

ROAD RUNOFF WATER: INTEGRATED APPROACH TO OVERCOMING BARRIERS TO WATER REUSE

EAUX DE RUISSELLEMENT DES ROUTES: UNE APPROCHE INTÉGRÉE POUR SURMONTER LES OBSTACLES À LA RÉUTILISATION DE L'EAU

Juline Volpellièr¹

ABSTRACT

The reuse of non-conventional water resources represents a strategic lever for strengthening territorial resilience in response to increasing pressure on water resources. While the reuse of treated wastewater is now governed by a structured regulatory framework in France, Europe, and elsewhere, other potential resources remain largely underexploited, particularly road runoff water collected in stormwater management infrastructure. This road infrastructure network may also provide a complementary territorial framework to conventional urban water reuse systems, particularly in peri-urban, agricultural and wildfire-prone areas where decentralised water resources are increasingly needed.

This paper is based on a prospective study conducted for the Mediterranean Interdepartmental Road Authority (DIRMED) on the valorisation of runoff water collected along the national road no.106 between Nîmes and Alès (Gard, France). The study focuses more specifically on a recently rehabilitated multifunctional road basin, initially designed to treat chronic road-related pollution and contain accidental pollution events.

The originality of the project lies in its position at the interface between several fields that are generally addressed separately: road infrastructure, water policy, agricultural and non-agricultural uses, public health and civil protection. In the absence of a specific regulatory framework applicable to the reuse of road basin water, the study required an integrated approach based on the cross-analysis of existing regulations, consultation with State services and the evaluation of several use scenarios.

The methodology combines a quantitative analysis based on twenty years of climate data, a detailed qualitative characterisation of the water, an analysis of territorial needs (fire defence, urban uses and agricultural irrigation), as well as a techno-economic assessment of different development scenarios. A monitoring campaign initially planned over eight months was extended to a full twelve-month period in order to improve the seasonal representativeness of water quality dynamics. The results show that road runoff water can constitute, under certain technical and organisational conditions, a relevant complementary resource for non-food uses and potentially for agricultural uses. However, feasibility mainly depends on stakeholders' ability to reconcile regulatory requirements, infrastructure governance, territorial acceptability and health responsibilities. The study highlights the value of a territorial and interdisciplinary approach for exploring new water resources adapted to local challenges of water conservation, resilience and climate change adaptation.

Keywords: Non-conventional water resources; Road runoff water; Infrastructure governance; Water conservation; Water conservation.

RÉSUMÉ

La réutilisation des ressources en eau non conventionnelles constitue un levier stratégique pour renforcer la résilience territoriale face à la pression croissante exercée sur les ressources en eau. Alors que la réutilisation des eaux usées traitées est désormais régie par un cadre réglementaire structuré en

¹ BRL Ingénierie, Nîmes, France Email: juline.volpellièr@brl.fr

France, en Europe et ailleurs, d'autres ressources potentielles restent largement sous-exploitées, notamment les eaux de ruissellement routier collectées dans les infrastructures de gestion des eaux pluviales. Ce réseau d'infrastructures routières peut également constituer un cadre territorial complémentaire aux systèmes conventionnels de réutilisation de l'eau en milieu urbain, notamment dans les zones périurbaines, agricoles et exposées aux feux de forêt, où le recours à des ressources en eau décentralisées est de plus en plus nécessaire.

Ce papier s'appuie sur une étude prospective menée pour la Direction interdépartementale des routes de la Méditerranée (DIRMED) sur la valorisation des eaux de ruissellement collectées le long de la route nationale n° 106 entre Nîmes et Alès (Gard, France). L'étude porte plus spécifiquement sur un bassin routier multifonctionnel récemment réhabilité, initialement conçu pour traiter la pollution routière chronique et contenir les incidents de pollution accidentels.

L'originalité du projet réside dans sa position à l'interface entre plusieurs domaines généralement traités séparément : les infrastructures routières, la politique de l'eau, les usages agricoles et non agricoles, la santé publique et la protection civile. En l'absence d'un cadre réglementaire spécifique applicable à la réutilisation des eaux des bassins routiers, l'étude a nécessité une approche intégrée reposant sur l'analyse croisée des réglementations existantes, la consultation des services de l'État et l'évaluation de plusieurs scénarios d'utilisation.

La méthodologie combine une analyse quantitative s'appuyant sur vingt ans de données climatiques, une caractérisation qualitative détaillée de l'eau, une analyse des besoins territoriaux (lutte contre les incendies, usages urbains et irrigation agricole), ainsi qu'une évaluation technico-économique de différents scénarios de développement. Une campagne de surveillance initialement prévue sur huit mois a été prolongée à une période complète de douze mois afin d'améliorer la représentativité saisonnière de la dynamique de la qualité de l'eau. Les résultats montrent que les eaux de ruissellement routier peuvent constituer, sous certaines conditions techniques et organisationnelles, une ressource complémentaire pertinente pour des usages non alimentaires et, potentiellement, pour des usages agricoles. Toutefois, la faisabilité dépend principalement de la capacité des parties prenantes à concilier les exigences réglementaires, la gouvernance des infrastructures, l'acceptabilité territoriale et les responsabilités en matière de santé. L'étude met en évidence l'intérêt d'une approche territoriale et interdisciplinaire pour explorer de nouvelles ressources en eau adaptées aux enjeux locaux de conservation de l'eau, de résilience et d'adaptation au changement climatique.

Mots-clés : Ressources en eau non conventionnelles; Eaux de ruissellement routier; Gouvernance des infrastructures; Conservation de l'eau; Adaptation au changement climatique.

INTRODUCTION

Climate change is increasing pressure on water resources in many Mediterranean territories. More frequent and more intense drought episodes are reducing the resources available for drinking water supply, agriculture and urban uses. In this context, resource diversification is a major strategic challenge. In France, this orientation was reinforced by the Water Plan presented in March 2023, which notably sets ambitious objectives for water conservation and the reuse of non-conventional water resources. Public policies have mainly focused on the reuse of treated wastewater, which is now governed by several European regulations and national texts.

However, other non-conventional resources remain poorly studied, particularly road runoff water collected in stormwater management basins. These structures, initially designed to protect natural environments from chronic and accidental pollution related to road infrastructure, nevertheless represent a potential source of reusable water.

To date, no directly comparable operational references regarding the reuse of road runoff water collected in stormwater management basins have been identified, either in France or internationally. In addition, the absence of a specific regulatory framework applicable to these waters creates technical, health and legal uncertainties.

This paper is based on a prospective study conducted for the Mediterranean Interdepartmental Road Authority (DIRMED) on the valorisation of road basin water along the RN106 between the cities of Nîmes and Alès. The main objective is to assess the regulatory, technical and territorial feasibility of reusing this resource in a context of climate change.

STUDY AREA AND METHODOLOGY

Study area

The study concerns around thirty road basins operated by DIRMED along the RN106 between Nîmes and Alès, in the Gard department in southern France. Particular attention was paid to basin no. 18, which was recently rehabilitated in 2022. This multifunctional structure includes a geomembrane and concrete lining to ensure watertightness. The basin has an area of approximately 1,800 m², a dead storage volume of around 920 m³ and a useful volume of approximately 3,600 m³.

The basin currently performs several functions:

- treatment of chronic pollution by sedimentation and flotation;
- containment of accidental pollution;
- gradual discharge of water to the natural environment.

The study area is subject to increasing water stress, with significant needs related to agricultural irrigation, urban uses and wildfire prevention.

Integrated methodology

The study was structured into five main phases:

1. regulatory analysis;
2. quantitative and qualitative characterisation of the resource;
3. identification of territorial needs;
4. assessment of health, environmental and technical impacts;
5. development of layout and equipment scenarios.

The chosen approach is based on an integrated logic combining hydrological analyses, water quality characterisation, institutional consultation and assessment of potential uses.

Quantitative assessment

The quantitative assessment of the resource was carried out using twenty years of meteorological data from the Cardet and La Rouvière stations located near the basin. The calculations made it possible to estimate:

- the annual volumes collected by the basin;
- the volumes discharged to the natural environment;
- the volumes potentially available for valorisation.
- Two hydraulic compartments were distinguished:
 - the useful volume, which is rapidly discharged after rainfall events;
 - the dead storage volume, which remains stored in the basin.

Simulations were carried out to evaluate different mobilisation scenarios according to storage capacities, collection frequencies and operating constraints.

Water quality assessment

An in-depth qualitative characterisation of the water was carried out as part of the study in order to assess the health and environmental risks associated with its valorisation.

The analysed parameters include in particular:

- physico-chemical parameters;
- suspended solids and turbidity;
- hydrocarbons;
- metals;
- perfluoroalkyl and polyfluoroalkyl substances (PFAS) ;
- microbiological parameters.

A monitoring campaign initially planned over eight months was extended to a full twelve-month period in order to improve the seasonal representativeness of water quality dynamics.

This campaign also aimed to compensate for the absence of historical data available on the quality of road basin water. Territorial needs assessment Potential needs were assessed through discussions with local authorities, the Gard departmental fire and rescue service (SDIS 30) and agricultural stakeholders. The main identified uses are:

- wildfire defence;
- irrigation of green spaces;
- street cleaning;
- hydrocleaning of sewerage networks;
- agricultural irrigation.

Regulatory and governance analysis.

The study required a cross-analysis of several regulatory frameworks:

- regulations relating to treated wastewater reuse;
- Environmental Code;
- Public Health Code;
- regulations relating to road infrastructure.

Discussions were held with several State services, including the DDTM, ARS, DREAL, the Water Agency and CEREMA.

RESULTS

Resource availability

The hydrological analysis shows that basin no. 18 collects significant volumes throughout the year. The average annual useful volume discharged by the basin is estimated at approximately 38,000 m³/year. However, the very rapid nature of this discharge strongly limits the possibilities for direct valorisation.

Table 1: Sum of useful volumes treated by the basin and discharged to the natural environment month by month over the last 20 years (in m³)

Year / Month	January	February	March	April	May	June	July	August	September	October	November	December	ANNUAL TOTAL
2003	1 085	1 192	726	3 685	618	0	0	1 620	5 517	6 173	11 097	9 662	41 375
2004	1 921	2 438	3 663	4 820	861	90	0	1 804	1 927	10 920	2 325	1 864	32 633
2005	73	266	279	2 834	1 745	617	0	0	17 975	5 831	2 620	192	32 432
2006	6 608	590	4 178	678	1 048	0	1 267	1 341	7 676	3 649	7 221	1 835	36 091
2007	631	1 884	883	1 944	7 951	4 275	0	0	2 286	1 231	5 958	558	27 602
2008	6 221	2 636	1 219	4 712	8 546	3 708	1 334	2 488	579	9 483	8 230	11 087	60 241
2009	3 654	5 868	2 958	5 898	643	1 756	688	1 164	584	6 599	1 028	6 236	37 077
2010	2 777	8 110	5 019	1 979	5 520	2 408	0	2 100	16 928	11 419	3 701	5 877	65 838
2011	2 787	1 041	8 932	902	321	1 980	2 096	4 066	4 123	2 723	11 088	257	40 314
2012	69	0	52	6 166	4 343	685	1 892	2 007	3 885	3 894	4 069	1 724	28 785
2013	2 680	806	9 646	2 854	2 959	1 174	4 599	2 529	3 041	7 420	2 258	3 391	43 357
2014	7 615	6 150	685	585	702	3 069	4 907	2 378	14 182	13 313	12 698	1 486	67 771
2015	3 558	1 634	1 747	5 847	152	2 583	0	2 631	5 947	9 787	2 036	1 307	37 230
2016	1 336	4 707	1 135	3 254	4 010	1 207	1 031	480	5 313	10 190	5 214	1 894	39 771
2017	3 069	2 122	5 946	2 319	1 530	460	0	0	0	0	4 193	562	20 201
2018	9 127	2 939	7 230	4 946	6 195	2 956	772	3 487	0	6 595	9 668	837	54 753
2019	1 289	1 138	274	4 880	2 065	909	235	0	2 357	5 200	7 141	1 660	27 149
2020	2 100	544	996	3 008	2 341	758	0	1 873	3 537	1 438	2 505	5 975	25 074
2021	612	3 285	50	2 988	3 356	3 009	876	921	4 859	9 033	2 057	1 346	32 391
2022	42	1 586	3 656	1 641	97	0	0	3 972	8 009	5 246	3 442	4 637	32 328
2023	957	1 194	863	288	3 586	4 623	0	0	1 862	8 824	1 403	1 616	25 216
Monthly average	2 772	2 387	2 864	3 154	2 790	1 727	938	1 660	5 266	6 617	5 236	3 048	
Volume discharged on average 4 years out of 5	619	677	441	1 198	628	238	0	0	1 095	3 093	2 138	672	

TOTAL	807 629 m³
Min (annual)	20 201 m ³
Max (annual)	67 771 m ³
Average (annual)	38 459 m³

Table 2: Monthly useful volume recoverable with intermediate storage of 120 m³ and a weekly collection frequency (in m³)

Year / Month	January	February	March	April	May	June	July	August	September	October	November	December
2003	120	174	240	240	208	0	0	120	240	240	480	273
2004	480	165	123	240	240	90	0	360	120	360	120	480
2005	67	120	120	360	247	120	0	0	120	246	240	162
2006	240	240	121	150	130	0	120	240	240	360	295	240
2007	112	240	186	240	240	360	0	0	120	360	120	147
2008	360	243	125	360	360	240	240	142	120	240	385	240
2009	446	121	120	360	240	240	120	120	120	240	327	281
2010	395	240	360	360	240	240	0	240	240	243	240	360
2011	240	360	120	240	120	180	240	240	360	120	360	180
2012	69	0	52	360	360	240	120	0	272	120	296	360
2013	240	333	360	230	360	240	240	240	188	360	240	120
2014	434	293	240	120	120	240	264	240	240	362	480	340
2015	120	293	360	120	122	120	0	240	240	360	269	360
2016	480	240	211	480	338	240	205	240	120	360	240	260
2017	177	240	360	120	360	120	0	0	0	0	183	148
2018	480	240	360	240	360	360	120	240	0	240	360	360
2019	120	120	120	240	370	240	120	0	179	360	360	360
2020	360	120	309	120	240	120	0	240	360	240	240	278
2021	240	331	50	120	360	167	240	224	195	360	360	240
2022	42	120	240	285	97	0	0	120	360	213	480	385
2023	240	132	360	179	293	360	88	0	120	120	366	246
Average	260	208	216	246	257	187	101	155	188	262	307	277
Volume 4 years out of 5	115	120	120	120	125	102	0	0	120	157	240	169

TOTAL	807 629 m³
Min (annual)	20 201 m ³
Max (annual)	67 771 m ³
Average (annual)	38 459 m³

Table 2: Monthly useful volume recoverable with intermediate storage of 120 m3 and a weekly collection frequency (in m3)

Year / Month	January	February	March	April	May	June	July	August	September	October	November	December
2003	120	174	240	240	208	0	0	120	240	240	480	273
2004	480	165	123	240	240	90	0	360	120	360	120	480
2005	67	120	120	360	247	120	0	0	120	246	240	162
2006	240	240	121	150	130	0	120	240	240	360	295	240
2007	112	240	186	240	240	360	0	0	120	360	120	147
2008	360	243	125	360	360	240	240	142	120	240	385	240
2009	446	121	120	360	240	240	120	120	120	240	327	281
2010	395	240	360	360	240	240	0	240	240	243	240	360
2011	240	360	120	240	120	180	240	240	360	120	360	180
2012	69	0	52	360	360	240	120	0	272	120	296	360
2013	240	333	360	230	360	240	240	240	188	360	240	120
2014	434	293	240	120	120	240	264	240	240	362	480	340
2015	120	293	360	120	122	120	0	240	240	360	269	360
2016	480	240	211	480	338	240	205	240	120	360	240	260
2017	177	240	360	120	360	120	0	0	0	0	183	148
2018	480	240	360	240	360	360	120	240	0	240	360	360

2019	120	120	120	240	370	240	120	0	179	360	360	360
2020	360	120	309	120	240	120	0	240	360	240	240	278
2021	240	331	50	120	360	167	240	224	195	360	360	240
2022	42	120	240	285	97	0	0	120	360	213	480	385
2023	240	132	360	179	293	360	88	0	120	120	366	246
Average	260	208	216	246	257	187	101	155	188	262	307	277
Volume 4 years out of 5	115	120	120	120	125	102	0	0	120	157	240	169

The simulations nevertheless show that the installation of intermediate storage would make it possible to recover part of this volume. Based on the selected assumptions, approximately 55,000 m³ could theoretically be mobilised over twenty years of simulation. The dead storage volume appears particularly interesting for valorisation.

The dead storage volume appears particularly interesting for valorisation.

Table 3: Monthly average dead storage volume (in m³)

Year / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	513	917	905	891	845	677	572	758	849	906	922	921
2004	920	913	902	903	839	755	517	861	838	897	899	921
2005	918	904	867	902	878	771	485	350	826	904	918	913
2006	919	915	906	863	857	545	585	800	840	917	915	920
2007	918	920	870	858	874	854	574	476	636	910	905	920

Year / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	920	918	902	899	907	822	820	778	868	902	920	920
2009	920	908	876	915	836	809	775	795	748	896	917	921
2010	920	920	914	903	885	888	558	823	874	908	919	919
2011	911	910	892	873	865	840	777	863	875	837	917	911
2012	897	881	836	900	905	866	774	650	898	894	918	916
2013	914	912	915	899	903	806	843	769	822	914	915	901
2014	922	917	887	866	825	842	902	878	876	919	921	920
2015	916	919	912	870	810	736	365	710	887	914	907	922
2016	921	915	913	905	897	860	803	849	788	916	917	916
2017	913	913	908	848	867	757	681	542	356	556	885	918
2018	919	916	914	892	912	870	768	859	625	840	920	915
2019	897	887	841	901	891	859	724	515	753	904	920	917
2020	912	908	898	854	836	796	660	847	883	910	916	920
2021	915	917	859	836	884	842	863	790	880	892	916	919
2022	916	892	896	882	778	554	402	559	897	902	922	922
2023	917	918	916	876	900	883	637	219	651	896	918	920

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Minimum	866	833	755	725	582	339	83	0	285	414	632	868
Maximum	923	923	923	923	923	923	923	923	923	923	923	923
Average	915	910	892	883	866	792	671	700	794	882	915	918

Table 4: Monthly evolution of the dead storage volume over the last 20 years (in m³)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Number of values per month	651	593	651	630	651	630	651	651	630	651	630	651
Number of values > 462 m ³	635	593	651	630	651	612	538	548	566	641	630	651
% of values > 462 m ³	98%	100%	100%	100%	100%	97%	83%	84%	90%	98%	100%	100%
Number of values > 612 m ³	633	593	651	630	647	565	435	455	521	629	630	651
% of values > 612 m ³	97%	100%	100%	100%	99%	90%	67%	70%	83%	97%	100%	100%
Number of values > 900 m ³	574	481	374	302	260	155	91	116	213	433	578	627
% of values > 900 m ³	90%	81%	57%	48%	40%	25%	17%	21%	38%	68%	92%	96%

The statistical analyses show that a available volume greater than 460 m³ remains available for most of the year, including during summer periods. This volume corresponds to the upper half of the basin dead storage volume (total dead storage capacity: approximately 920 m³), as DIRMED required that a permanent residual storage volume be maintained within the basin and that the dead storage should not be fully depleted for operational and environmental reasons.

This permanent availability is an important advantage for uses requiring rapid response, particularly firefighting.

Table 5: Summary of water quality analyses with sample classification according to French regulations on treated wastewater reuse

Parameters	Full analysis #0 31/07/2024	Full analysis #1 09/07/2025	Restricted analysis #1 23/07/2025	Full analysis #2 05/08/2025	Restricted analysis #2 19/08/2025	Full analysis #3 05/09/2025	Restricted analysis #3 17/09/2025	Full analysis #4 06/10/2025	Full analysis #5 04/11/2025	Full analysis #6 05/12/2025	Full analysis #7 07/01/2026	Full analysis #8 03/02/2026	Restricted analysis #4 20/03/2026	Restricted analysis #5 02/04/2026	Restricted analysis #6 06/05/2027
Sample classification according to REUSE ² regulations	D	C	D	B	B	C	non-compliant due to helminth egg >1	B	B	C	A	B	A	B	B
Microbiological analyses	D	C	D	B	B	C	C	B	B	C	A	B	A	B	B
Parasitological analyses	ok	ok	ok	ok	ok	ok	non-compliant	ok	ok	ok	not measured	ok	ok	ok	ok
Physico-chemical analyses	A		A			A	A	A	A	A	A	A	A	A	A
Metals PAHs PFAS	Below thresholds	Below thresholds	Not measured	Below thresholds	Not measured	Below thresholds	Not measured	Below thresholds	Below thresholds	Below thresholds	Below thresholds	Below thresholds	Not measured	Not measured	Not measured
HAP															
PFAs															

Quality	A	B	C	D	out of classification
15 samples	2	7	3	2	1

2 French Government. 2023a. Decree of 29 August 2023 on Uses and Conditions for the Use of Rainwater and Treated Wastewater. Official Journal of the French Republic, France.
French Government. 2023b. Order of 14 December 2023 on the Production and Use of Treated Wastewater for Irrigation of Green Spaces. Official Journal of the French Republic, France.
French Government. 2023c. Order of 18 December 2023 on the Production and Use of Treated Wastewater for Crop Irrigation. Official Journal of the French Republic, France.

Water quality assessment

The analyses carried out show physico-chemical quality that is broadly compatible with several non-food uses, subject to appropriate additional treatment. Concentrations of hydrocarbons, metals and PFAS remained low during the monitoring campaigns. However, microbiological contamination was observed, requiring the implementation of disinfection treatments for certain uses.

The results also show strong temporal variability in quality parameters, confirming the importance of monitoring over a long and representative period. However, the absence of a specific regulatory reference framework applicable to road basin water makes the interpretation of the results more complex. The existing regulatory thresholds for treated wastewater reuse were therefore used as comparison criteria to assess potential compatibility with different uses.

Technical feasibility and development scenarios

Several valorisation scenarios were studied. For the dead storage volume, different solutions were considered:

- a filtering sump integrated into the basin;
- an external underground tank;
- direct pumping from the basin.

For the useful volume, a scenario based on external intermediate storage was studied. The proposed solutions include:

- mechanical filtration systems;
- disinfection treatments;
- collection protocols;
- maintenance and operating constraints.

The techno-economic analyses show that feasibility depends strongly on operating conditions and on the governance established between the different stakeholders.

Regulatory and governance barriers

One of the main lessons of the study concerns the absence of a specific regulatory framework applicable to the valorisation of road runoff water.

The texts currently in force on the reuse of treated wastewater do not explicitly cover this resource. The project is therefore located at the interface of several regulatory frameworks without clearly falling within any one of them. This situation requires close consultation with State services in order to define:

- the responsibilities of the stakeholders;
- health monitoring procedures;
- authorisation conditions;
- monitoring protocols.

The discussions held with the administrations showed that governance and responsibility issues represent barriers at least as significant as technical constraints.

DISCUSSION

The study highlights the potential of road infrastructure as a new source of non-conventional water resources. Unlike conventional reuse approaches centred on wastewater treatment plants, this approach is based on the valorisation of existing structures initially designed for environmental and

hydraulic functions. This multifunctional infrastructure approach appears particularly relevant in a context of climate change and land-use efficiency. The study also highlights the limitations of current regulatory frameworks. Regulations relating to treated wastewater reuse were mainly designed for treated wastewater from wastewater treatment plants. They do not take into account hybrid resources such as road runoff water.

In practice, project developers must therefore build solutions at the intersection of several regulatory frameworks, in close consultation with health and environmental authorities. A territorial approach appears essential to ensure project feasibility. Potential uses, operating constraints, social acceptability and stakeholder responsibilities must be considered in a coordinated manner. The study also shows that technical constraints are not necessarily the main barrier. Some important risk mitigation measures are already inherently integrated into the infrastructure design, including the secured and fenced configuration of the site and the controlled access to the basin.

For non-food uses, the treatment solutions considered remain relatively simple. However, the management of accidental pollution events remains a key issue that still requires specific operational protocols and governance arrangements in order to ensure safe reuse practices. Finally, the transferability of the methodology is an important point. Although the results obtained are specific to the basin studied, the methodology developed can be replicated on other road infrastructures with similar stormwater management structures.

CONCLUSION

This work shows that road runoff water collected in multifunctional basins can constitute an interesting complementary resource in territories subject to increasing water stress. The study shows that an integrated approach combining hydrological analysis, health characterisation, institutional consultation and territorial assessment makes it possible to explore new forms of valorisation of non-conventional water resources. The results show that certain non-food uses appear technically feasible, subject to appropriate treatment and a clearly defined governance framework. However, the main challenges relate less to technical aspects than to regulatory, health and organisational issues. The future development of this type of project will therefore require:

- clarification of regulatory frameworks;
- consolidation of scientific knowledge;
- implementation of appropriate monitoring protocols;
- coordinated governance between infrastructure managers, local authorities and State services.

Beyond the case study, this approach opens broader perspectives regarding the diversification of water resources and the adaptation of infrastructure to the challenges of climate change.

Beyond the present case study, the approach opens broader perspectives regarding both the diversification of water resources and the adaptation of existing infrastructure to climate change challenges.

Following the results of this study, DIRMED is already considering the replication of similar reuse schemes on other road stormwater basins within its network, with a longer-term perspective of extending this approach to other French road authorities. However, each site remains highly context-specific and requires a dedicated feasibility assessment taking into account local hydrological, technical, sanitary and territorial conditions.

At this stage, the economic model has not been developed from a financial profitability perspective, as the objective is not to commercialise the resource. Rather, the approach should be understood through a broader territorial and economic perspective, including avoided costs, resource preservation, resilience benefits and support to public-interest uses such as wildfire prevention.

REFERENCES

- ANSES. n.d. Reusing Non-potable Water. French Agency for Food, Environmental and Occupational Health & Safety (ANSES), France.
- CEREMA. 2021. Qualification and Characterisation of Chronic Road Pollution. CEREMA, France.
- Eaufrance. 2023. Guide to the Assessment of the Status of Continental Surface Waters, 4th Cycle. Eaufrance, France.
- European Parliament and Council. 2020. Regulation (EU) 2020/741 on Minimum Requirements for Water Reuse. Official Journal of the European Union.
- French Government. 2015. Order of 21 July 2015 on Wastewater Treatment Systems and Stormwater Collection Systems. Official Journal of the French Republic, France.
- French Government. 2022. Order of 30 December 2022 Amending the Order of 11 January 2007 on Quality Limits and Reference Values for Raw Water and Water Intended for Human Consumption. Official Journal of the French Republic, France.
- French Government. 2023a. Decree of 29 August 2023 on Uses and Conditions for the Use of Rainwater and Treated Wastewater. Official Journal of the French Republic, France.
- French Government. 2023b. Order of 14 December 2023 on the Production and Use of Treated Wastewater for Irrigation of Green Spaces. Official Journal of the French Republic, France.
- French Government. 2023c. Order of 18 December 2023 on the Production and Use of Treated Wastewater for Crop Irrigation. Official Journal of the French Republic, France.
- French Government. n.d. Environmental Code, Article R214-1. France.
- Météo-France. 2026. Public Data API Portal. Météo-France, France.
- SETRA. 2007. Road-origin Pollution: Design of Water Treatment Facilities — Technical Guide. Service d'Études Techniques des Routes et Autoroutes (SETRA), France.