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*Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment*

# *Monitored and Intentional Recharge (MIR). A conceptual model to draft water quality regulations for Managed Aquifer recharge (MAR) and water reuse.*

## *Intensive observation as a key to achieve water quality improvement.*

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(Tragsa Group - IAH MAR Commission)

*2023 January 18th*

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# INTRODUCTION

**Monitored and Intentional Recharge (MIR)** conceptual model:

- MIR provides a basis to formulate **MAR guidelines** applied to specific **environmental conditions** that generally conform to each country´s regulations.
- MIR proposes a **set of blocks** establishing a framework for MAR implementations with a high **technical guarantee** of success.
- Due to intense and planned **monitoring**, the MIR concept and its methodology are **key for water quality and security**.

***MIR is a conceptual model to draft MAR guiding documents***

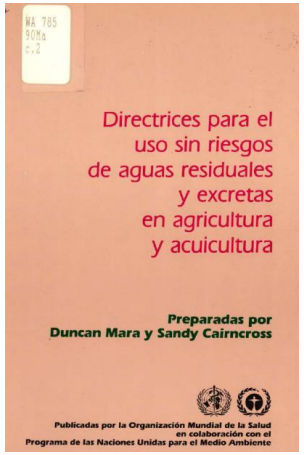
# METHODOLOGY

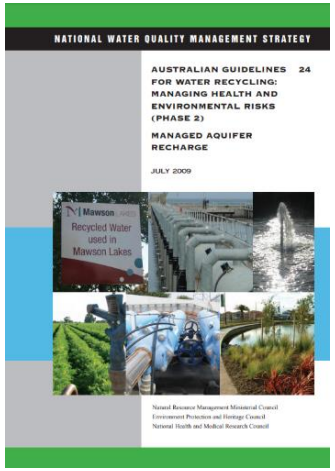
Review of **22 existing regulations and guidelines** on water reuse and MAR:

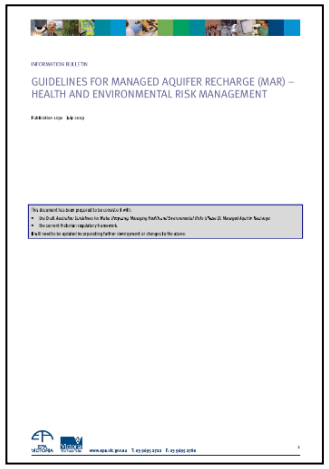
- European Union
- WHO
- USA
- Chile
- Australia

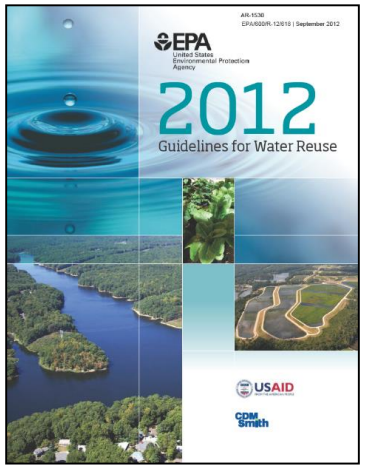
…

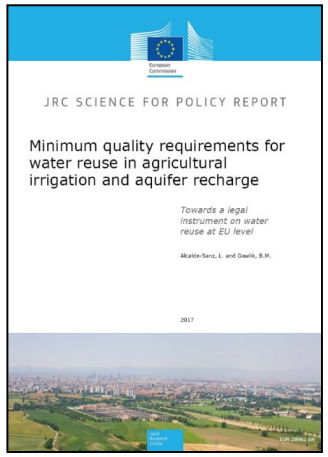
Special attention to monitoring guidelines and **risk/impact**-based analyses.

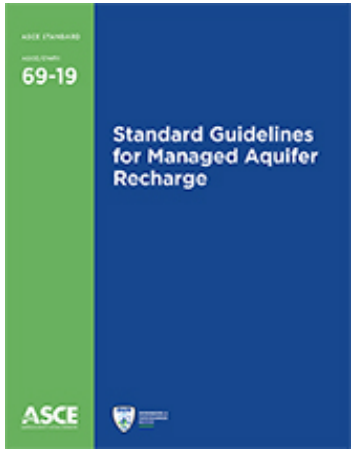


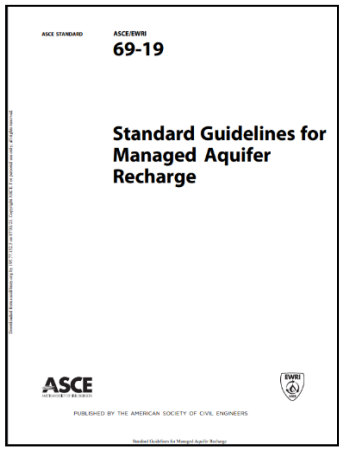



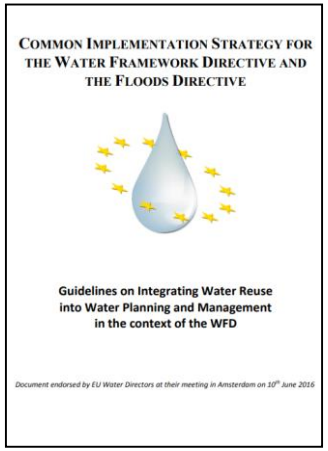



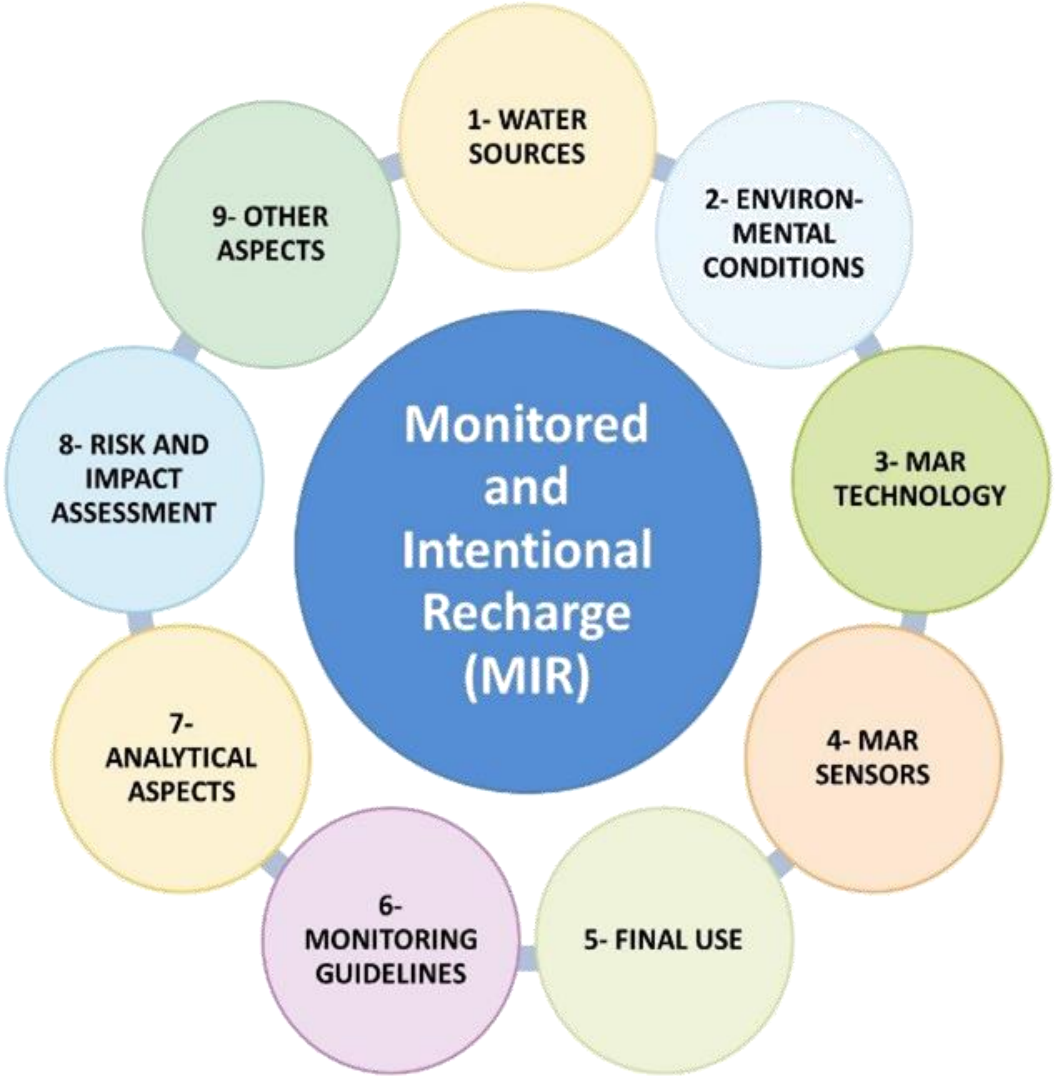
# METHODOLOGY (2)

1. Selection of most important **aspects**
2. Scoring based on the **level of development** in the document
3. Final **score**

| Group | Aspect | Score |
|---|---|---|
| General context | Wastewater reuse, including water sources and final uses | 28 |
| Risk and impact assessment | Health protection | 27 |
| MAR planning | Review of policy and legal framework | 24 |
| Operation aspects | Monitoring and pilot testing | 24 |
| Receiving medium | Groundwater source protection | 22 |
| Risk and impact assessment | Agriculture supply protection | 22 |
| Risk and impact assessment | Risk assessment | 21 |
| Risk and impact assessment | maximum allowable concentration (MACs) list | 21 |
| MAR planning | MAR system design and characteristics | 20 |
| General context | Definition of terms | 19 |
| Social aspects | Water management framework, including entities and their duties | 19 |
| Financial issues | Funding/financial issues/costs | 18 |
| Risk and impact assessment | Dependent ecosystems protection | 18 |
| Receiving medium | Recharged water—unsaturated zone interaction | 17 |

# RESULTS

1. Water **sources**
2. (Hydro)geological and environmental **conditions**
3. **MAR** technology
4. **Sensorics** for MAR
5. Final **use**
6. **Monitoring** guidelines
7. **Analytical** aspects
8. **Risk and impact** assessment
9. Others




**Components of the MIR conceptual model**

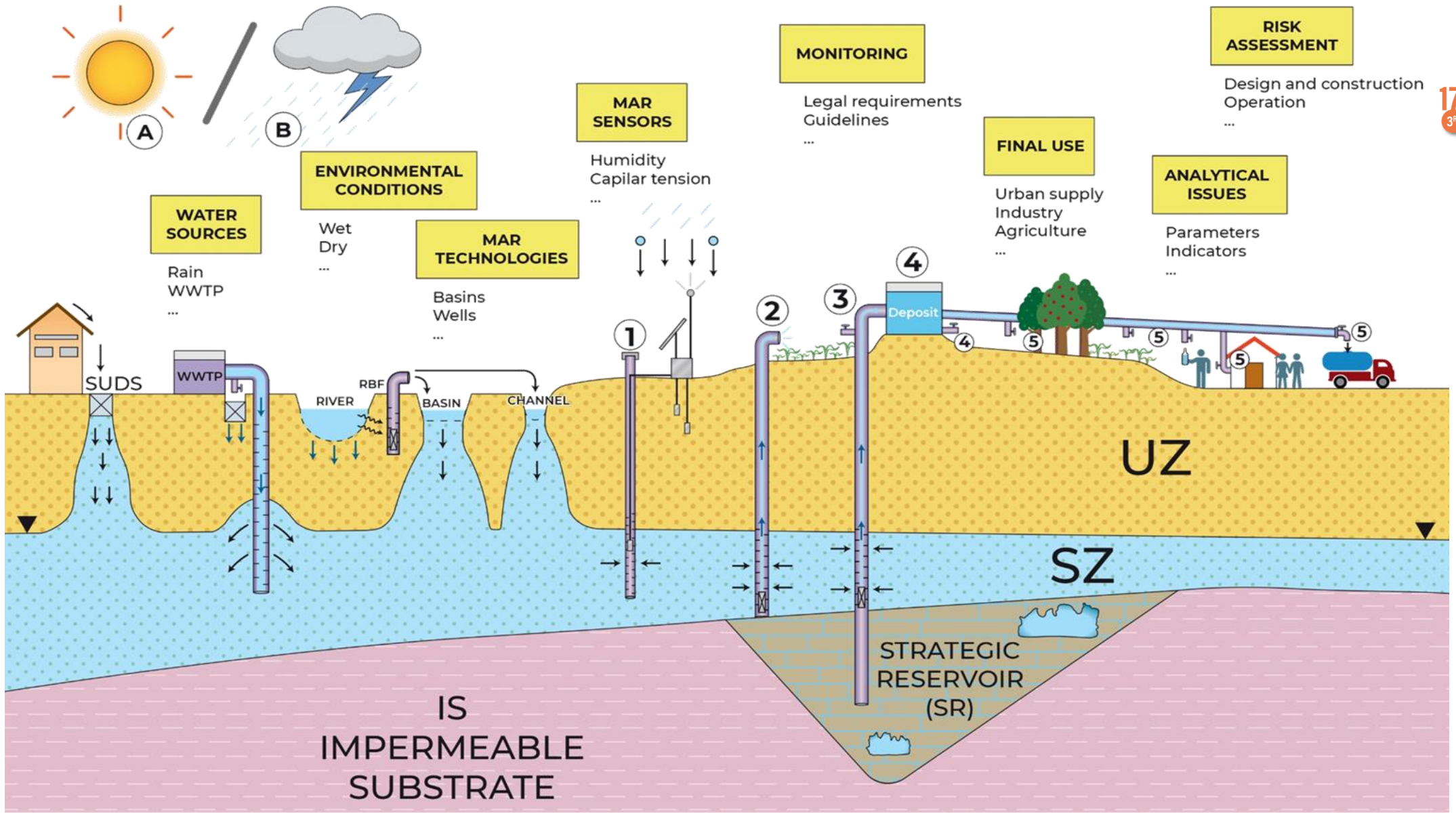



**Figure summarising the Monitored & Intentional Recharge (MIR) conceptual model**

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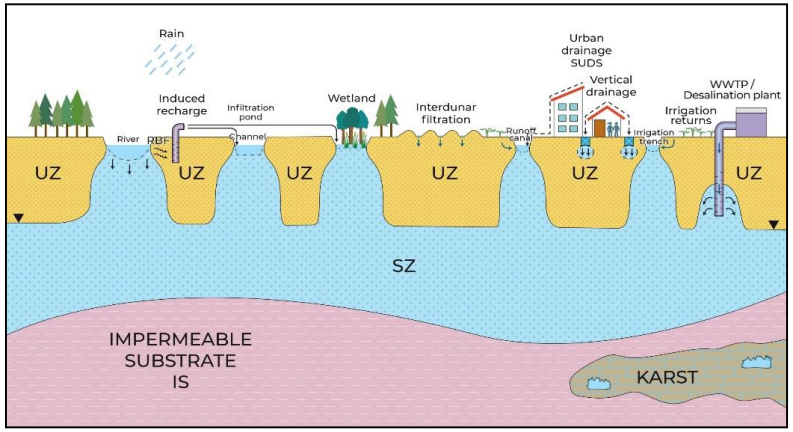
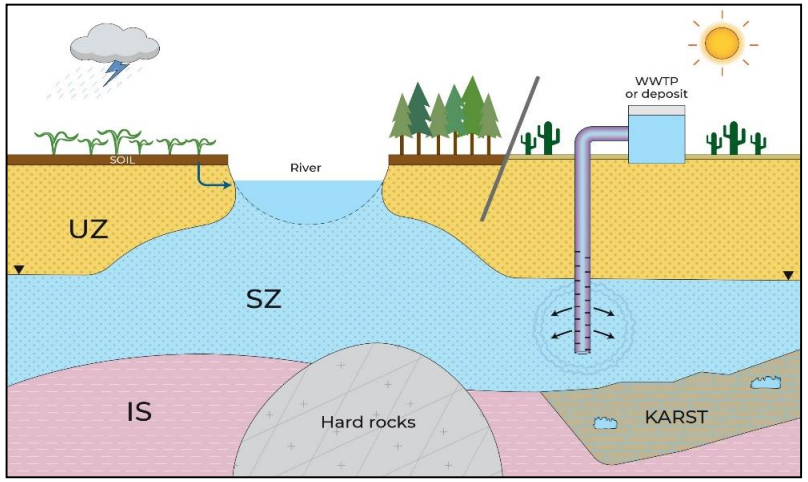
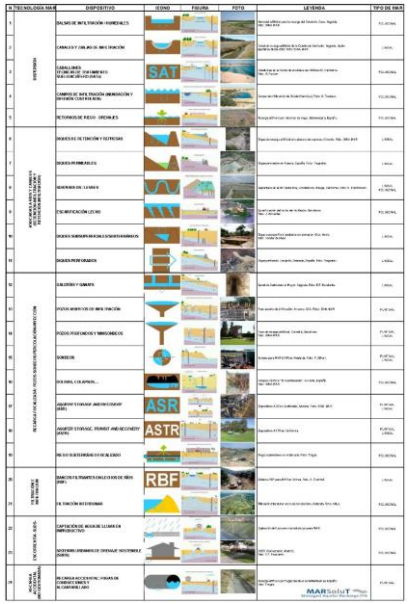
## 1. WATER SOURCES



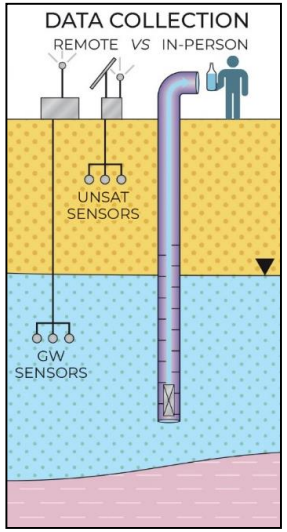

## 2. (HYDRO)GEOLOGICAL AND ENVIRONMENTAL CONDITIONS



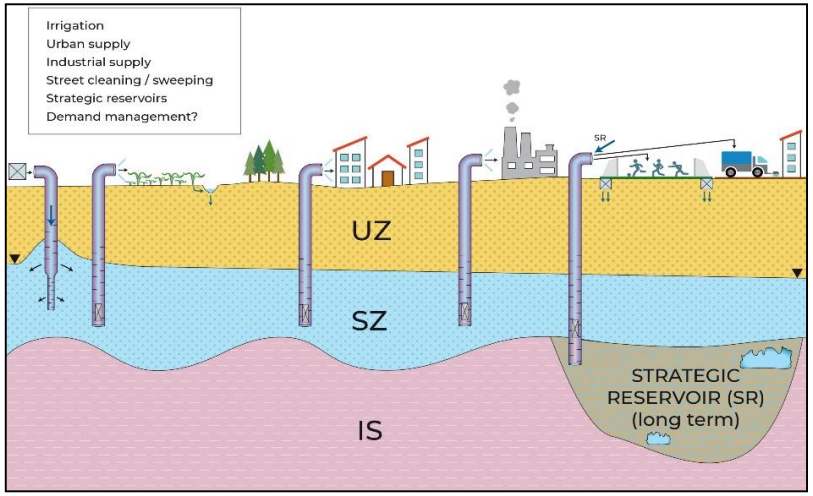

## 3. MAR TECHNOLOGY



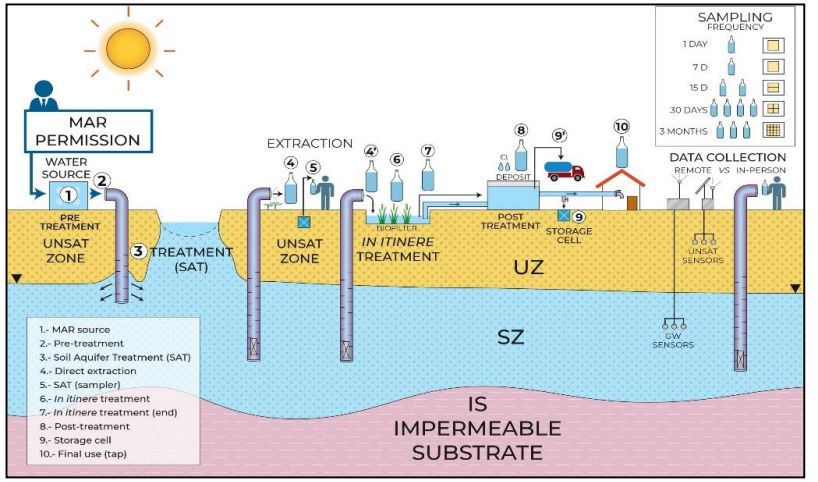

## 4. SENSORIC FOR MAR



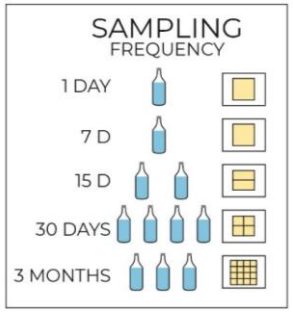

## 5. FINAL USE




## 6. MONITORING GUIDELINES




## 7. ANALYTICAL




- Maximum allowable concentrations (MACs)
- Proposal for monitoring parameters
- Sampling point & frequency

## 8. RISK ASSESSMENT

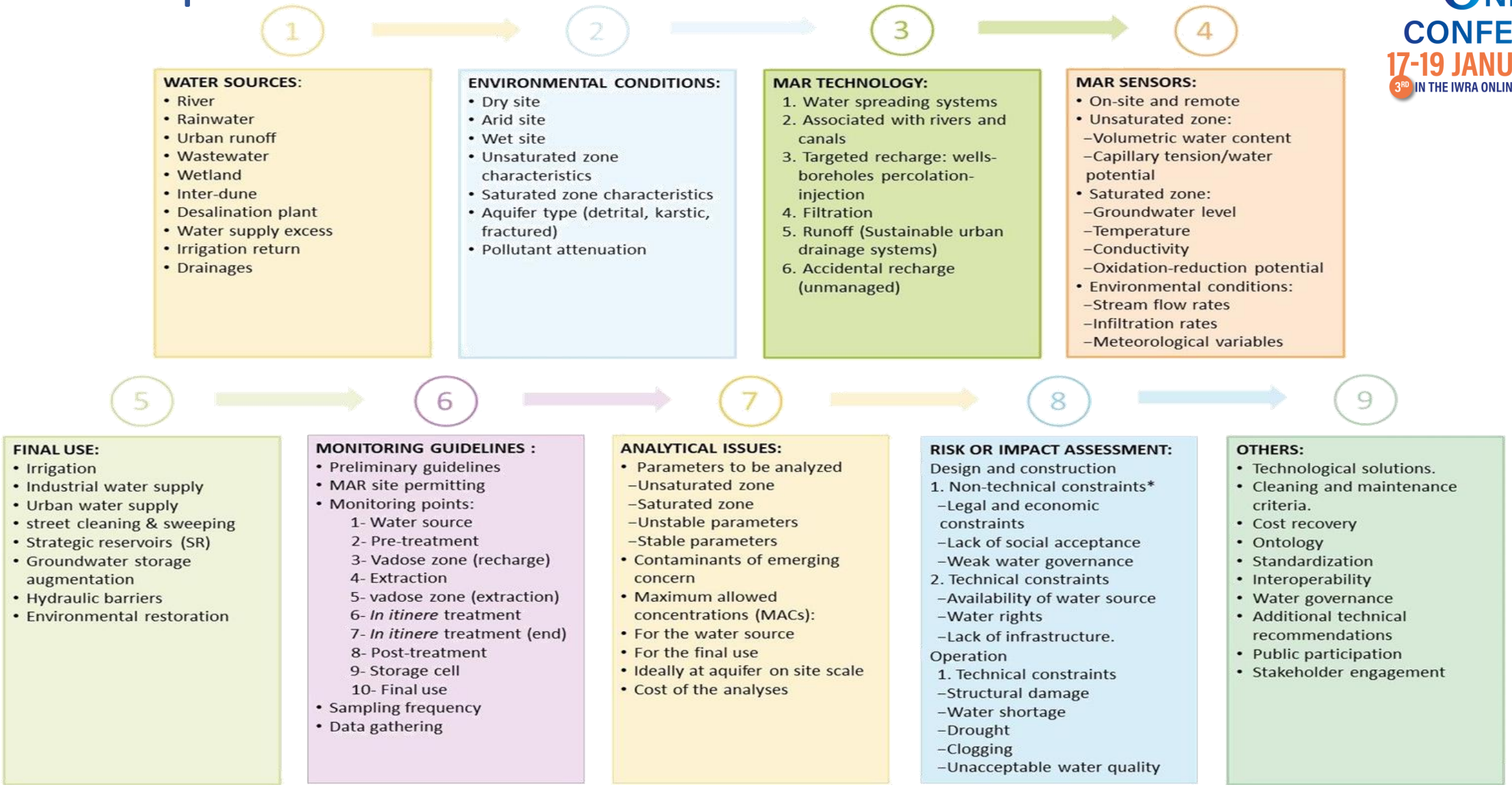
**Table 6.** Important risks to consider when dealing with MAR as per the Monitored and Intentional Recharge (MIR) conceptual model, block 8.

| | Technical aspects | "Non-technical" aspects |
|---|---|---|
| Design and construction | - Legal constraints<br>- Economic constraints<br>- Lack of social acceptance<br>- Weak water governance | - Availability of water source<br>- Concessions or water rights constraints<br>- Water scarcity<br>- Hydrogeological assessment<br>- Lack of infrastructure.<br>- Dependence of valuable habitats |
| Operation (and management) | - Legal constraints<br>- Economic constraints<br>- Lack of social acceptance<br>- Weak water governance | - Structural damage<br>- Water shortage and volume constraints at the source<br>- Drought<br>- Clogging<br>- Unacceptable water quality in a sensitive location<br>- Specific objectives<br>- Distortion of local ecological relations |

## 9. OTHER ASPECTS (OPEN)

# MIR components






**MIR conceptual model: the 9 essential blocks**

# Key messages



**M.I.R. can contribute to improve WATER SECURITY WORLDWIDE**

- The MIR conceptual model proposes a complete list of **elements** to consider when **drafting guidelines and regulations on MAR**.
- It encourages a **tailored approach** based on the **specific context** of the country or region (open concept).
- MIR stresses the **importance of alternative water sources** and **increasing awareness of water quality** and human and ecosystem health protection
- MIR entails **water quality and security improvements** based on organized and planned monitoring activities.
- **Peru's and Niger´s** water authorities are already considering the MIR conceptual model for MAR regulation. In the future, this model could be applied in **Europe and beyond.**

# For more information…

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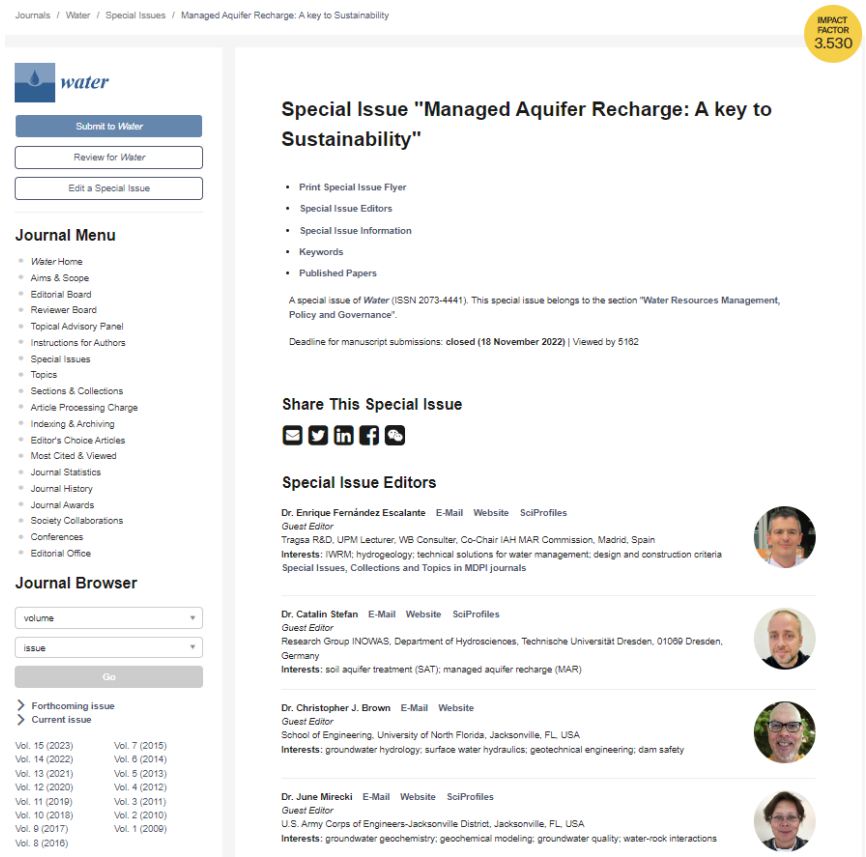
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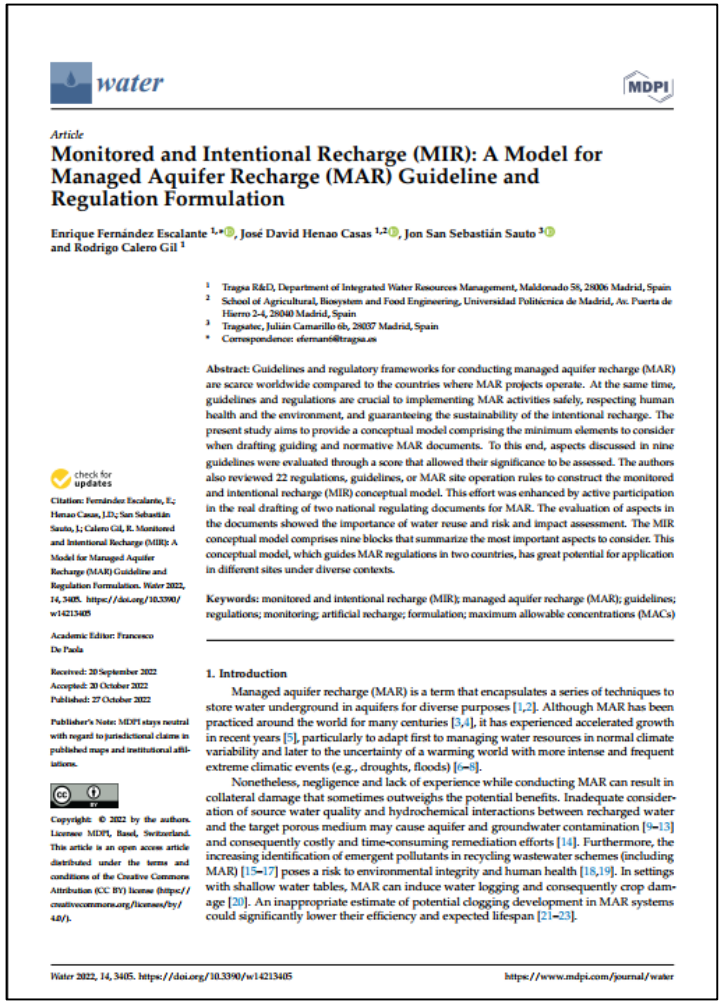
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*Article*

**Monitored and Intentional Recharge (MIR): A Model for Managed Aquifer Recharge (MAR) Guideline and Regulation Formulation**


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**Abstract:** Guidelines and regulatory frameworks for conducting managed aquifer recharge (MAR) are scarce worldwide compared to the countries where MAR projects operate. At the same time, guidelines and regulations are crucial to implementing MAR activities safely, respecting human health and the environment, and guaranteeing the sustainability of the intentional recharge. The present study aims to provide a conceptual model comprising the minimum elements to consider when drafting guiding and normative MAR documents. To this end, aspects discussed in nine guidelines were evaluated through a score that allowed their significance to be assessed. The authors also reviewed 22 regulations, guidelines, or MAR site operation rules to construct the monitored and intentional recharge (MIR) conceptual model. This effort was enhanced by active participation in the real drafting of two national regulating documents for MAR. The evaluation of aspects in the documents showed the importance of water reuse and risk and impact assessment. The MIR conceptual model comprises nine blocks that summarize the most important aspects to consider. This conceptual model, which guides MAR regulations in two countries, has great potential for application in different sites under diverse contexts.



**Keywords:** monitored and intentional recharge (MIR); managed aquifer recharge (MAR); guidelines; regulations; monitoring; artificial recharge; formulation; maximum allowable concentrations (MACs)


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**Citation:** Fernández Escalante, E.; Henao Casas, J.D.; San Sebastián Sauto, J.; Calero Gil, R. Monitored and Intentional Recharge (MIR): A Model for Managed Aquifer Recharge (MAR) Guideline and Regulation Formulation. *Water* 2022, *14*, 3405. https://doi.org/10.3390/w14213405

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## 1. Introduction

Managed aquifer recharge (MAR) is a term that encapsulates a series of techniques to store water underground in aquifers for diverse purposes [1,2]. Although MAR has been practiced around the world for many centuries [3,4], it has experienced accelerated growth in recent years [5], particularly to adapt first to managing water resources in normal climate variability and later to the uncertainty of a warming world with more intense and frequent extreme climatic events (e.g., droughts, floods) [6–8].

Nonetheless, negligence and lack of experience while conducting MAR can result in collateral damage that sometimes outweighs the potential benefits. Inadequate consideration of source water quality and hydrochemical interactions between recharged water and the target porous medium may cause aquifer and groundwater contamination [9–13] and consequently costly and time-consuming remediation efforts [14]. Furthermore, the increasing identification of emergent pollutants in recycling wastewater schemes (including MAR) [15–17] poses a risk to environmental integrity and human health [18,19]. In settings with shallow water tables, MAR can induce water logging and consequently crop damage [20]. An inappropriate estimate of potential clogging development in MAR systems could significantly lower their efficiency and expected lifespan [21–23].



*MIR at the Journal Water*

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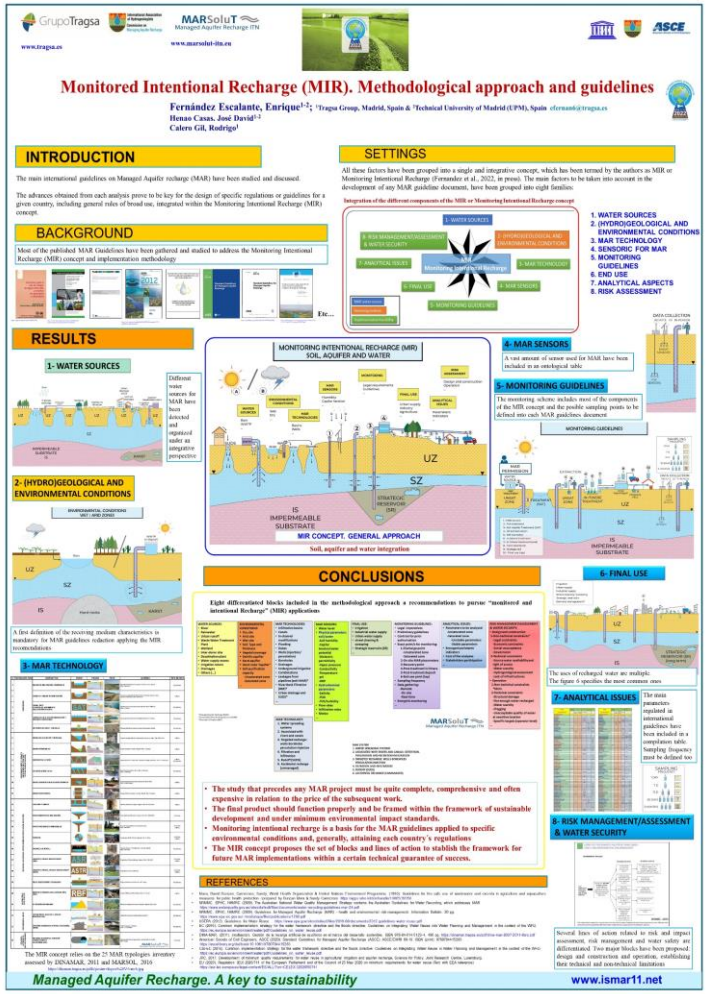
Monitored Intentional Recharge (MIR). Methodological approach and guidelines

Fernández Escalante, Enrique[1,2]; [1]Tragsa Group, Madrid, Spain & [2]Technical University of Madrid (UPM), Spain
Henao Casas, José David[1,2]
Calero Gil, Rodrigo[1]

INTRODUCTION

BACKGROUND

SETTINGS

1. WATER SOURCES
2. (HYDRO)GEOLOGICAL AND ENVIRONMENTAL CONDITIONS
3. MAR TECHNOLOGY
4. SENSORIC FOR MAR
5. MONITORING GUIDELINES
6. END USE
7. ANALYTICAL ASPECTS
8. RISK ASSESSMENT

RESULTS

1- WATER SOURCES

2- (HYDRO)GEOLOGICAL AND ENVIRONMENTAL CONDITIONS

3- MAR TECHNOLOGY

MONITORING INTENTIONAL RECHARGE (MIR) SOIL, AQUIFER AND WATER

UZ
SZ
IS IMPERMEABLE SUBSTRATE

MIR CONCEPT. GENERAL APPROACH

Soil, aquifer and water integration

4- MAR SENSORS

5- MONITORING GUIDELINES

6- FINAL USE

7- ANALYTICAL ISSUES

8- RISK MANAGEMENT/ASSESSMENT & WATER SECURITY

CONCLUSIONS

Eight differentiated blocks included in the methodological approach a recommendations to pursue "monitored and intentional Recharge" (MIR) application

- The study that precedes any MAR project must be quite complete, comprehensive and often expensive in relation to the price of the subsequent work.
- The final product should function properly and be framed within the framework of sustainable development and under minimum environmental impact standards.
- Monitoring intentional recharge is a basis for the MAR guidelines applied to specific environmental conditions and, generally, attaining each country's regulations
- The MIR concept proposes the set of blocks and lines of action to stablish the framework for future MAR implementations within a certain technical guarantee of success.

REFERENCES

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www.ismar11.net

*MIR at ISMAR 11*

https://dinamar.tragsa.es/file.axd?file=/PDFS/P-ISMAR-11.pdf

***Thank you very much for your kind attention. Madrid, 18 January 2023***