The logo was developed by Christian Wolkersdorfer, who kindly provided it.

SPONSORED BY THE
Federal Ministry of Education and Research

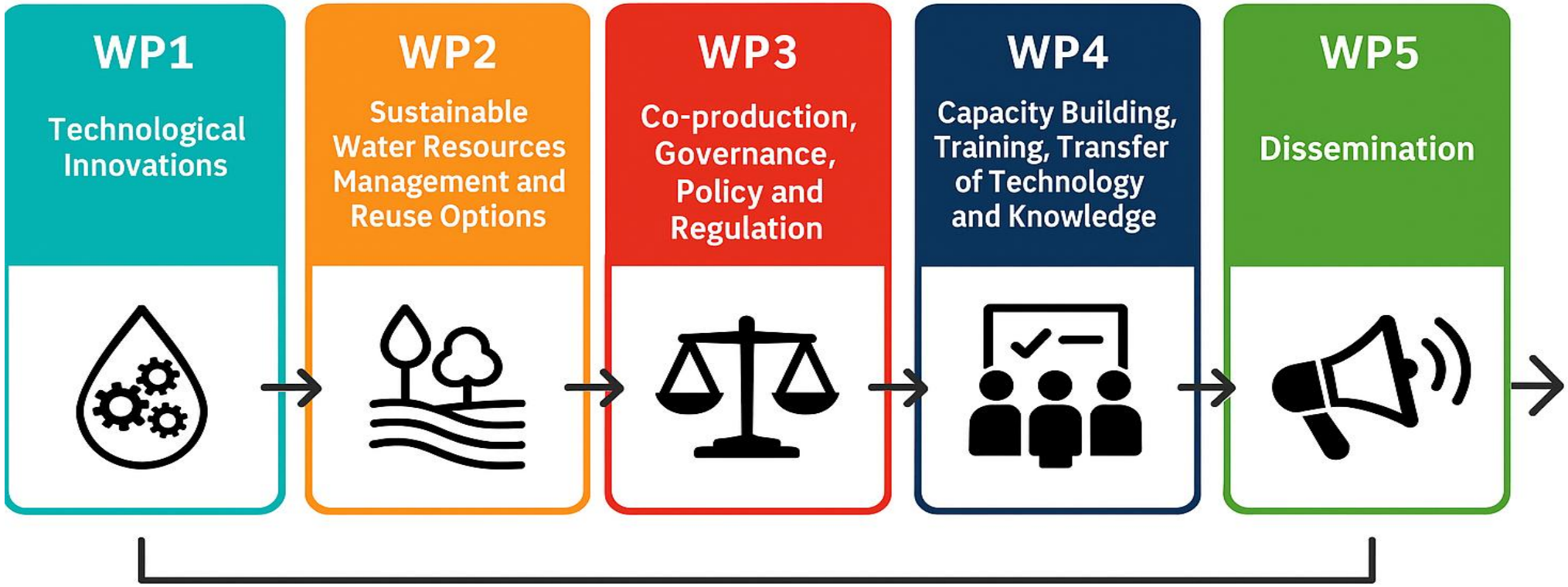
# Making mining-influenced water a driver for change to improve water security in South Africa

Dr Christoff Truter – Stellenbosch University
Yasim Imran Rony – Wuppertal Institute

**Online "Ask the Experts" Webinar 2025-10-07**

UNIVERSITÄT DUISBURG ESSEN
Open-Minded
IWW
Wuppertal Institut
university of south africa UNISA
Stellenbosch UNIVERSITY IYUNIVESITHI UNIVERSITEIT
IMA tec

# An Integrated Solution for Mine Water Reuse




SPONSORED BY THE
Federal Ministry of Education and Research

# The Problem: Untreated Mine-influenced water in South Africa

- **Environmental & Health Risks:**
  - Untreated mine-influenced water (MIW), especially acid mine drainage (AMD), threatens ecosystems and communities.
- **Economic & Social Impact:**
  - Hinders post-mining land use and poses long-term risks for water security and public health.
- **Urgency & Opportunity:**
  - South Africa is rich in mining history – and in need of sustainable transition strategies.



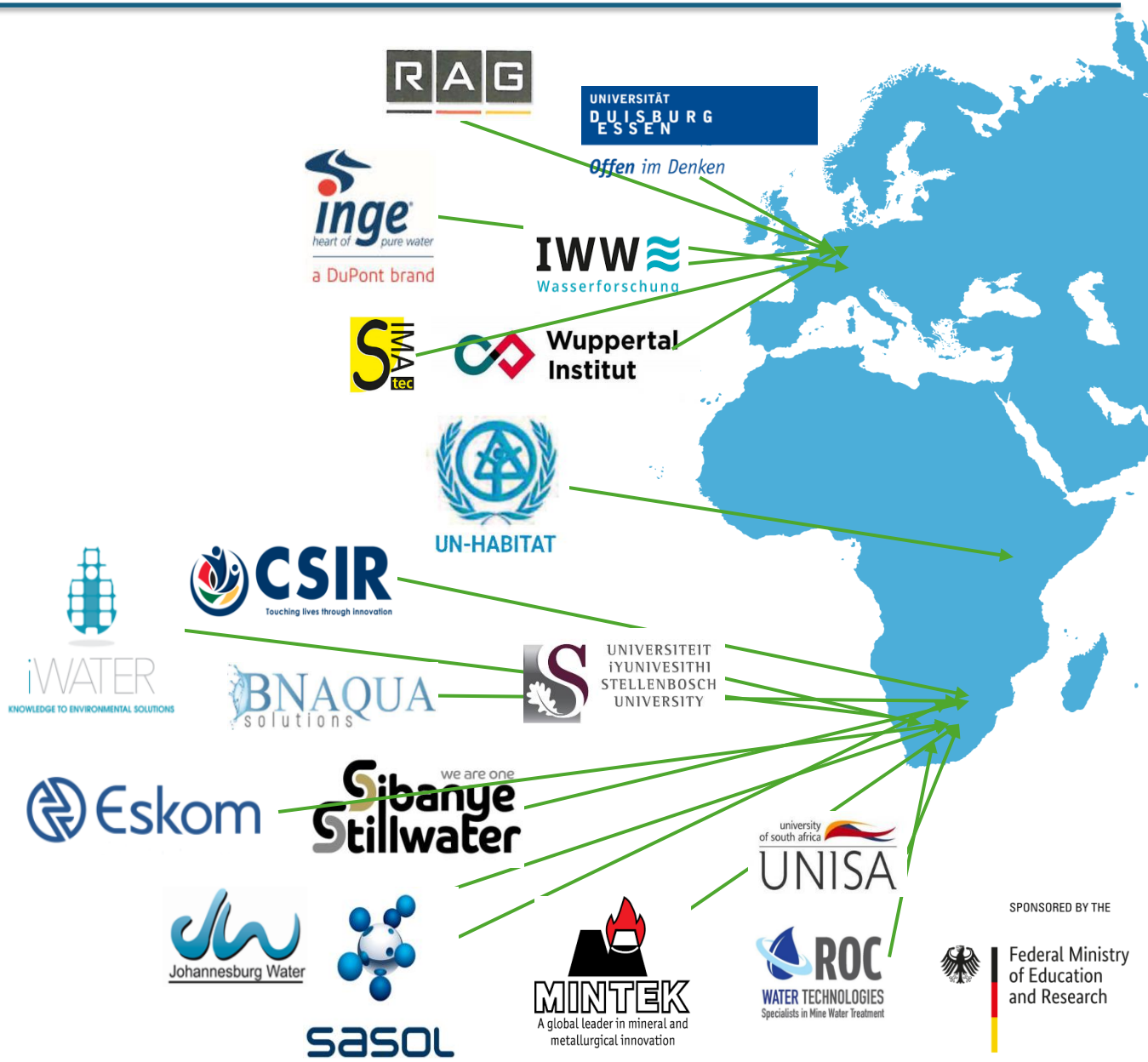




SPONSORED BY THE
Federal Ministry of Education and Research

# Impact for South Africa and Beyond

- **Local Benefits:**
  - New approaches for cleaner water
  - Improved health
  - Economic diversification options
- **Scalable Innovation:**
  - Technology and governance models transferable to other mining regions.
- **Collaboration:**
  - Strong German-South African partnership
  - Real-world testing
  - Stakeholder ownership.



The logo was developed by Christian Wolkersdorfer, who kindly provided it.

SPONSORED BY THE

Federal Ministry of Education and Research

Eine Initiative des Bundesministeriums für Bildung und Forschung

Wasser: N
SCHUTZ. NUTZUNG. INNOVATION.

# WP2: Integrated water resource management


**Dr. Christoff Truter, Senior Project Manager**
**Stellenbosch University Water Institute**

**Dr. Tim aus der Beek – IWW**
**Dr. Katharina Gimbel– IWW**
**Dr. Gerhard Schertzinger– IWW**
**Prof. Gideon Wolfaardt – Stellenbosch University**
**Dr. Alno Carstens – Stellenbosch University**


UNIVERSITÄT DUISBURG ESSEN
Open-Minded

IWW

Wuppertal Institut

university of south africa
UNISA

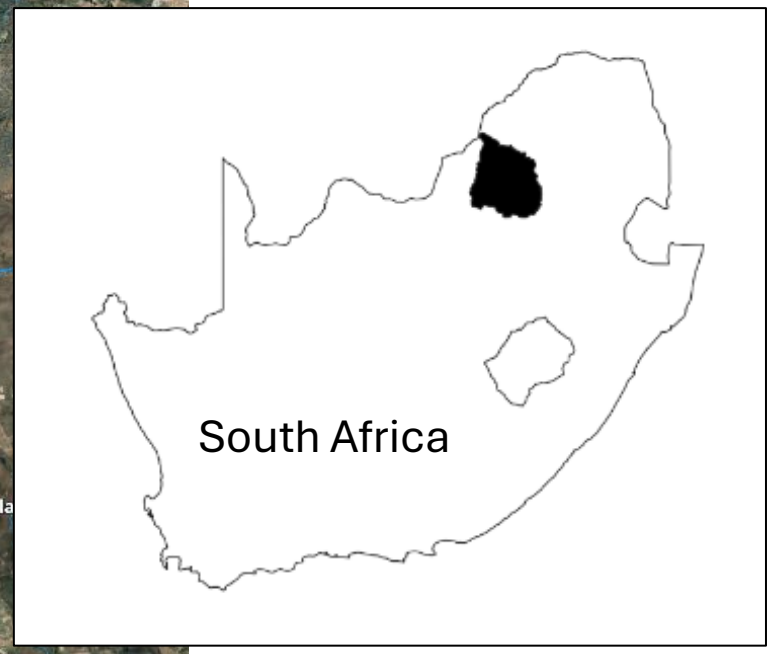
Stellenbosch
UNIVERSITY
IYUNIVESITHI
UNIVERSITEIT

IMA tec

# Study Area – Crocodile River (West)




MAMDIWAS Sites

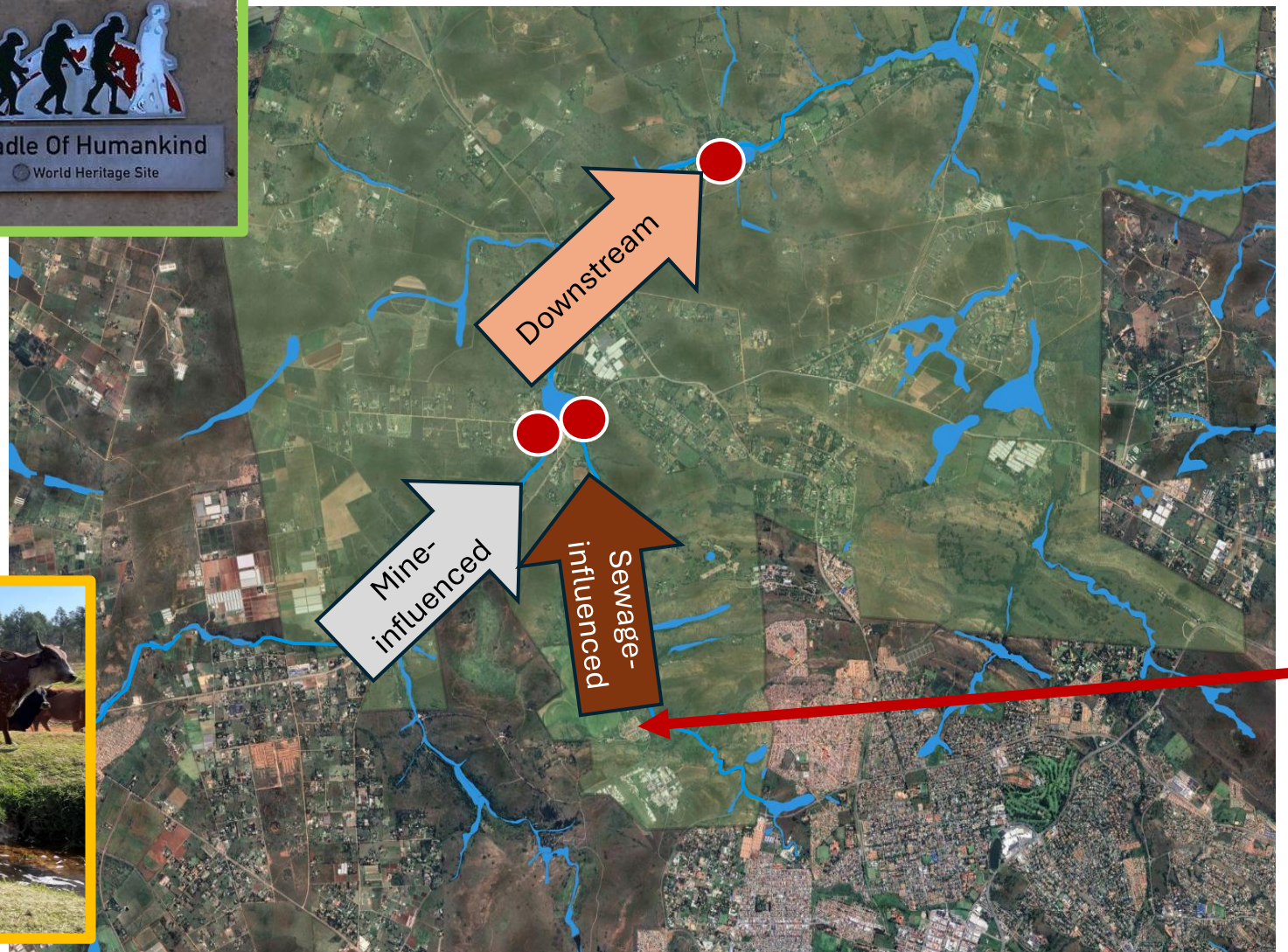



SPONSORED BY THE

Federal Ministry of Education and Research

# Study Area




MAMDIWAS Sites

UNESCO Cradle of Humankind

Mine water – Tweelopie Stream





# Study Area

Focal sites (for today's talk)

Sewage-influenced



Mine-influenced



Downstream



SPONSORED BY THE
Federal Ministry of Education and Research

# Aim

**Assess the quality of surface water resources influenced by mine water in the Black Reef region, South Africa**

- Perform baseline water quality assessment
- Assess health risks to humans and ecosystems
- Identify sources of pollution

SPONSORED BY THE
Federal Ministry of Education and Research

# Materials and Methods

## Water collection:

### Initial campaign (Entire MAMDIWAS study area)

- Sept 2024 (Spring) – Low flow
- Feb 2025 (Summer) – High flow

### Follow-up campaign (Black Reef only)

- May 2025 (Autumn) – Lower flow
- August 2025 (Spring) – Low flow

SPONSORED BY THE
Federal Ministry of Education and Research

# Materials and Methods

## Water quality:

### *In situ*

- Dissolved Oxygen, pH, Electrical Conductivity

### General water quality

- *E. coli*, Chemical Oxygen Demand etc.

### Hazardous metals

- Al, As, Cr, Mn, Ni, Co, Fe, Zn, Cd, Sb, U, V, etc.

### Contaminants of emerging concern

- Pharmaceutical, illicit drugs and pesticides (LCMS)

SPONSORED BY THE
Federal Ministry of Education and Research

# Materials and Methods

## Toxicity:

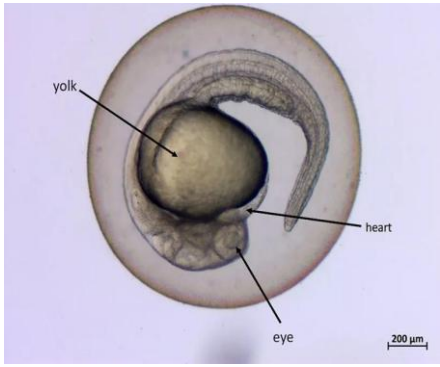
*In vitro*

| Endpoint | Bioassay |
|---|---|
| Cytotoxicity | MTT-Test |
| Estrogenicity | ERα CALUX |
| Genotoxicity | umu-assay |
| Mutagenicity | Ames-fluctuation assay |

*In vivo*



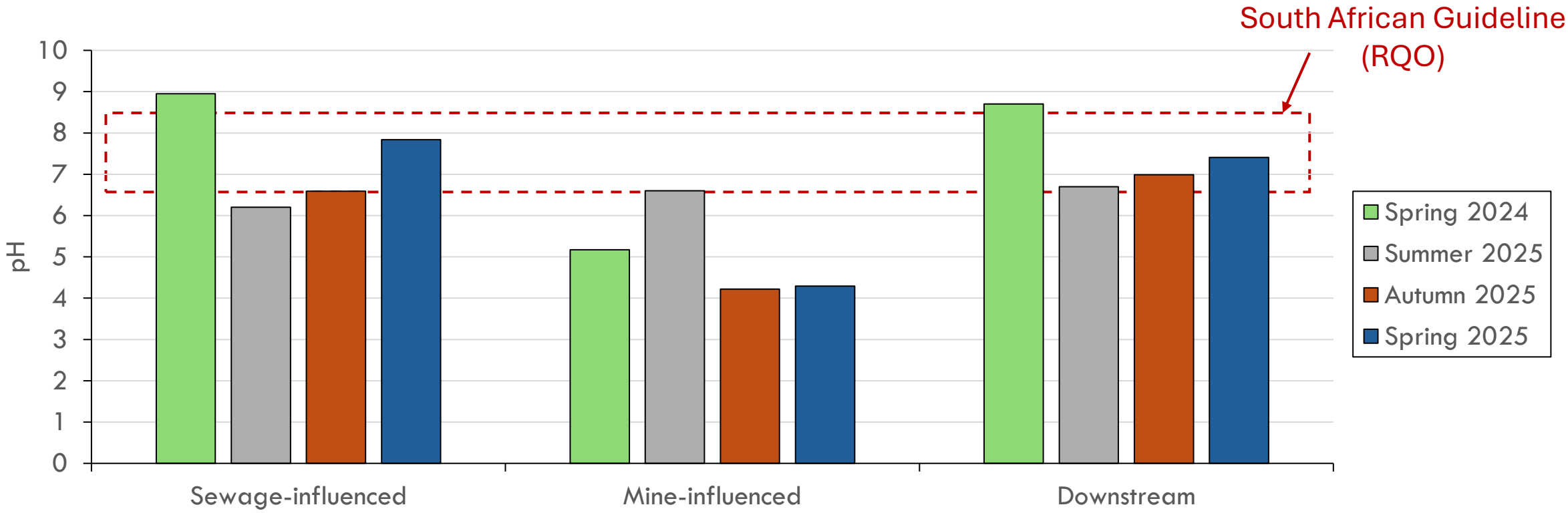
Colon cancer mouse model




Fish embryo assay

SPONSORED BY THE
Federal Ministry of Education and Research

# General water quality



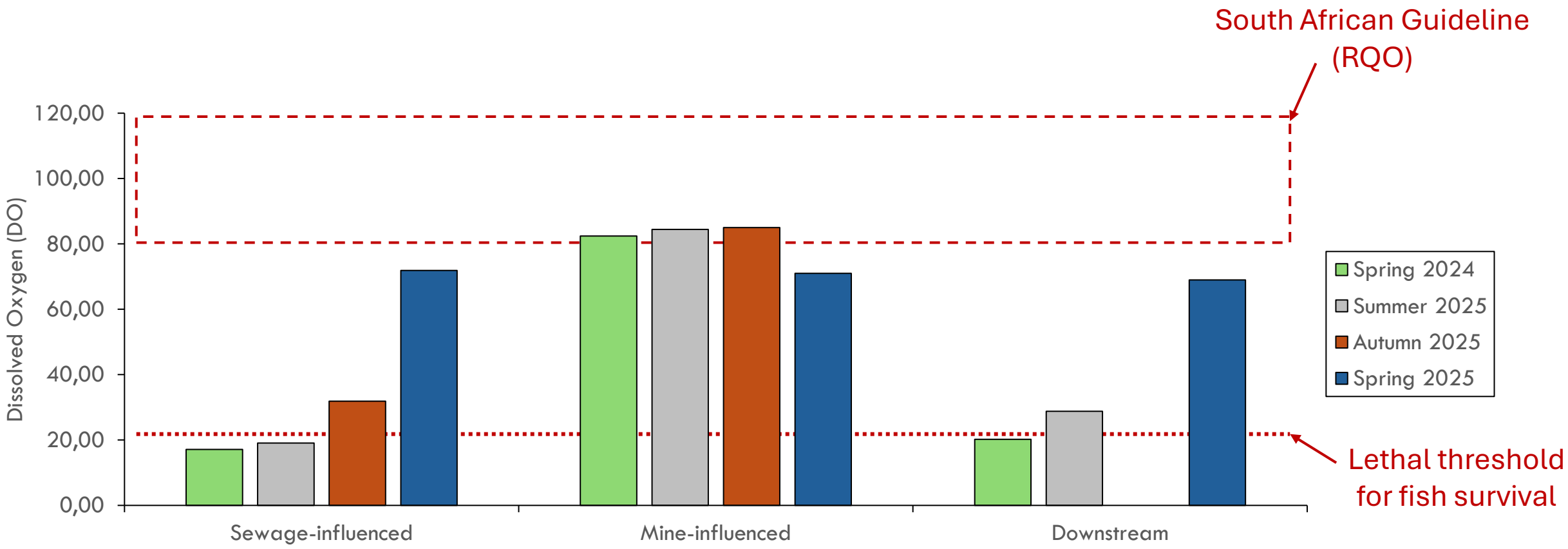






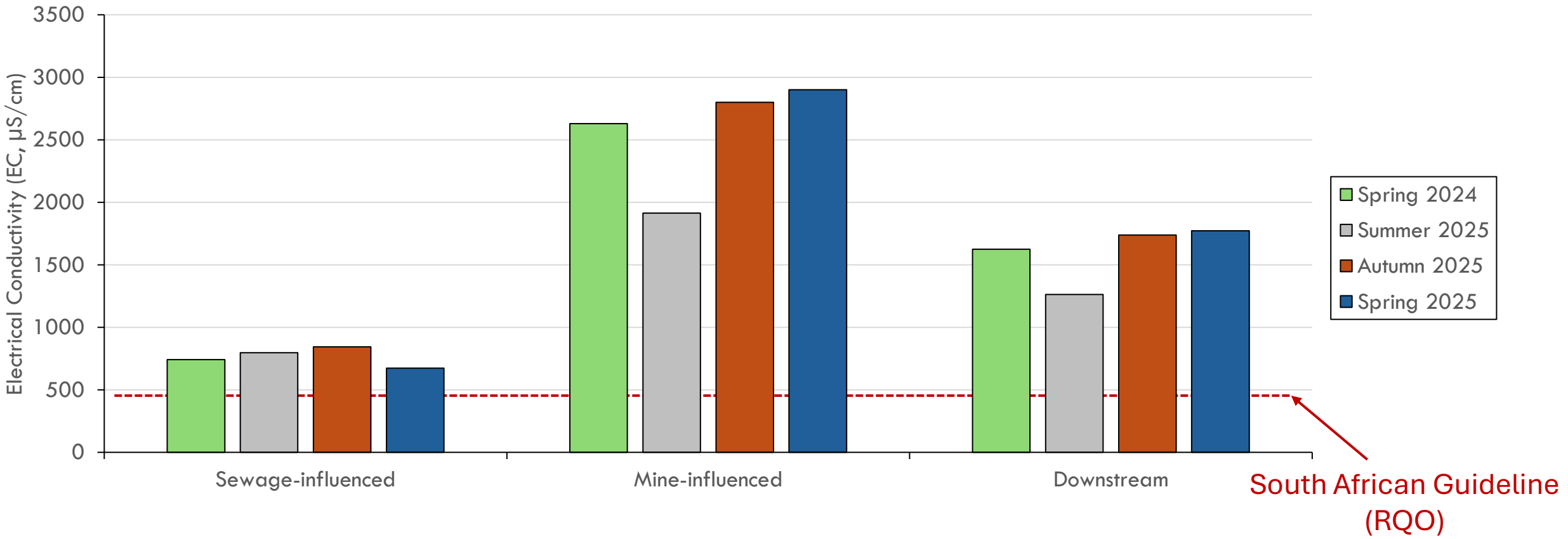

SPONSORED BY THE
Federal Ministry of Education and Research

# General water quality



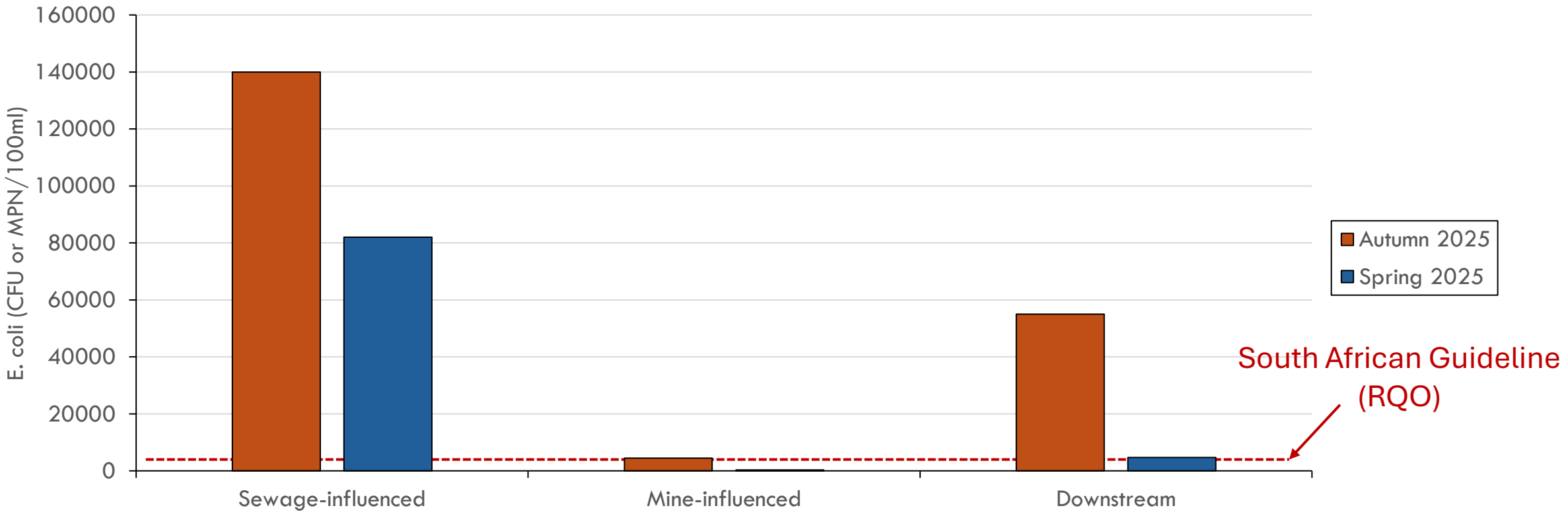

SPONSORED BY THE
Federal Ministry of Education and Research

# General water quality



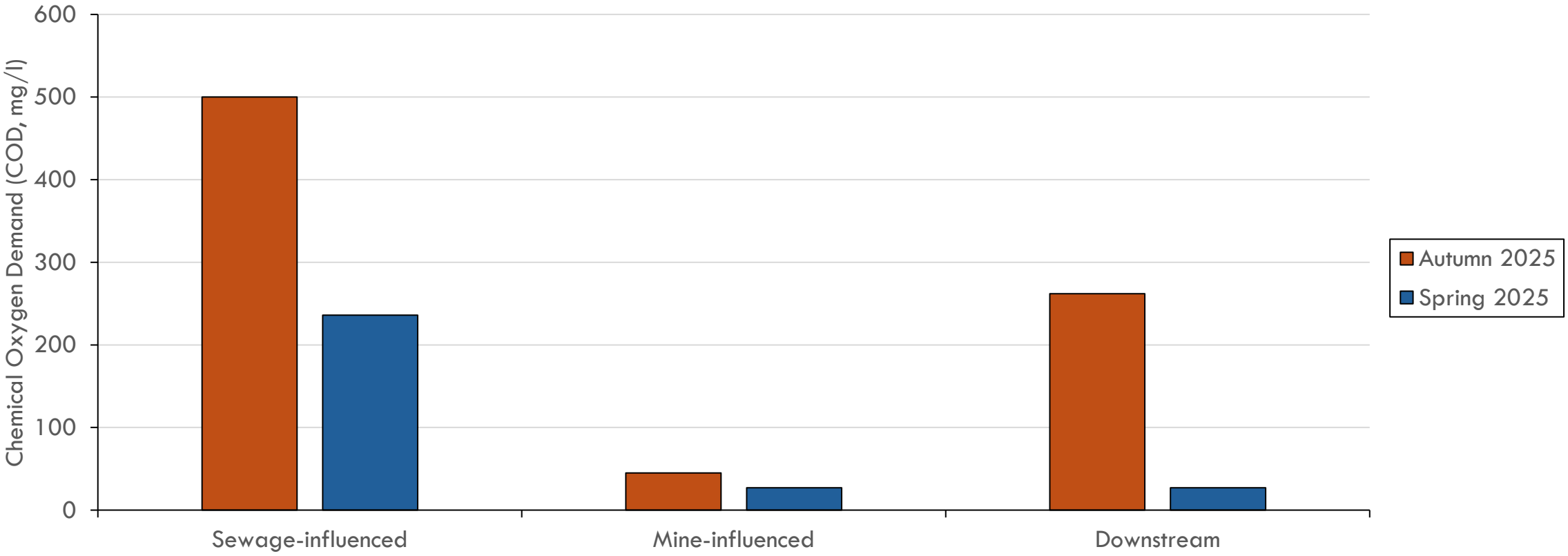

SPONSORED BY THE
Federal Ministry of Education and Research

# General water quality



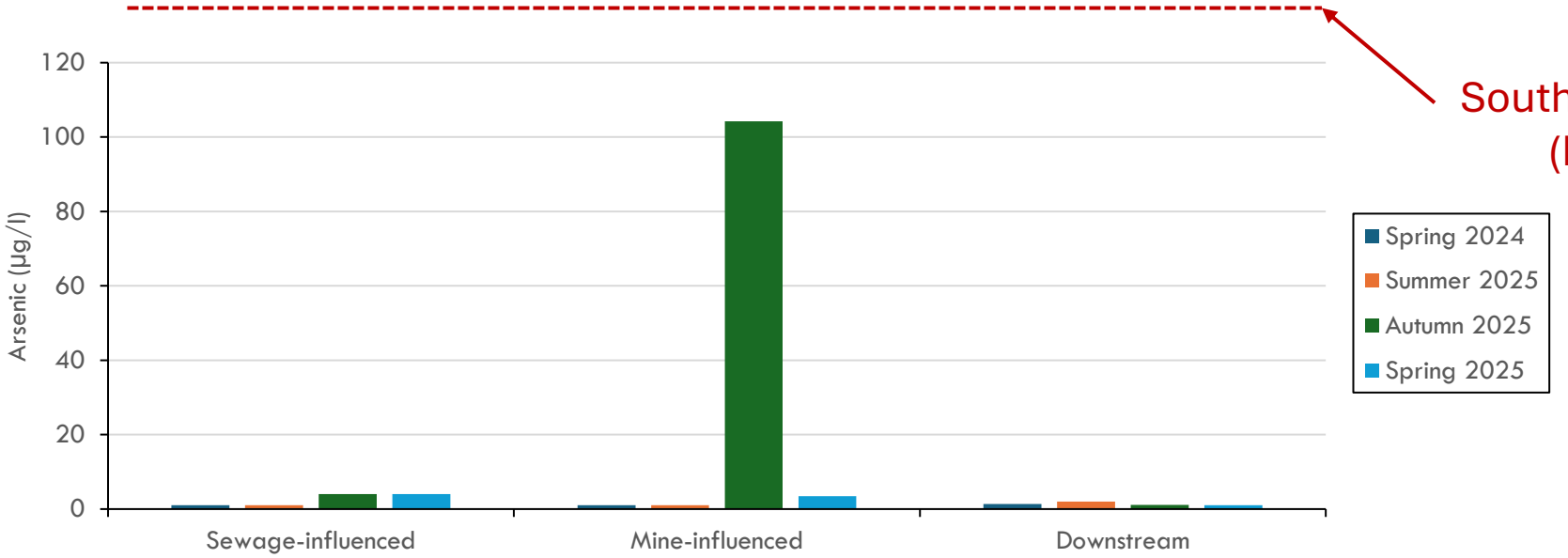

SPONSORED BY THE
Federal Ministry
of Education
and Research

# General water quality

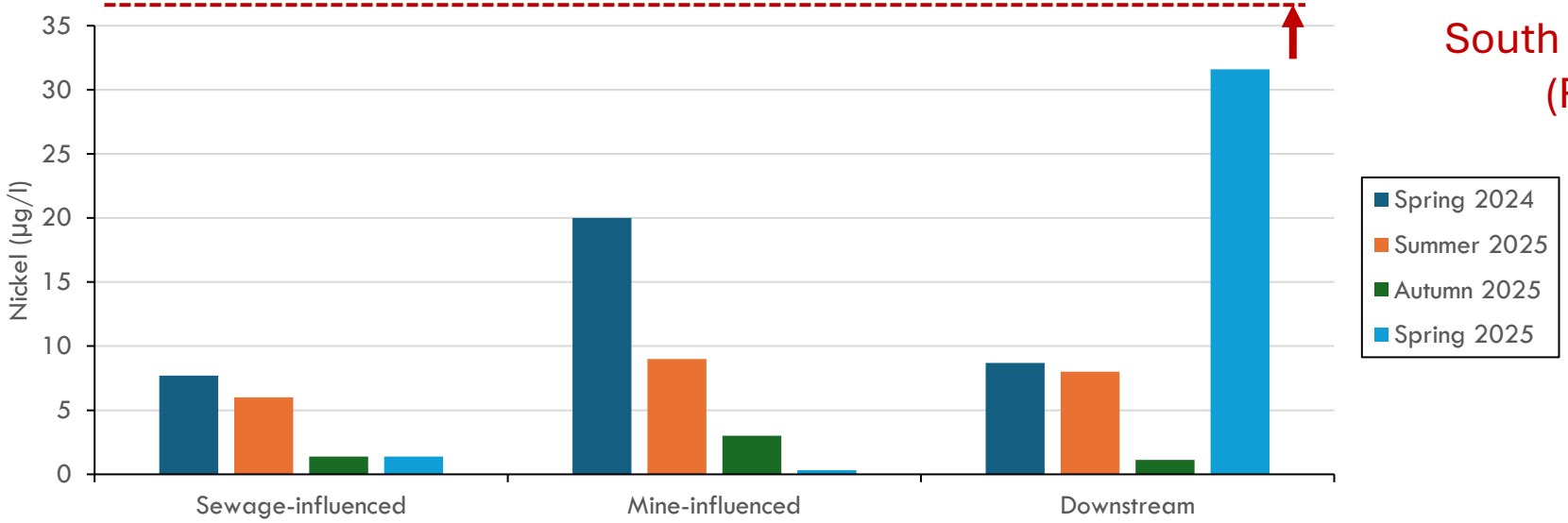



SPONSORED BY THE
Federal Ministry of Education and Research

# Trace metals



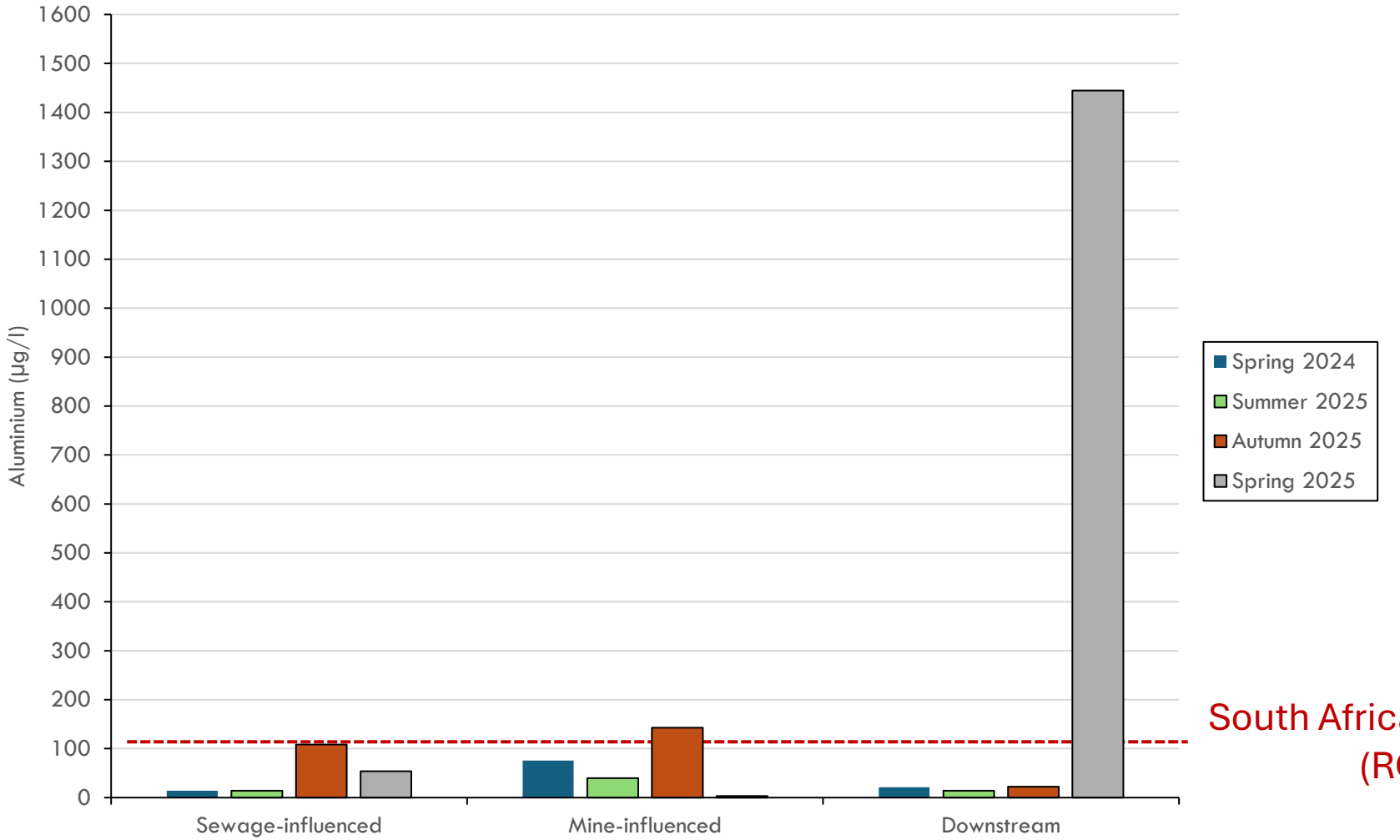

South African Guideline (RQO) 130 µg/l




South African Guideline (RQO) 70 µg/l

SPONSORED BY THE
Federal Ministry of Education and Research

# Trace metals

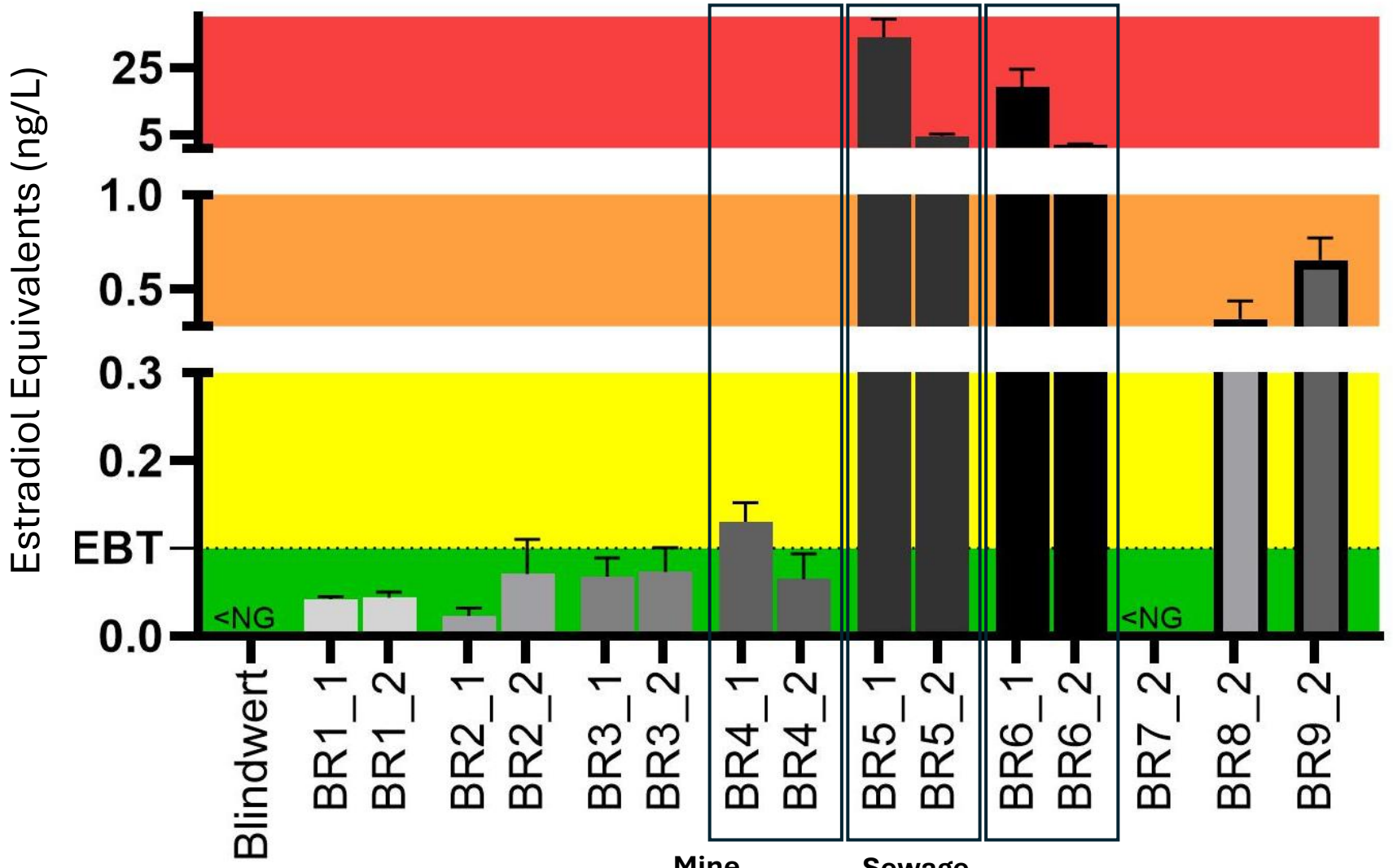



South African Guideline (RQO)

SPONSORED BY THE
Federal Ministry of Education and Research

# Effect-based method - Estrogenicity

Spring 2024 and Summer 2024/2025 Data




EBT – effect-based trigger value

IWW Wasserforschung

SPONSORED BY THE

Federal Ministry of Education and Research

# Colon cancer mouse model assessment

Ngwedha Ndjene (PhD student – SU Physiology)

Exposed to surface water for 3 months

C57BL/6 mouse



Cancer pathogenesis?

Cancer progression?

General health?

Endocrine system?

SPONSORED BY THE
Federal Ministry of Education and Research

# Colon cancer mouse model assessment

- Selected animals treated with azoxymethane (AOM) – colon cancer+
- 3-month exposure to ***sterile filtered*** river water

## 2 phases:

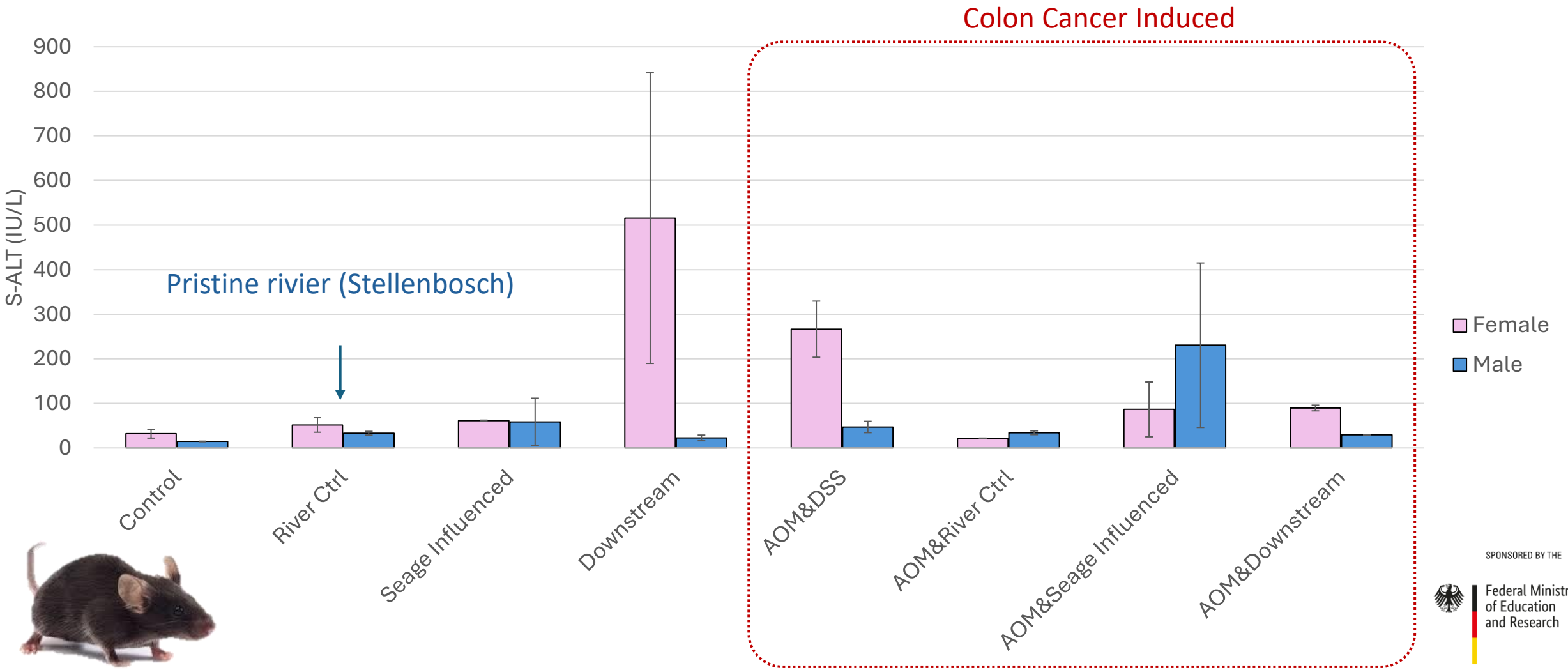
1. Pilot study – Two sites, 4 animals per treatment
2. Full study – Three sites, 8 animals per treatment



SPONSORED BY THE
Federal Ministry of Education and Research

# Colon cancer mouse model assessment

## Pilot study – Alanine Aminotransferase – Liver injury

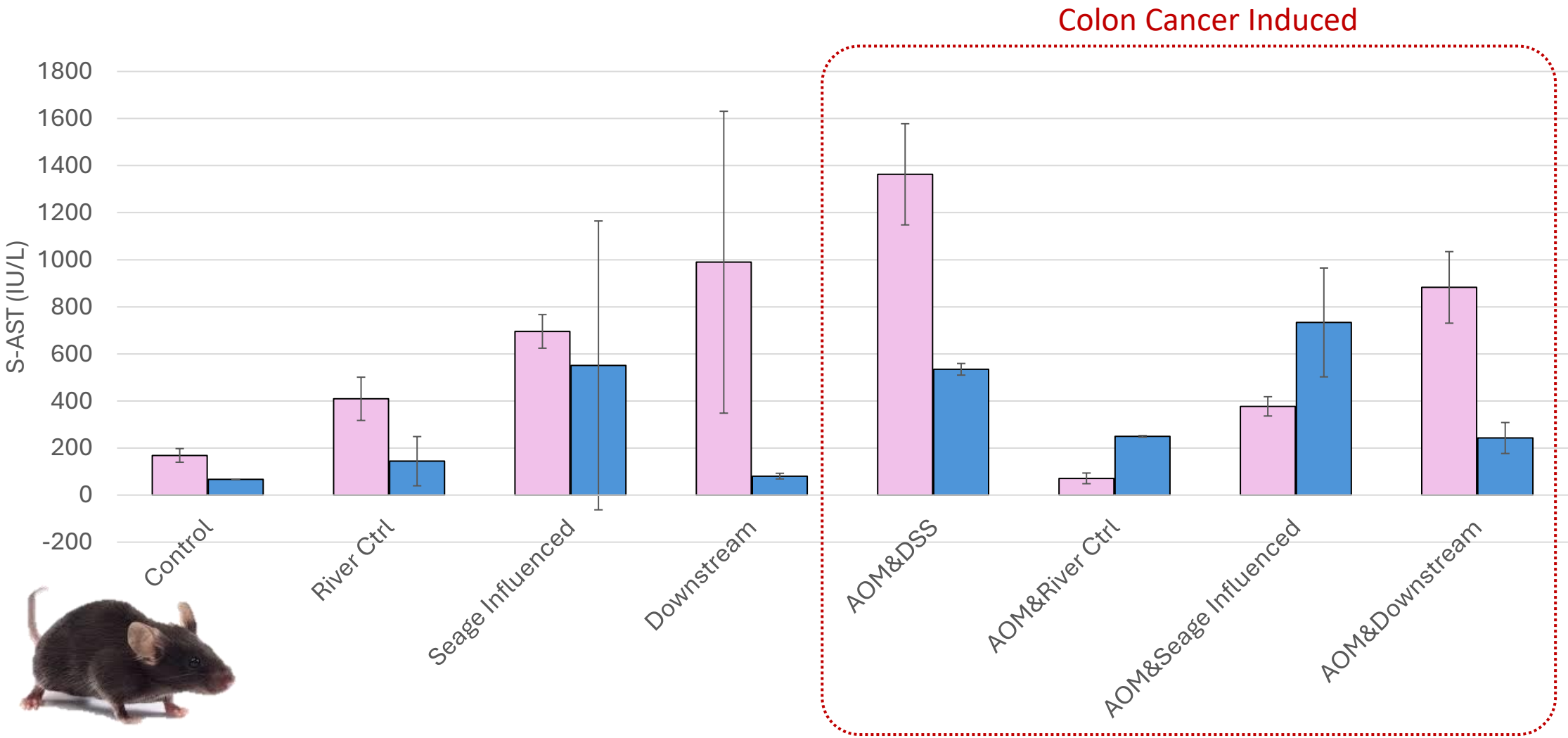





SPONSORED BY THE
Federal Ministry of Education and Research

# Colon cancer mouse model assessment

## Pilot study – Alanine Aminotransferase – Liver and non-liver injury






SPONSORED BY THE
Federal Ministry of Education and Research

# Colon cancer mouse model assessment

## Pilot study

## Next steps:

- Histopathology
- Additional biomarkers for cancer and health

**Full study** is currently running!



SPONSORED BY THE

Federal Ministry of Education and Research

# Zebrafish embryotoxicity and malformation screen

## Caroline Woerner (Honours Student, SU Zoology)

3 Sites: Sewage- and mine-influenced





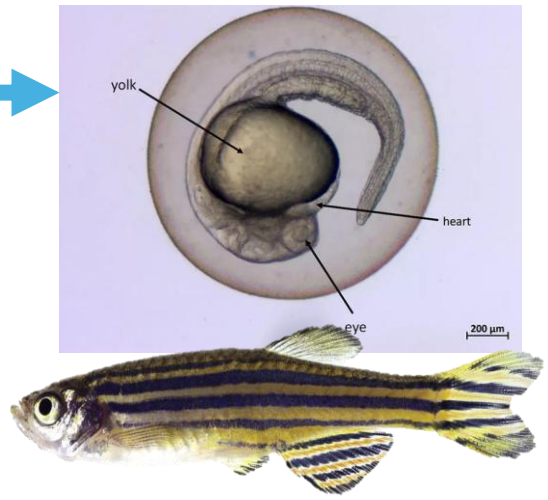


**Organic extract**
Polar and non-polar



**Total sample**
Inorganic + Organic

Zebrafish embryo
4 day exposure




SPONSORED BY THE
Federal Ministry
of Education
and Research

# Zebrafish embryotoxicity and malformation screen

## Autumn 2025 (Higher flow)

### Total Sample



### Organic extract







Federal Ministry of Education and Research

# Health risks to vertebrates

## Spring 2025 (Lower flow)

a

Total Sample



Organic extract







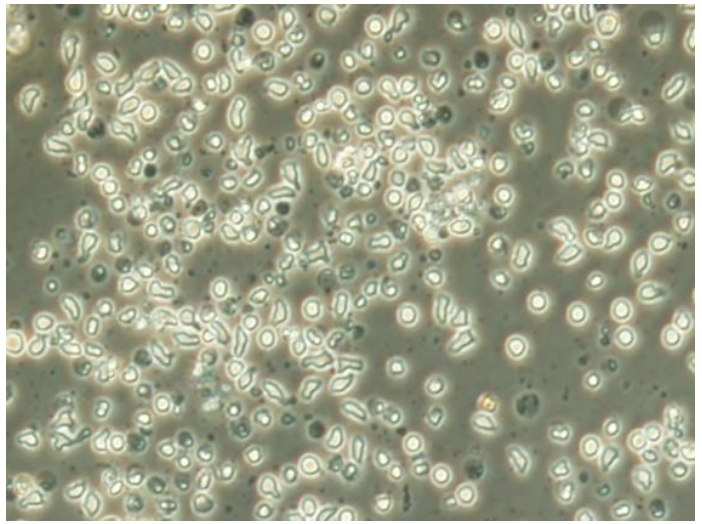
SPONSORED BY THE
Federal Ministry of Education and Research

# Ongoing research

## Cancer risks

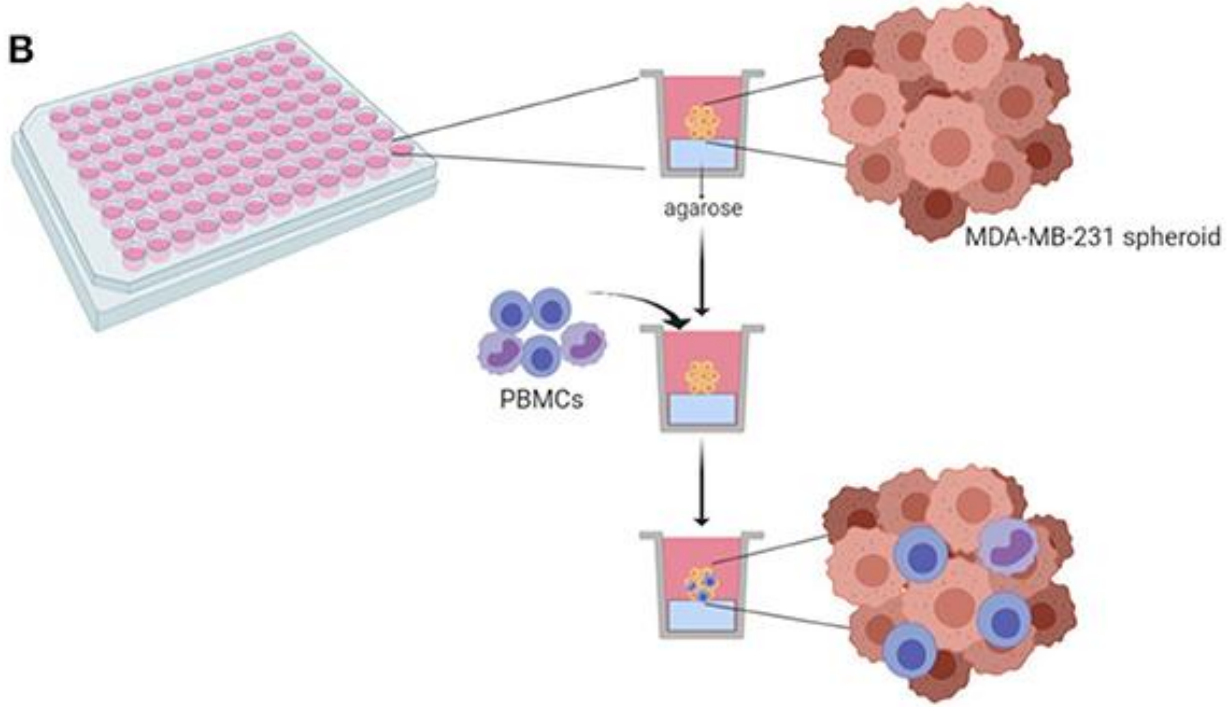
White blood cells (PBMCs) from cervical cancer patients

**Cultured PBMC (white-blood) Cells**



- Mitochondrial respiration
- Cytotoxicity

**PBMC intrusion into Hela (cancer cell) spheroids**




Saraiva et al. 2020 – Frontiers in Oncology, https://doi.org/10.3389/fonc.2020.01543

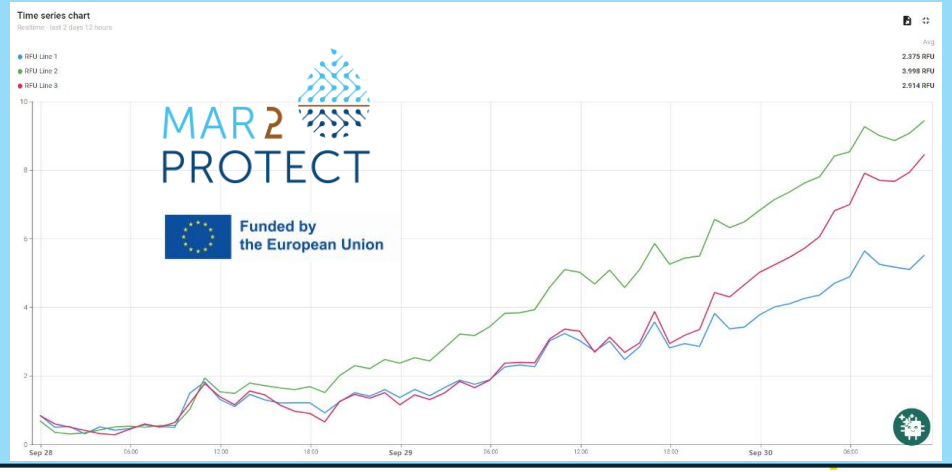
Federal Ministry of Education and Research

# Conclusions

- Apparent risks to humans and wildlife Bloubank Drainage
- Mine- and sewage-influenced water have distinct influences on water quality and toxicity
- Seasonal variation in water quality was evident
  - Grab sampling methodology is limiting
  - Real-time biosensors could be a practical solution to water quality monitoring

Real-Time Estrogenicity Sensor





The logo was developed by Christian Wolkersdorfer, who kindly provided it.

SPONSORED BY THE

Federal Ministry of Education and Research

Eine Initiative des Bundesministeriums für Bildung und Forschung

Wasser: N
SCHUTZ. NUTZUNG. INNOVATION.

# WP3: Co-production, governance, policy and regulation


**Yasin Imran Rony, Researcher,**
**Urban Living Lab Center, Wuppertal Institute**

**Dr. Oliver Lah - Wuppertal Institute**
**Boitumelo Manala - Wuppertal Institute**
**Dr. Richard Meisner - University of South Africa**
**Dr. Anja Du Plessi - University of South Africa**


UNIVERSITÄT DUISBURG ESSEN
Open-Minded

IWW

Wuppertal Institut

university of south africa
UNISA

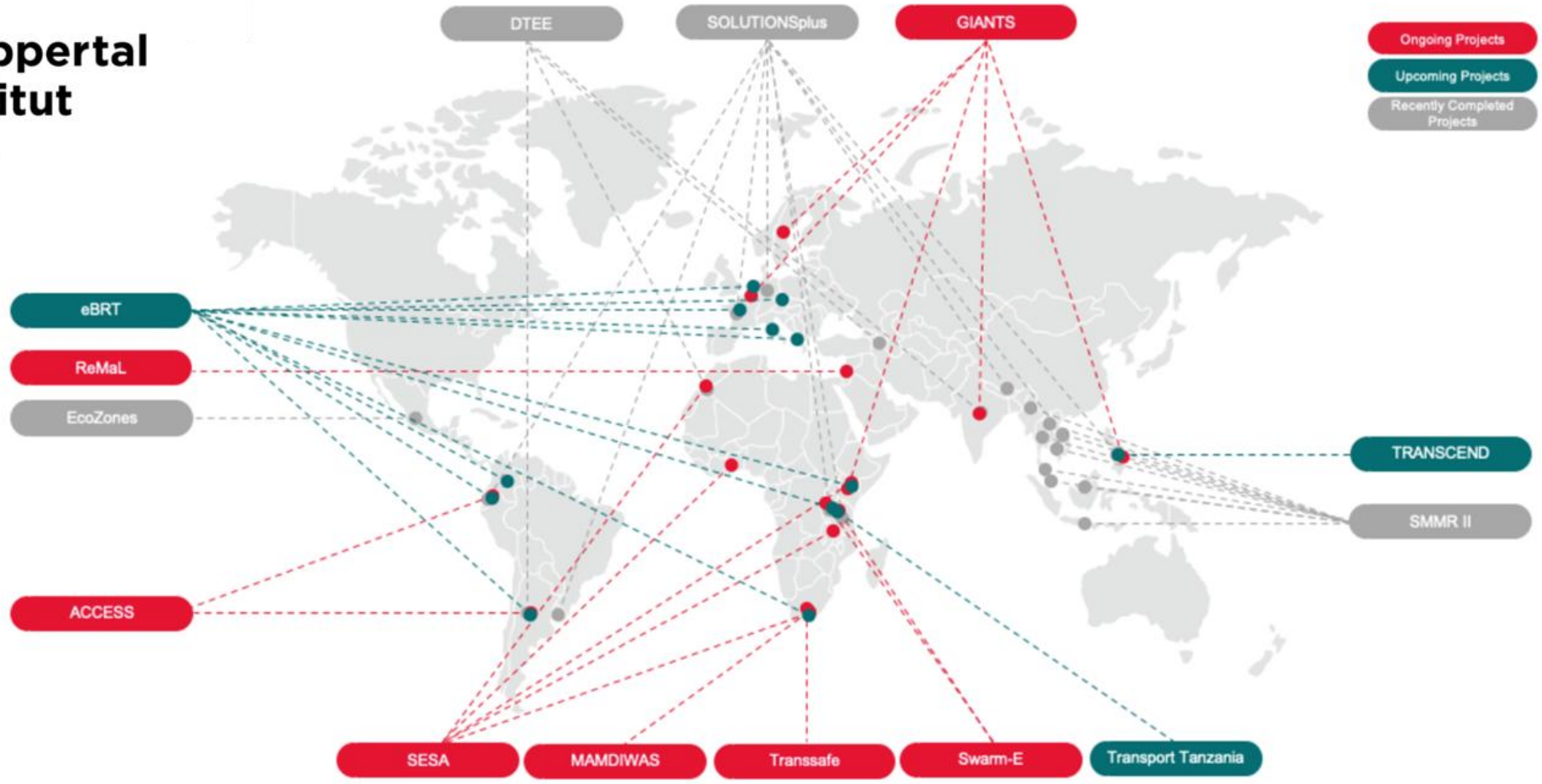
UNIVERSITEIT iYUNIVESITHI STELLENBOSCH UNIVERSITY

IMA tec

# Intro

The Wuppertal Institute Institute is a Germany-based leading research institute on sustainability.
It co-implements the  international collaboration platform “Urban Living Lab Center”, created by UN-Habitat.

Wuppertal Institut




SPONSORED BY THE
Federal Ministry of Education and Research

# Objective

Identify gaps in existing policies and explore regulatory frameworks to support the development of sustainable and integrated management measures for the productive use of reclaimed MIW, focusing on the post-mining phase and its benefits for local communities.

SPONSORED BY THE
Federal Ministry of Education and Research

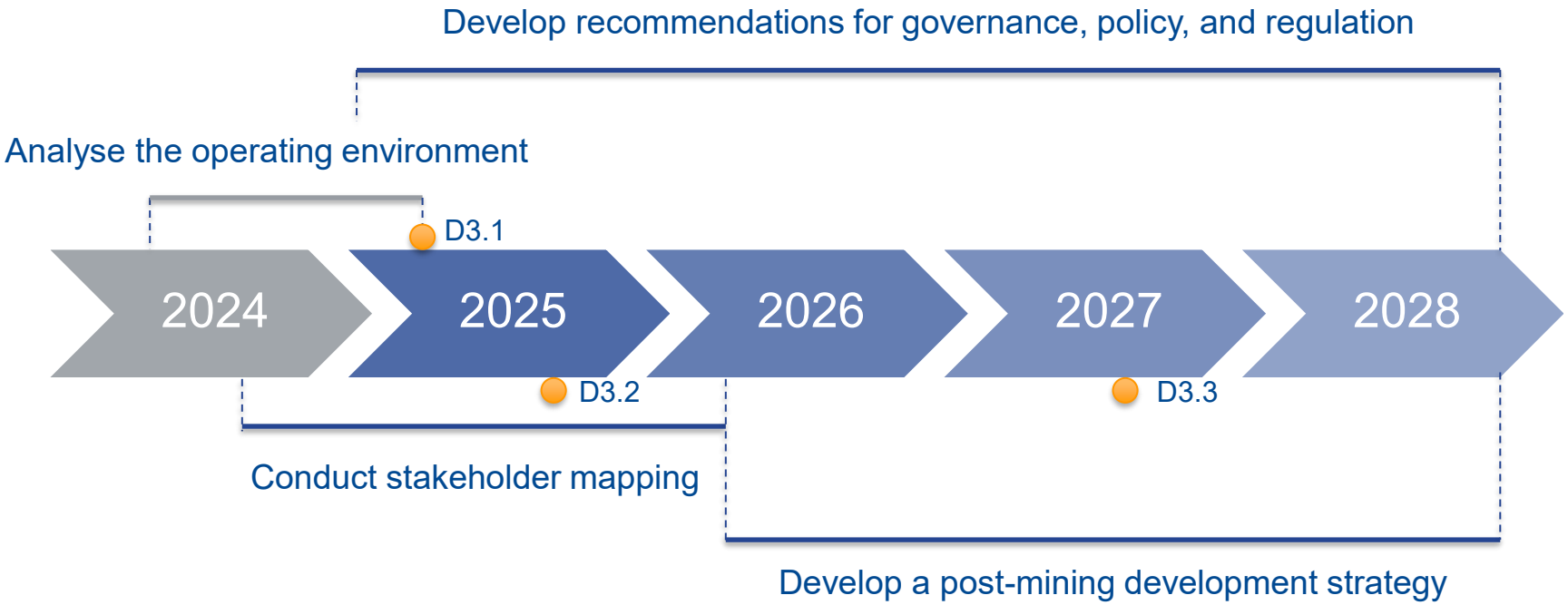
# Overview

WP3.1:Analyse the operating environment - (M1-12)

WP3.2: Conduct stakeholder mapping - (M6-24)

WP3.3: Develop recommendations for governance, policy, and regulation - (M12-48)

WP3.4: Develop a post-mining development strategy - (M24-28)

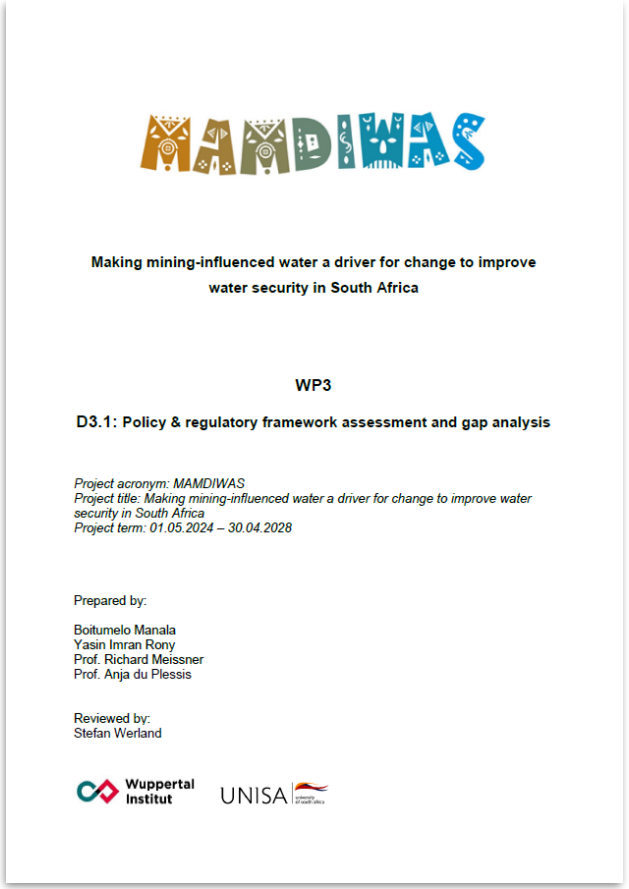



SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Policy and Governance Assessment

- **Purpose**
  - To analyse the policy, regulatory, and governance frameworks shaping the management of mining-influenced water (MIW) in South Africa, with a focus on Merafong as a case study.

- **Objectives**
  - Map existing laws, policies, and institutional roles relevant to MIW, mine closure, and post-mining transition.
  - Identify gaps, overlaps, and enforcement challenges in the governance framework.
  - Assess how current systems impact water security, communities, and post-mining development pathways.
  - Provide learnings from case study and a baseline for WP3 to inform pilot activities, stakeholder dialogues, and recommendations for improved closure and transition planning.



Making mining-influenced water a driver for change to improve water security in South Africa

WP3

D3.1: Policy & regulatory framework assessment and gap analysis

*Project acronym: MAMDIWAS*
*Project title: Making mining-influenced water a driver for change to improve water security in South Africa*
*Project term: 01.05.2024 – 30.04.2028*

Prepared by:

Boitumelo Manala
Yasin Imran Rony
Prof. Richard Meissner
Prof. Anja du Plessis

Reviewed by:
Stefan Werland

Wuppertal Institut UNISA

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Methodology

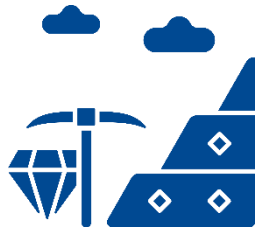
- **Literature review**
  - Focus: Water security, mine closure, mining, mine water management
  - Synthesise and identify gaps in relevant South African legislation
  - Post mining case study - Germany (Ruhr coal region)

- **Site identification**
  - Driefontein (Merafong City Local Municipality)
  - Data Collection

- **Stakeholder engagement**
  - Semi-structured interviews with Sibanye Stillwater, Federation for a Sustainable Environment (FSE)

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Context analysis



## Mining and Environmental Impact in Merafong

- Mining has been central to South Africa's development but left behind severe environmental and social legacies, especially mining-influenced water (MIW) including acid mine drainage (AMD).
- Mining-influenced water (MIW) is affecting water quality and increasing uranium concentrations in local water sources.
- MIW threatens water security, aquatic ecosystems, human health, and local economies.
- Merafong City (Gauteng) is highly dependent on mining (~33.8% of local economy), but mines are approaching closure in the next 5–15 years → urgent need for post-mining transition planning.

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Context Analysis



## Socio-Economic Challenges

- **Economic Decline vs. Urban Expansion:**
  - Unemployment: 27.7% overall; youth unemployment 37.7%.
  - Despite a 3.2% economic decline urban expansion increased by 35%, driven by informal settlements.
  - 10% population decrease (out-migration due to shrinking mining sector)
- **Municipal Service Dissatisfaction**:
  - Only 16% of residents are satisfied with municipal service costs.
  - 72% dissatisfaction rate with local government (up from 45% in 2017/18).
- **Water Security Issues:**
  - Despite 81.9% piped water access, high non-revenue water (~36.6%) due to infrastructure inefficiencies.
  - Debt to Rand Water (~R54 million) impacting service delivery.

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Policy analysis



## Governance and policy landscape

- **Strong legal framework:**
  - Mine closure governance includes strong legal structure: Planning for closure, financial provisions for rehabilitation, & closure certification
  - Involves multiple government departments with sometimes overlapping responsibilities.
    - The Department of Mining Resource and Energy (DMRE)
    - The Department of Water and Sanitation (DWS)
    - The Department of Environment, Forestry and Fisheries (DEFF)
  - One Environmental System
    - Implemented the system to bring together three key departments (DMRE, DWS, DEFF) for better coordination.

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Key Gaps



## Governance, Mine Closure and Post-Mining Transition

- **Regulatory Gaps:**
  - Institutional fragmentation: lack of coordination between ministries and unclear role division.
  - Financial limitations: Rehabilitation funds often inadequate to cover long-term closure and post-closure management.
  - Enforcement challenges: Laws exist but are inconsistently applied; few closure certificates issued (2011–2016: 787 total, only 27 for actual mining rights).
  - Unclear liability: No effective mechanisms to address historical pollution and assign responsibility.
- **Community Struggles:**
  - Lack of consultation and participation in mine closure planning.
  - Poor collaboration between mining companies and municipalities worsens transition planning.
  - Prevailing illegal mining (zama-zamas) in the abandoned or poorly closed shafts

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Post-Mining Transition in Germany



## Regulatory Framework for Mine Closure

- Germany has a highly regulated mine closure process, ensuring that mining companies fulfill environmental and social responsibilities.

## Environmental Rehabilitation and Repurposing

- Post-mining land use strategies in Germany include:
  - Renewable energy projects, such as converting former mining sites into solar farms (e.g., Matra Power Plant in Hungary)
  - Industrial heritage and tourism, where former mining infrastructure is repurposed for cultural and economic activities (e.g., Zollverein World Heritage Site)

## Governance and Multi-Stakeholder Engagement

- Governance structures in German coal transition regions emphasize multi-level collaboration, involving regional authorities, civil society, and private stakeholders.

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Post-Mining Job Creation in Germany



## Economic Diversification & Skills Development

- Fostering industries such as renewable energy, digital economy, and sustainable tourism.
- Reskilling and upskilling programs for former miners.
- Investment in local entrepreneurship and small businesses

## Public and Private Sector Cooperation

- Supports collaboration between business associations, trade unions, and municipalities to create new job opportunities in post-mining regions.

## Long-Term Employment Strategies

- Focusing on integrating employment strategies with environmental and social goals. For example:
  - Using former mining infrastructure for water management and ecological restoration, creating new technical and environmental jobs.
  - Supporting startups and innovation hubs in affected regions

SPONSORED BY THE
Federal Ministry of Education and Research

# WP3.1: Key lessons



## Opportunities identified

- **Policy & Coordination:**
  - Strengthen One Environmental System with regional closure planning.
  - Harmonize closure criteria & environmental risk thresholds.
  - Align municipal IDPs and MSDFs with mine-closure strategies.
- **Water reuse as opportunity:**
  - Treat AMD/MIW for potable, industrial, or irrigation use where safe.
  - Develop PPPs for treatment plants.
- **Job opportunity:**
  - New roles in monitoring, O&M of treatment plants.
  - Small enterprises in reuse, sludge management, stormwater retrofits, nature-based solutions.
- **Multi-actor approach:**
  - Effective post-mining governance requires involvement from government, private sector, civil society, and communities.

SPONSORED BY THE
Federal Ministry of Education and Research

The logo was developed by Christian Wolkersdorfer, who kindly provided it.

SPONSORED BY THE
Federal Ministry of Education and Research

# Thank you!

Open-Minded