainfall levels from July to September 2016 and record high temperatures in the first fortnight of September.

Over the whole five-year period, the months with the highest proportion of "dried out" and "no visible flow" conditions were late August 2012 (29.5%) and late September 2016 (25%).

Geographical distribution of stations where dry river conditions were observed at least once in the 2012-2016 period (ongoing and additional monitoring)



Of the stations where the river was observed as "dried out" at least once during the 2012-2016, the Atlantic coastline (Brittany and Pays-de-la-Loire), the Western parts of Occitanie, and the Mediterranean coast were most strongly affected.

More specifically, in 2012, 81 of 93 *départements* in which observations were carried out had "dried out" rivers reported. Of these 81 *départements*, 29 had more than 12% of observations that reported "dried out" conditions. Conditions were particularly difficult in the South East (especially Vaucluse, Hautes-Alpes, Gard and Hérault), South-West (Ariège, Haute-Garonne and Lot-et-Garonne) and also in the Charente-Maritime, Loiret, Nièvre and Oise *départements*.

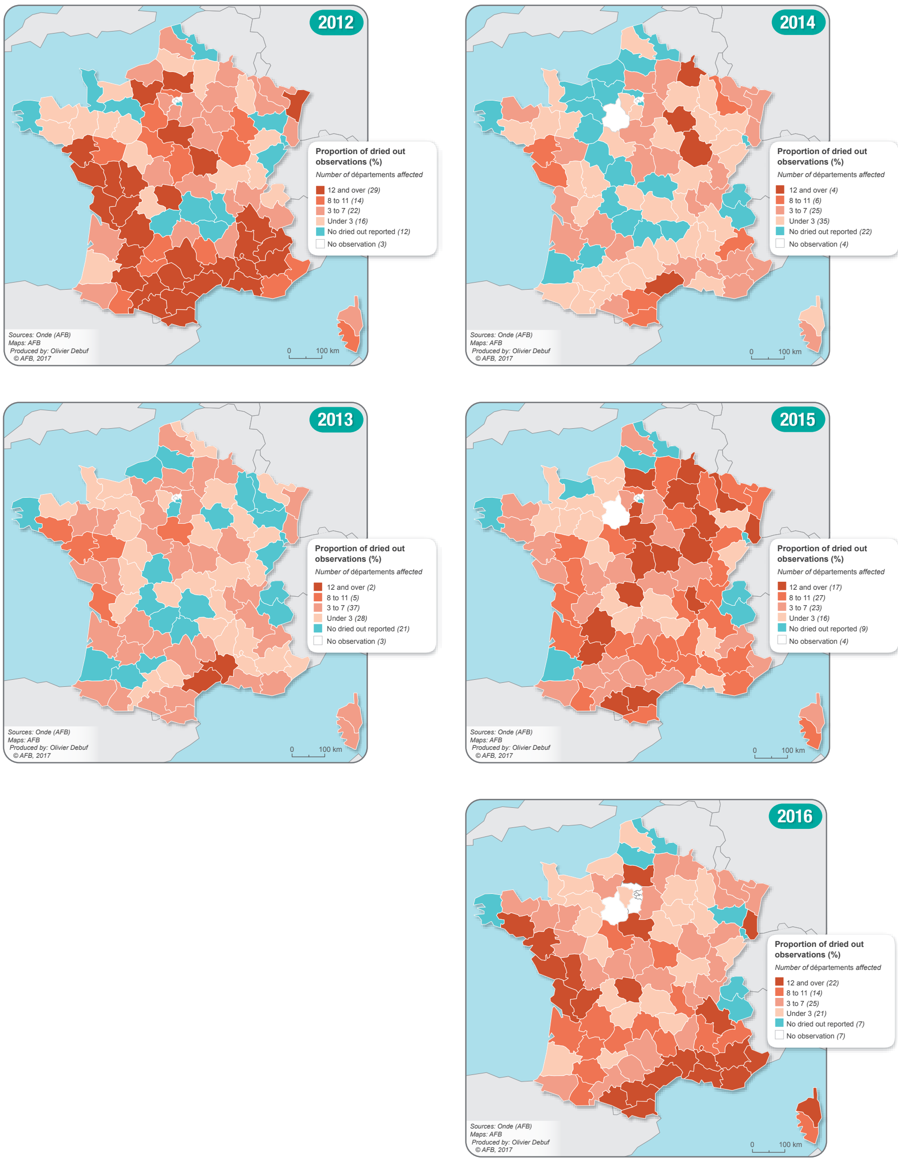
In 2013, the number of *départements* with "dried out" rivers fell to 72, and only two had more than 12% of observations reported as "dried out" (Gard and Hérault).

In 2014, 70 *départements* had "dried out" rivers observed, and only 4 exceeded the 12% mark: Hérault once again and three *départements* in Eastern France, Ardennes, Aube and Côte d'Or.

2015 saw the highest number of *départements* with "dried out" rivers – 83 – including 17 with more than 12% of observations reported as "dried out". The biggest difficulties were in some areas around Paris (Oise, Loiret), South-Western France (Lot-et-Garonne, Ariège and Aude) and in the Creuse and Côte-d'Or *départements*.

In 2016, "dried out" rivers were observed in 82 *départements*, and more than 12% of observations reported as "dried out" in 22 *départements*, chiefly in South-Eastern France (Bouches-du-Rhône, Var, Vaucluse, Alpes-de-Haute-Provence, Alpes-Maritimes, Haute-Corse, Gard and Hérault) and Western France (Vendée, Loire-Atlantique, Charente-Maritime, Charente and Deux-Sèvres).

Territories mapped by proportion of observations reporting "dried out" rivers each year (ongoing monitoring)



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Initial analysis of the duration of low-flow levels

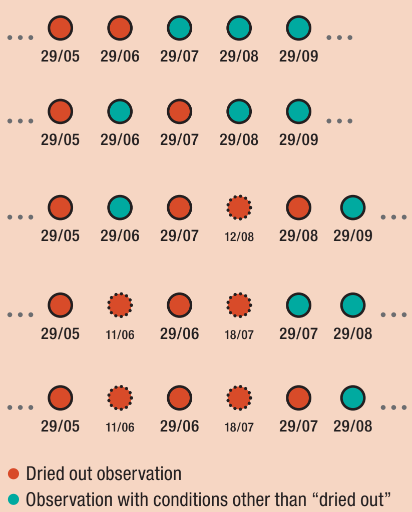
With data available over a five-year period, the duration of low-flow levels can also be explored. Unlike the annual national analysis presented above, which only required data from the ongoing monitoring, both monitoring types (ongoing and additional monitoring) are essential to estimate the duration of low-flow levels. Additional monitoring is mainly triggered under critical hydrological conditions, i.e. when rivers are dry.

The stations considered here are those where at least one period of low-flow levels was reported over the year, regardless of the type of flow monitoring at the start and end of the observation period. Since monitoring is not carried out every day, the exact date at which the dried out conditions started or ended cannot be known. Here, a "duration" is therefore only an estimate. The duration corresponds to the number of days of each low-flow level, i.e. the number of days between the first observation of a "dried out" river and the date at which flow is observed to have resumed at the same station. This information is presented in duration "categories" defined in months, in order to highlight the fact that the observations in question are not performed every day (of a month or year) and also not performed at the same frequency (variation by monitoring type and by station).

This all results in a smaller sample of stations analysed. Depending on the year assessed in the 2012-2016 period, the number of stations represent just 4% to 16% of all stations in the Onde network.

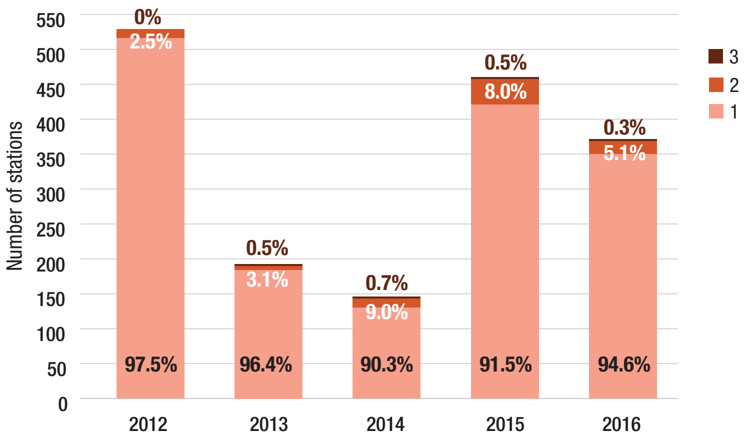
Having presented these limitations for data interpretation, it should be noted the vast majority of selected stations (between 90% and 97% depending on the year) were only affected by a single low-flow level. The highest number of low-flow levels per station was three, and this was found only for one or two stations in any one year[37]. 2014 and 2015 were a little different, with a slightly higher proportion of stations reporting two low-flow levels (9% and 8% respectively)[38].

Examples used to assess the duration of low-flow levels observed (ongoing and additional monitoring)



Episodes	Classe
1 dried out episode of 60 days max.	1 to 2 months
2 dried out episodes each of 30 days max.	0 to 1 month each
2 dried out episodes: first of 30 days max., second of 60 days max.	0 to 1 month for first, 1 to 2 months for second
1 dried out episode of 49-60 days	1 to 2 months
1 dried out episode of 90 days max.	2 to 3 months

Distribution of stations by number of "dried out" river episodes per year (ongoing and additional monitoring)



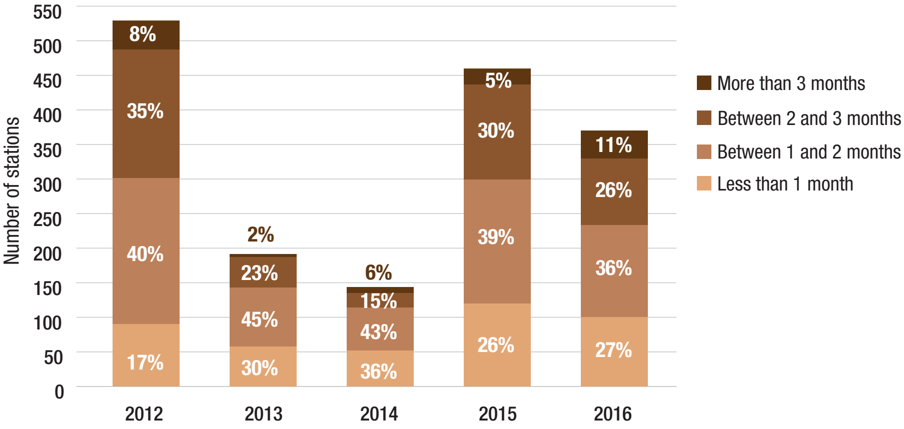
37. One station on the Guirande stream in the Lot *département* in 2013, one station on the Lignée river in Vendée *département* in 2014, two stations in the Creuse *département* (Chantadoux stream and Planches de Mollas stream) in 2015 and one station on the Petite Creuse river in the Creuse *département* in 2016.
38. Regardless of the annual number of observations performed in the period, as described above.

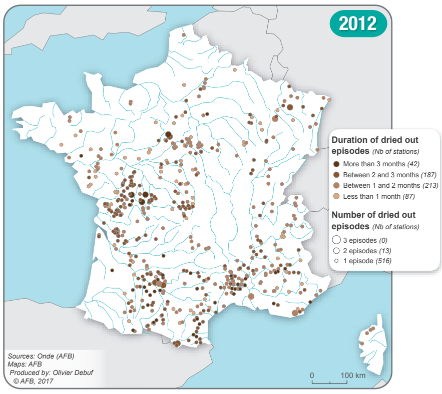
The low-flow levels most frequently lasted one month or two. The proportion of stations with a two-to three-month low-flow levels episode was fairly high in 2012 and 2015, and 2016 was the year with the highest proportion of stations with a longer-than-three-month episode.

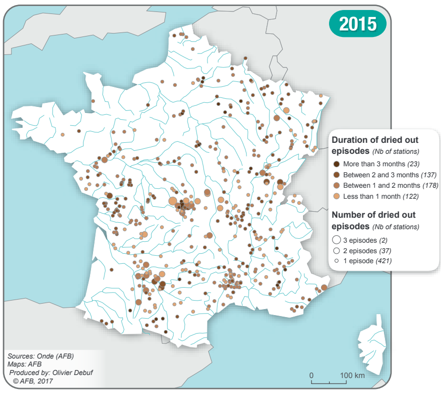
More specifically, the handful of stations with two or three low-flow levels generally saw durations of one to two months.

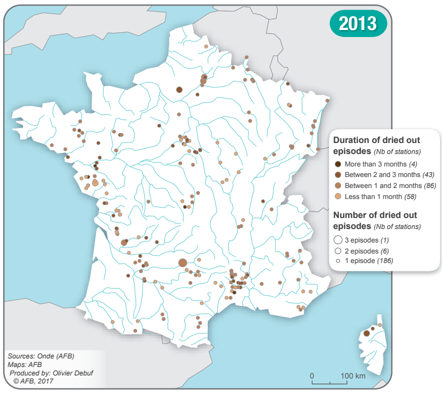
The geographical distribution of stations with such episodes varied fairly significantly year on year. The areas most frequently affected by low-flow levels lasting more than three months were the Mediterranean Coast, the Garonne, Dordogne and Charente river basins and some parts of the Loire and Rhône rivers, particularly in 2012, 2015 and 2016.

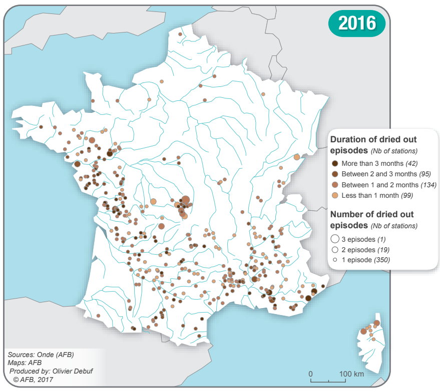
Distribution of stations by duration of low-flow level per year (ongoing and additional monitoring)

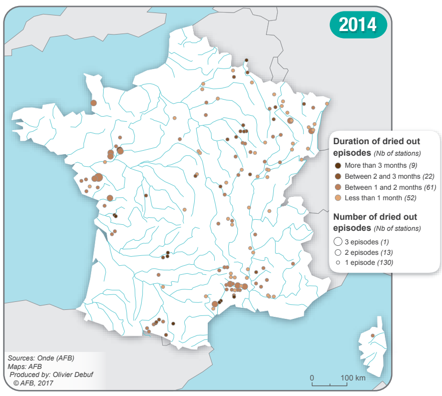












Additional data collection

The data collected via the Onde observatory provides information that is essential for forming a good understanding of aquatic environments and managing water shortages. Given the extent of the French river network, there still remain some stretches of rivers that are not monitored. One option for enhancing the coverage of this type of observation would be to work with voluntary observers[39].

A test is ongoing in 2017 in three pilot regions – Nouvelle Aquitaine, Occitanie and Centre-Val-de-Loire – with various river stakeholders, such as fishing federations, local AFB staff, river technicians and local water management plan coordinators, to test flow information feedback techniques using the river observation methods defined in the Onde protocol, with an additional descriptor "overflow" (for instances of flooding). This test will also provide an opportunity to enhance information on flows with observations on aquatic flora on the riverbanks, in particular certain invasive species.

These additional observations could be reported throughout the year and for all rivers, using a prototype tool to collect data made available to participants. Participants will receive prior training and will be given aids such as tutorials and examples from their first field outing onwards.

After this test phase, any necessary adaptations and improvements will be made to the tools or the way the network is organised. The aim is to deploy this AFB-coordinated project, which is called "En quête d'eau" much more widely in 2018-2019.

En quête d'eau, a citizen science programme

The French agency for biodiversity (AFB) is launching *En quête d'eau*, a new citizen science programme, capitalising on the national observatory to monitor low-flow levels (Onde).

The aim of the project is to improve knowledge of river flows by increasing the number of visual observations. The project seeks to develop a wider network of observers in order to monitor a larger number of rivers over a longer period of time. Tools will be made available to assist observation reporting, thereby increasing the density of river flow data.

The project has also been born out of the AFB's desire to draw in key stakeholders and voluntary contributors, who have an interest in river monitoring, from the project definition phase onwards. This is why a qualitative survey was carried out in late 2016 in order to identify which key features should be included in the 2017 test phase in order to meet the needs and expectations of future contributors.

For more information: **enquetedeau.eaufrance.fr**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39. As part of the citizen science project *"En quête d'eau"*, which can be accessed at enquetedeau.eaufrance.fr.

Note on methods

The figures and map data are taken exclusively from the Onde database. Data for 2012 to 2015 was extracted in June 2016 and data for 2016 was extracted in February 2017. The Onde observatory has been up and running since 2012, storing records of visual observations performed by AFB staff. The results presented only cover Metropolitan France. The system will need to be redesigned to adapt it to overseas territories, where hydrological conditions are different.
The only observations taken into account in national reporting are those made under the ongoing monitoring programme between May and September throughout Metropolitan France. The calculations only include observations that reported "visible flow", "no visible flow" or "dried out". The descriptors "observation not possible" and "no data" were excluded. The proportion of observations reporting "dried out" rivers each year is calculated as the ratio of "dried out" observations to the total number of observations.
For any given year, the estimated number and duration of low-flow levels takes into account, for each year, the stations reporting at least one "dried out" observation (regardless of monitoring type), which had a flow at the start and end of the observation period, in order to determine the probable start and end of the dry period analysed. The duration corresponds to the number of days of each low-flow level, i.e. the number of days between the first observation of a low-flow level and the date at which flow is observed to have resumed at the same station. This information is presented in duration "categories" defined in months, in order to highlight the fact that the observations in question are not performed every day (of a month or year) and also not performed at the same frequency (variation by monitoring type and by station).

For more information

Data on low-flow level observations can be found at:
onde.eaufrance.fr

Hydrological situation reports can be found at:
eaufrance.fr/docs/bsh

Water usage restriction ordinances can be found at:
propluvia.developpement-durable.gouv.fr

Find this document on the Internet at:
www.eaufrance.fr/IMG/pdf/onde_2012-2016_201706_EN.pdf

eaufrance The French water information portal:
www.eaufrance.fr

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