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XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco| 1-5 December 2025

Kingdom of Morocco
Ministry of Equipment and Water

The Testing and Application of the SWAT+ Water Allocation and Decision Tables for Nutrient Loads Simulations: A Case Study of the Integrated Vaal River System, South Africa

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01 December 2025

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Introduction

Gauteng river turns toxic

POLITICS

Sewage pollution in Vaal River catchment threatens water security - AfriForum

Marais de Vaal | 15 November 2024

Gauteng's water systems are already under tremendous pressure due to chronic municipal mismanagement

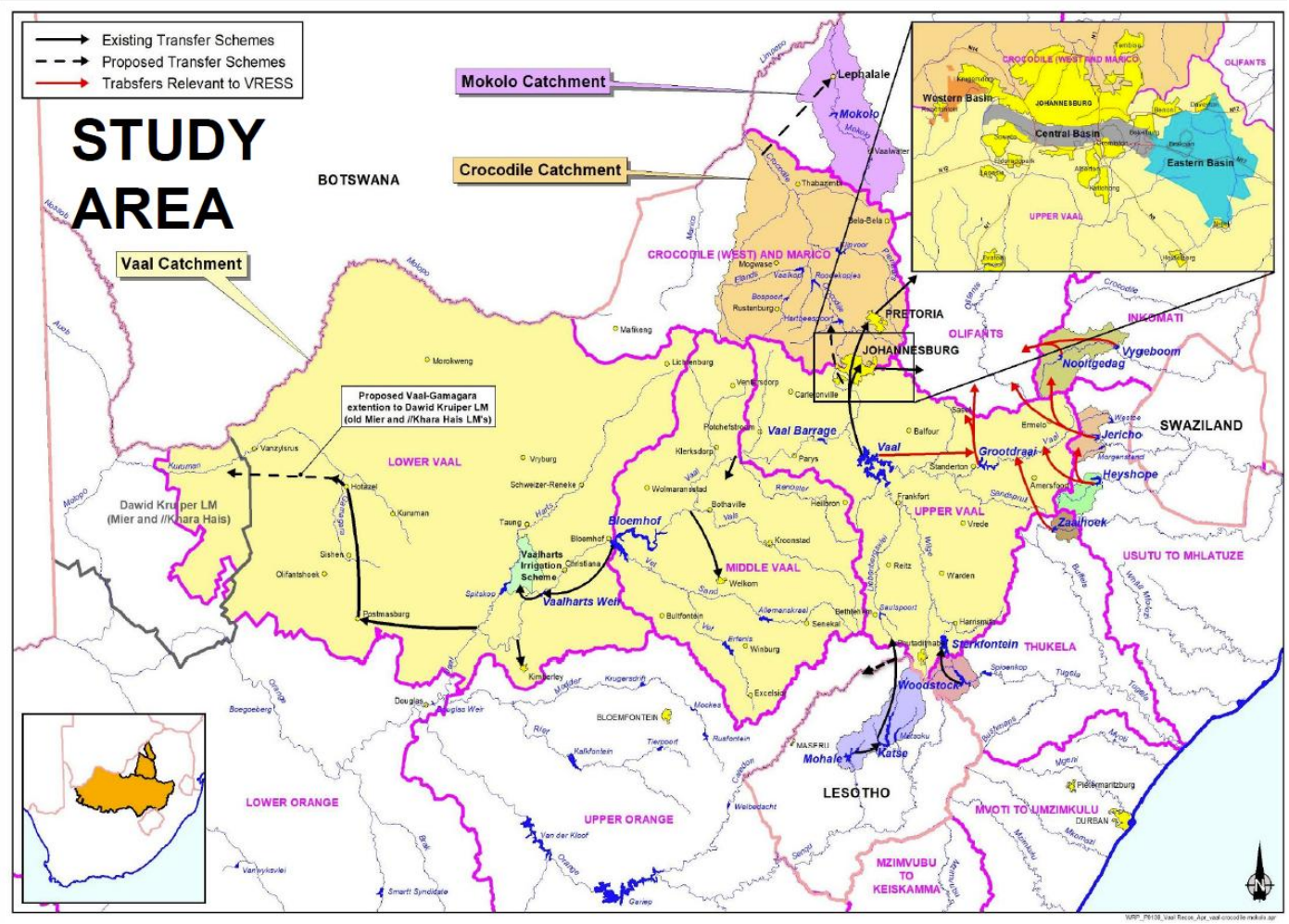
Sewage pollution in the Vaal River catchment threatens Gauteng's water security

Pollution in Vaal River poses risk after detection of cholera

by Charné Kemp in News on 10 October 2024

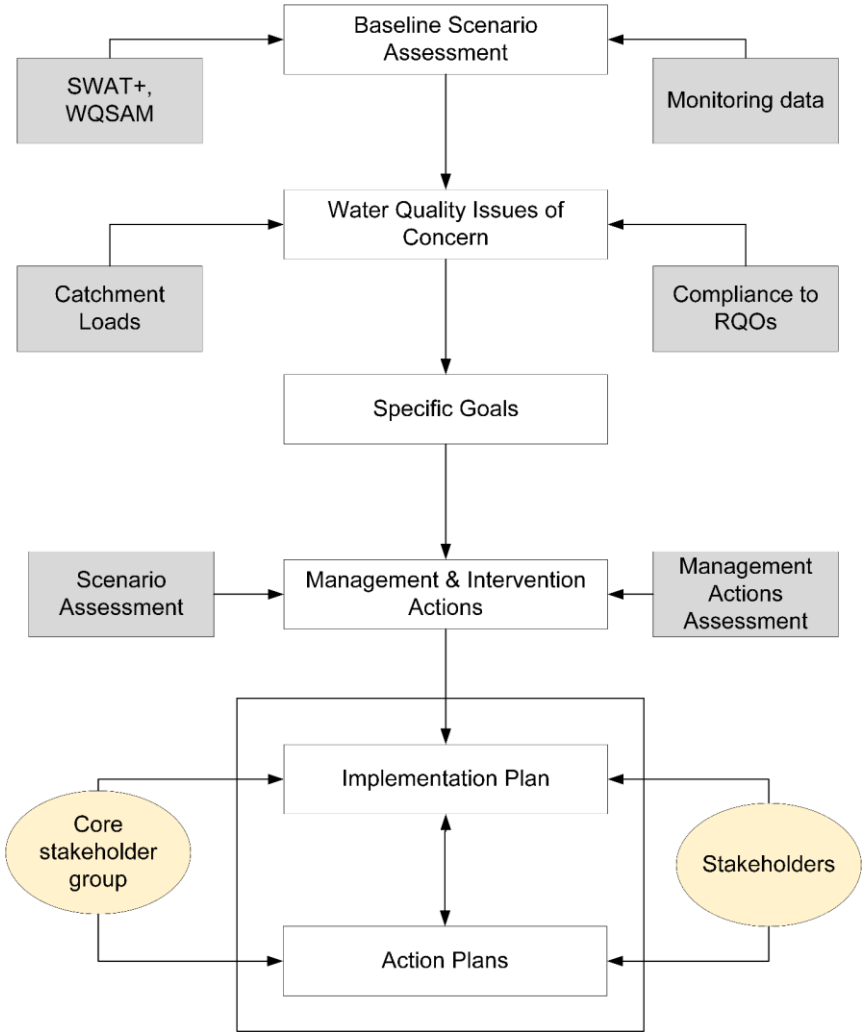
- The catchment areas of the IVRS are experiencing a **deterioration in water quality** at an alarming rate
- **Salinity , Eutrophication, Localized microbial contamination & emerging pollutants.**
- Water requirements already exceed the available supply
- Impacts of **climate related pressures** and the increase in water demands, more pressure on water quality will continue to be evident in the water resources of the IVRS.

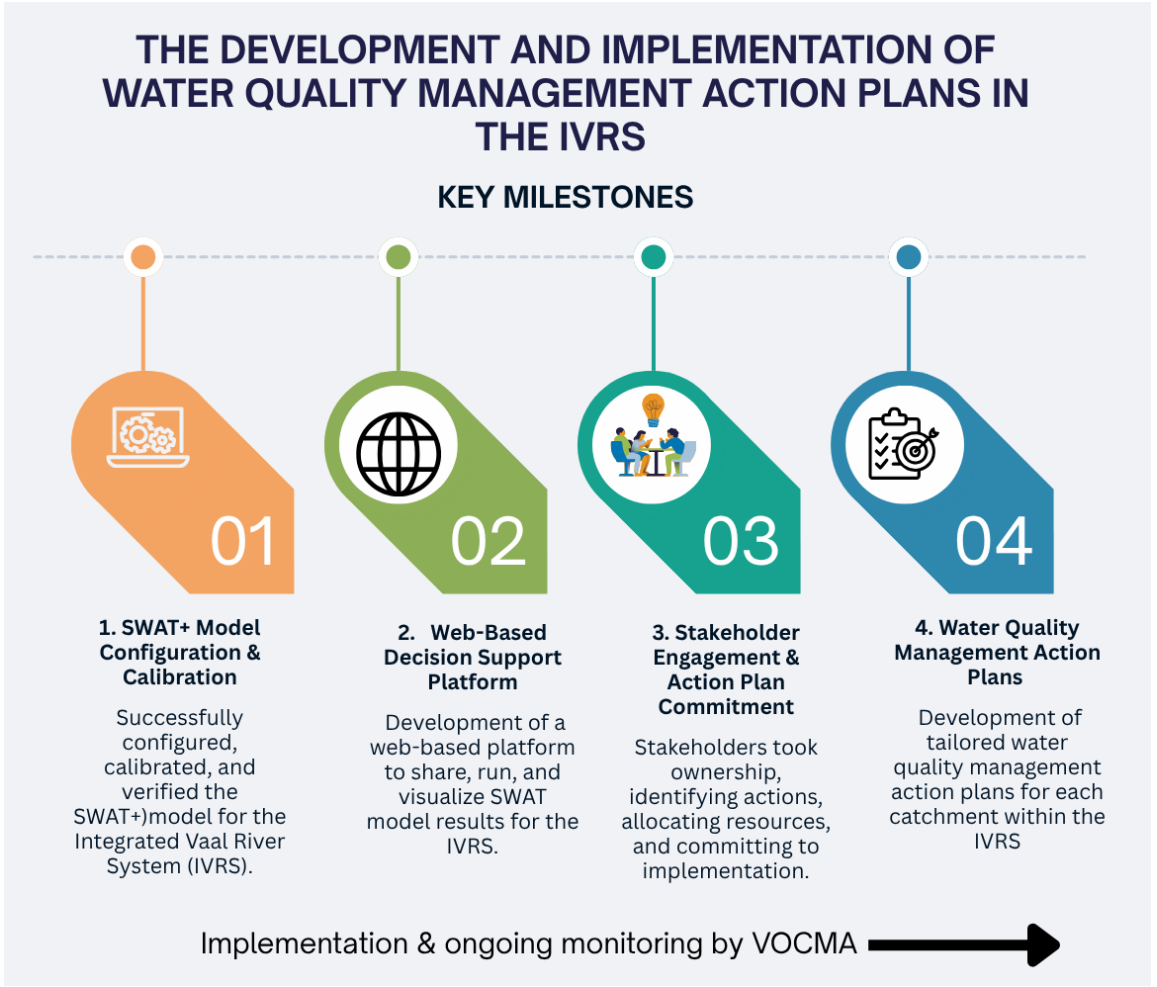
Integrated Vaal River System (IVRS)



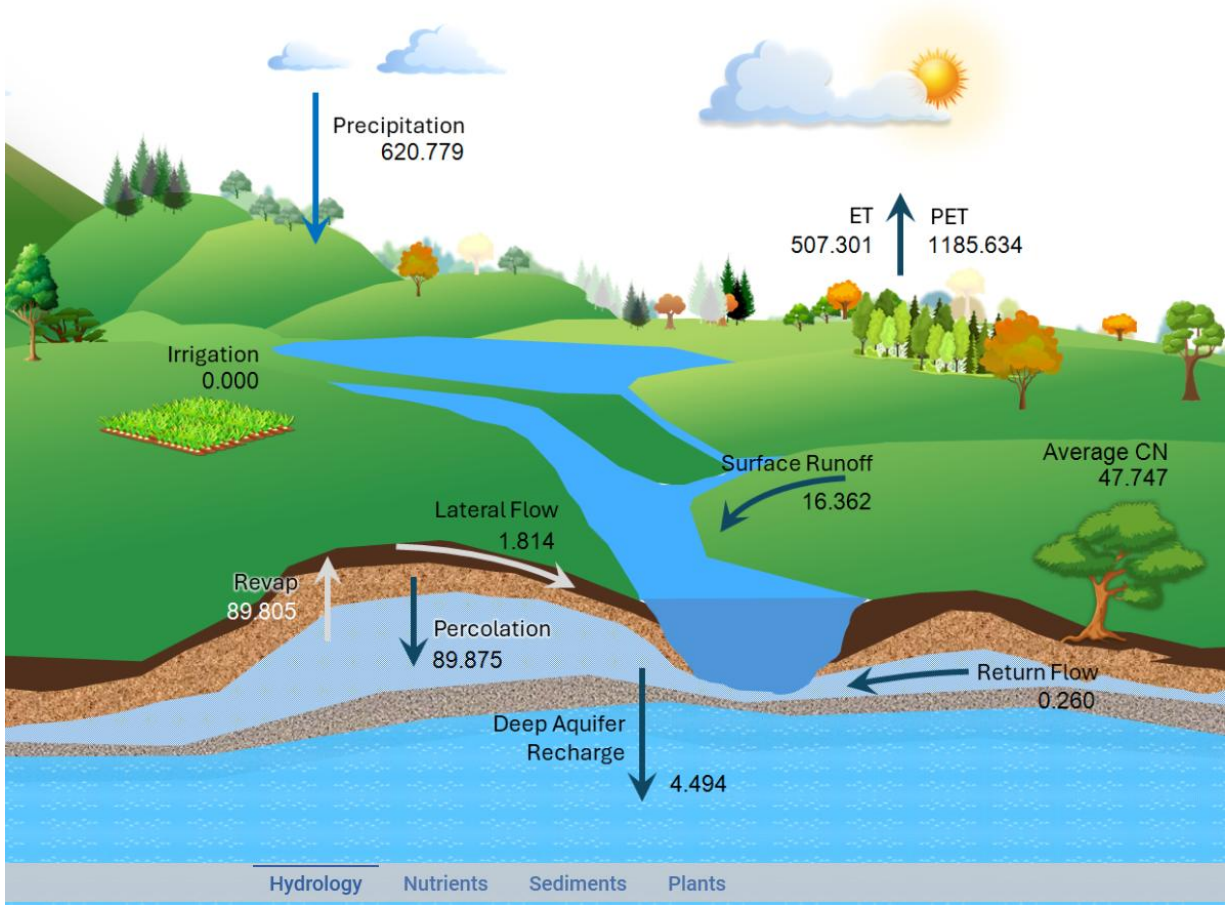
- The IVRS is a critical system in South Africa that **supplies bulk water to the Gauteng Province** (economic hub).
- **Critical for Transboundary Obligations**
- Water quality management in this IVRS complex water system has been mainly based on the Water Quality TDS (WQT) Model – **WRPM (operating rules).**
- Traditional Rainfall-Runoff models do not incorporate **management actions**

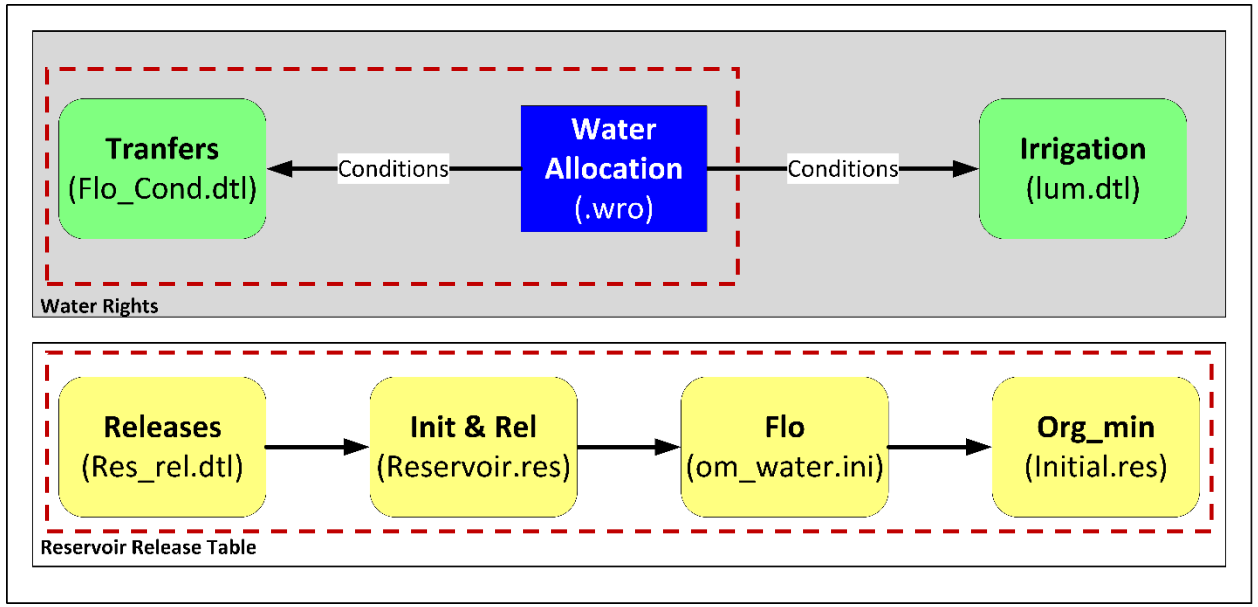
Integrated Water Quality Management Action Plans





SWAT-plus Model: Management Actions





- **Water transfers and abstractions -** (water allocation.wro & flo_cond.dtl).
- **Dam Releases** – Reservoir Release tables

Water Allocation (transfers-in & abstractions)

A

NAME	RULE_TYP	SRC_OBS	DMD_OBS	CHA_OB
groot_sink	high_right_first_serve	3	5	n

NUM	OB_TYP	OB_NUM	MIN MONTHLY (M3/S FOR CHANNELS; FRAC PRIN SPILL FOR RES; DEP BELOW SURF FOR AQU)
1	res	3	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01
2	res	1	0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18 0.18
3	unl	0	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00

B

NUMB	OB_TYP	OB_NUM	WITHDR	AMOUNT	W_RT	TR_TYP	TREAT	RCV_OB	RCV_NUM	RCV_DTL	SRCS	SCRC1	FRAC1	COMP1	DESCRIPTION
1	divert	1	ave_day	518400.0	sr	null	null	groot_vlak	1	null	1	1	1.0	n	
2	divert	1	ave_day	52000.0	sr	null	null	groot_tutu	1	null	1	1	1.0	n	
3	divert	1	ave_day	2353110.5	sr	null	null	zuikerb	1	null	1	2	1.0	n	
4	divert	1	ave_day	2063731	sr	null	null	cha	267	null	1	3	1.0	n	
5	divert	1	heyszaai_gro	0.0	sr	null	null	cha	72	null	1	3	1.0	n	

name	conds	alts	acts
heyszaai_gro	1	1	1

var	obj	obj_num	lim_var	lim_op	lim_const	alt1
vol	res	3	pvol	*	0.75000	<

act_typ	obj	obj_num	name	option	const	const2	fp	outl
divert	null	0	groot_in	flo_cms	4.8	0.00000	null	y

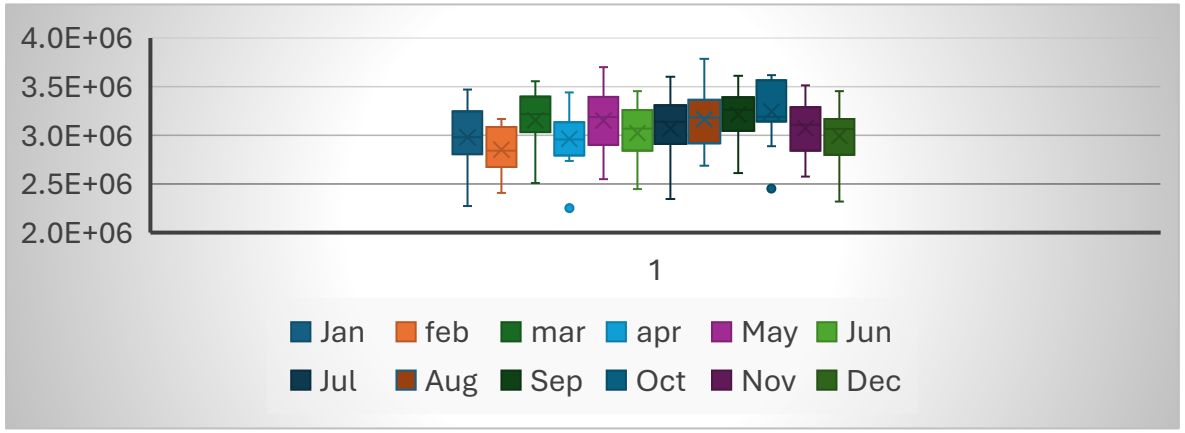
Reservoir Releases dtl

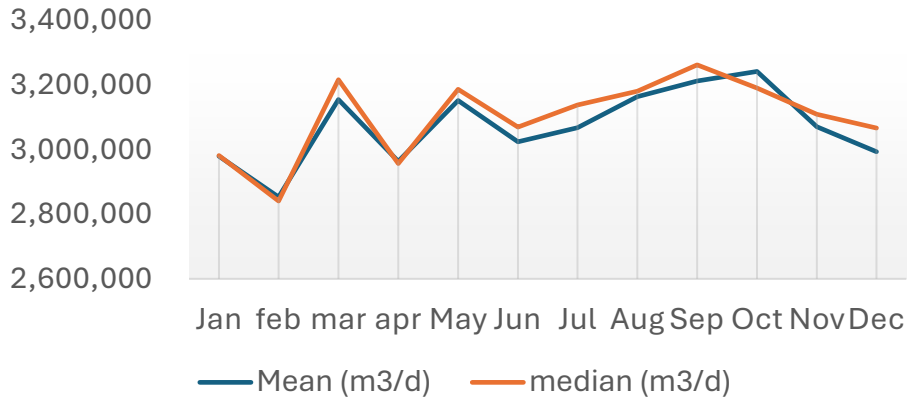
name	conds	alts	acts							
vaal_release	5	3	3							
var	obj	obj_num	lim_var	lim_op	lim_const			alt1	alt2	alt3
vol	res	1	pvol	*	1.00000			-	>=	-
vol	res	1	pvol	*	0.18000			>=	-	-
res_inflo	res	1	null	-	100.00000			-	>=	-
jday	null	0	null	-	271.00000			-	-	>
jday	null	0	null	-	274.00000			-	-	<
act_typ	obj	obj_num	name	option	const	const2	fp	outcome		
release	res	0	vaal_const	rate	17.50000	0.00000	null	y	n	n
release	res	0	vaal_flood	inflo_frac	1.00000	0.00000	null	n	y	n
release	res	0	vaal_tds	rate	33.00000	0.00000	null	n	n	y

```
! If  water volume in reservoir 1 [alt]  principal volume
! If  water volume in reservoir 1 [alt] 18.00% of  principal volume
! If res_inflo in reservoir 1 [alt] 100
! If julian day [alt] 271
! If julian day [alt] 274

! release  at the rate of 17.5 m3/s
! release  100% of inflow
! release  at the rate of 33 m3/s
```

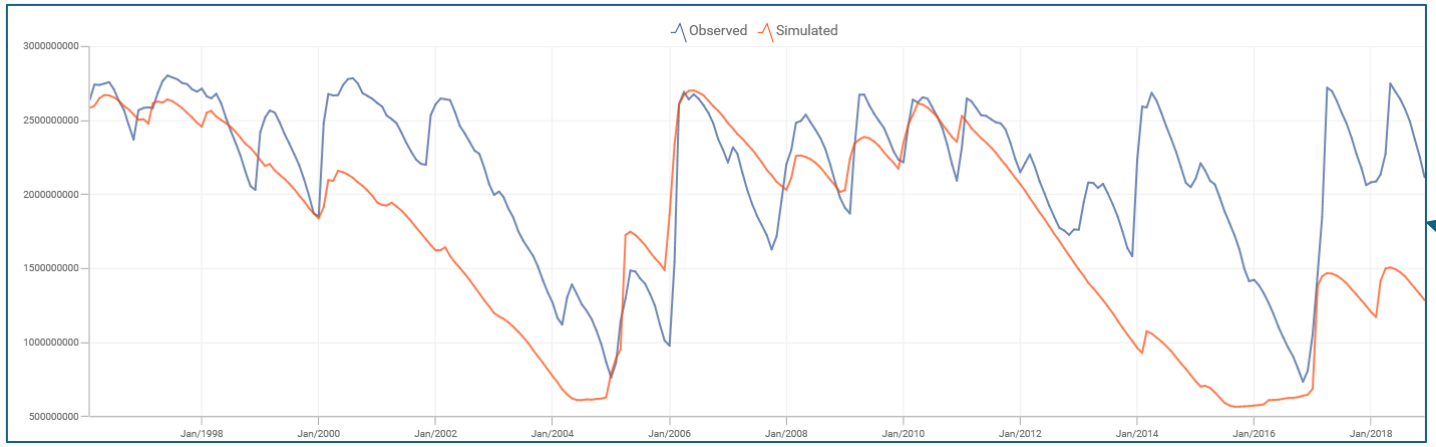
name	conds	alts	acts						
groot_release	2	2	2						
var	obj	obj_num	lim_var	lim_op	lim_const			alt1	alt2
vol	res	3	pvol	*	1.00000			>=	-
vol	res	3	pvol	*	0.10000			-	>=
act_typ	obj	obj_num	name	option	const	const2	fp	outcome	
release	res	0	groot_flood	inflo_frac	1.00000	0.00000	null	y	n
release	res	0	groot_const	rate	0.90000	0.00000	null	n	y

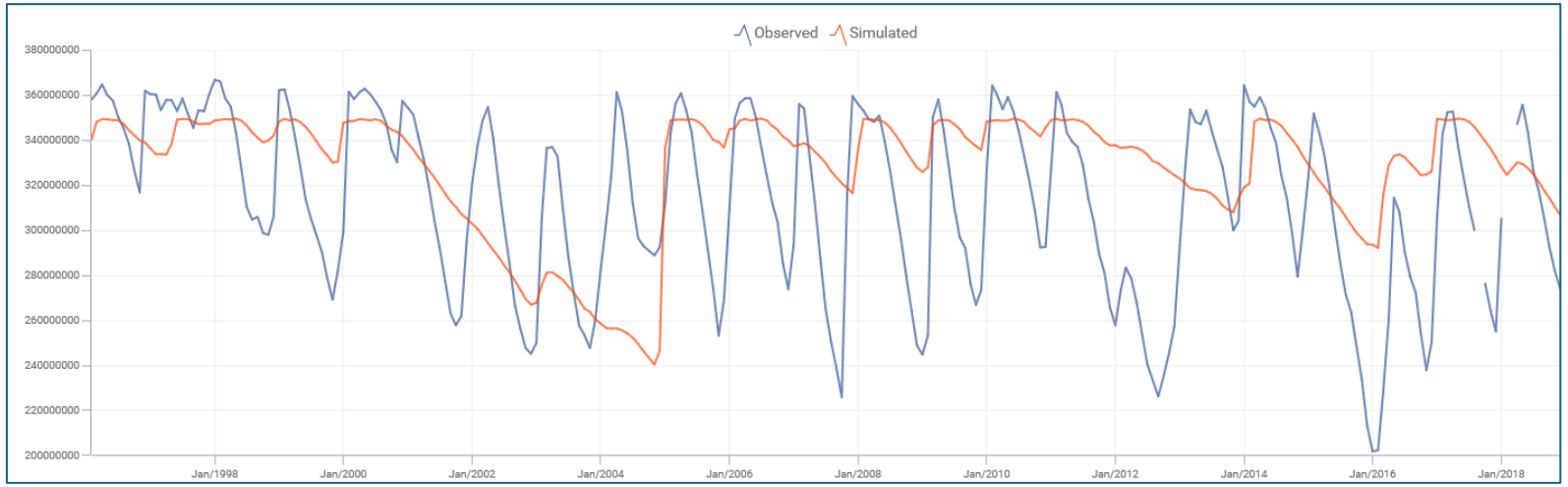
```
! If  water volume in reservoir 3 [alt]  principal volume
! If  water volume in reservoir 3 [alt] 10.00% of  principal volume

! release  100% of inflow
! release  at the rate of 0.9 m3/s
```

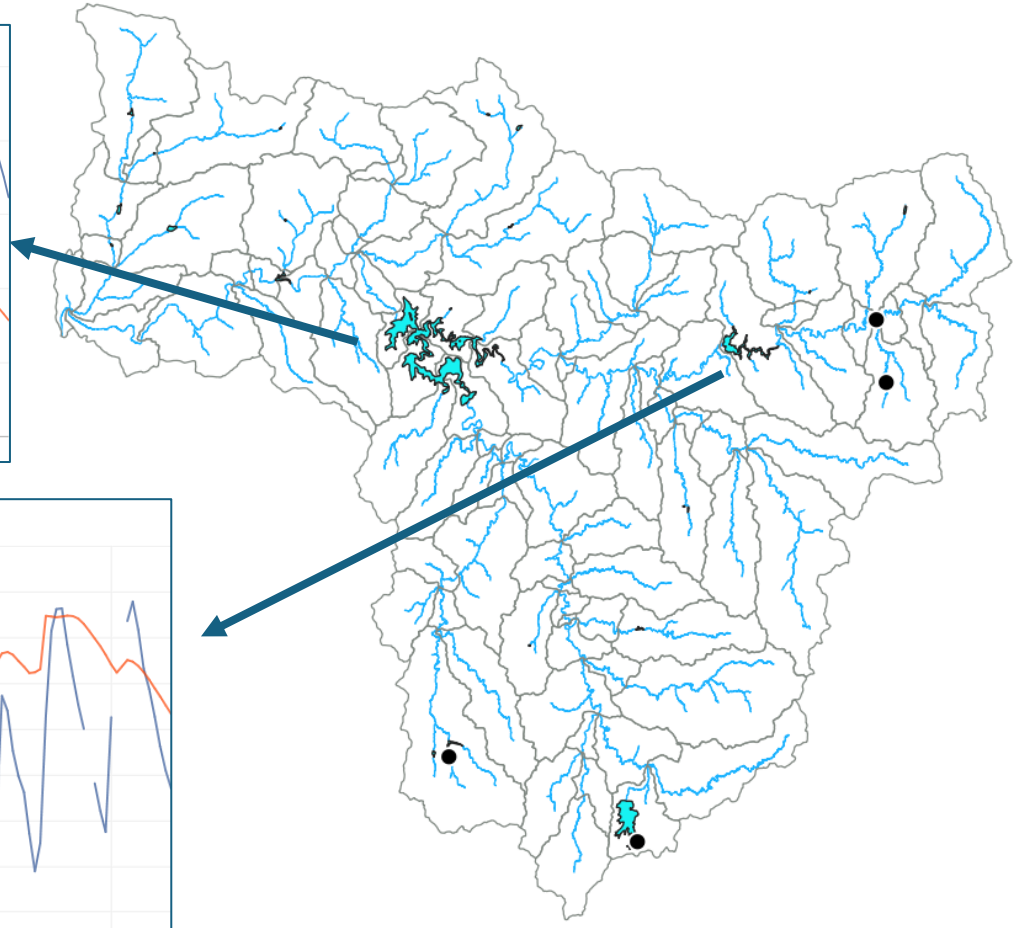




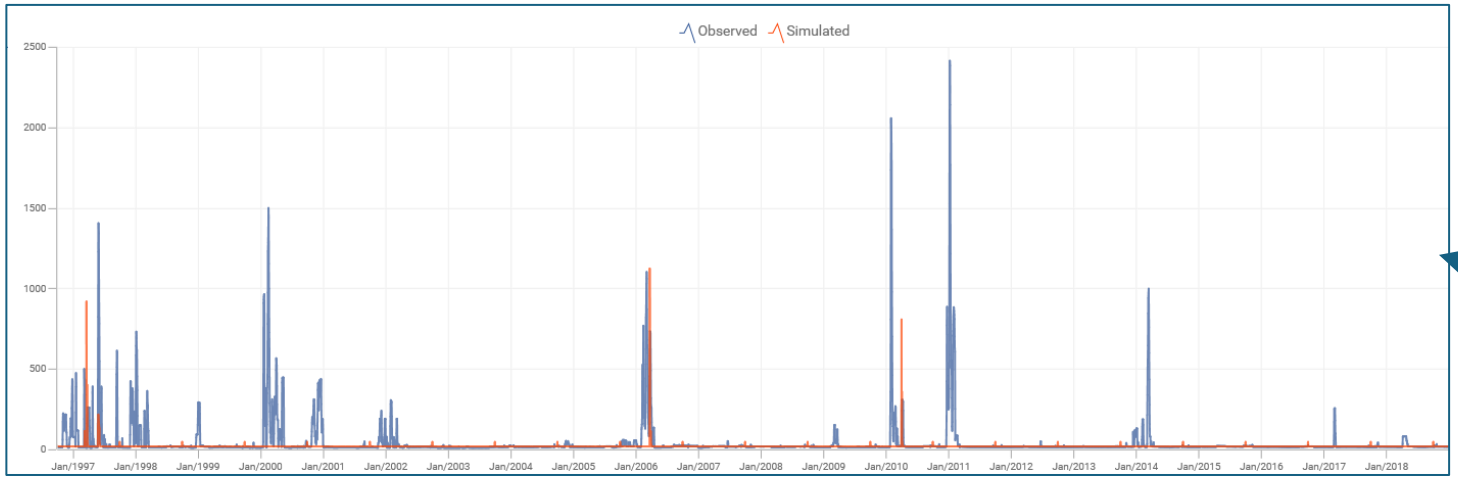
Results: Storage

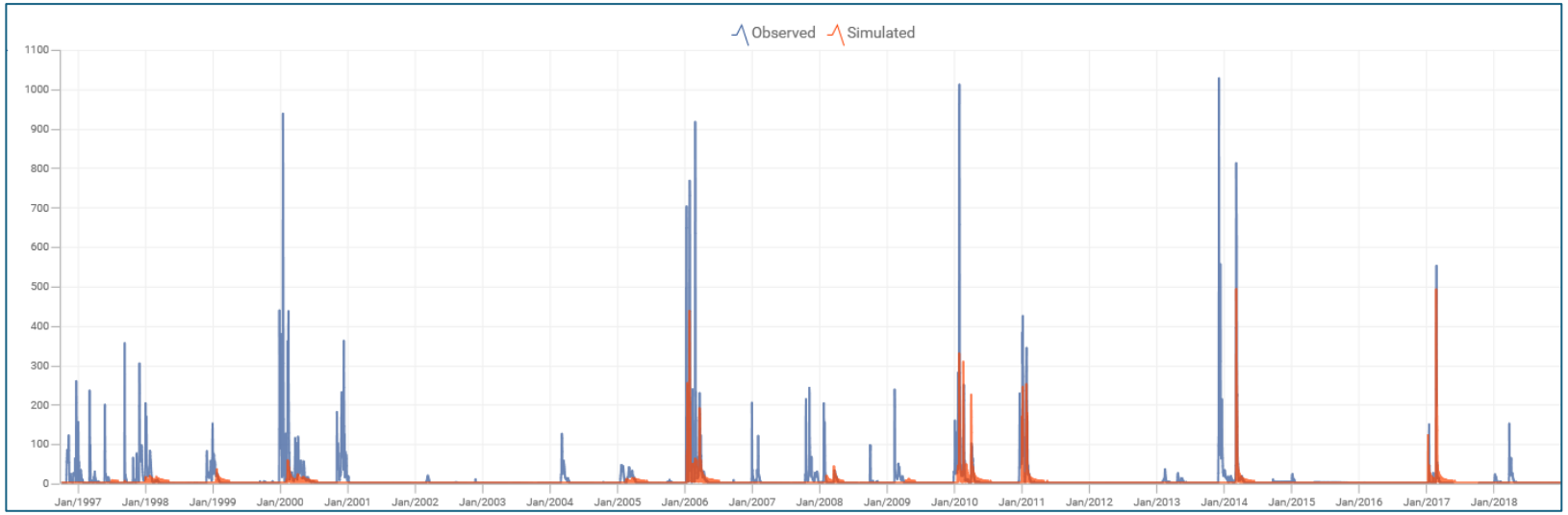


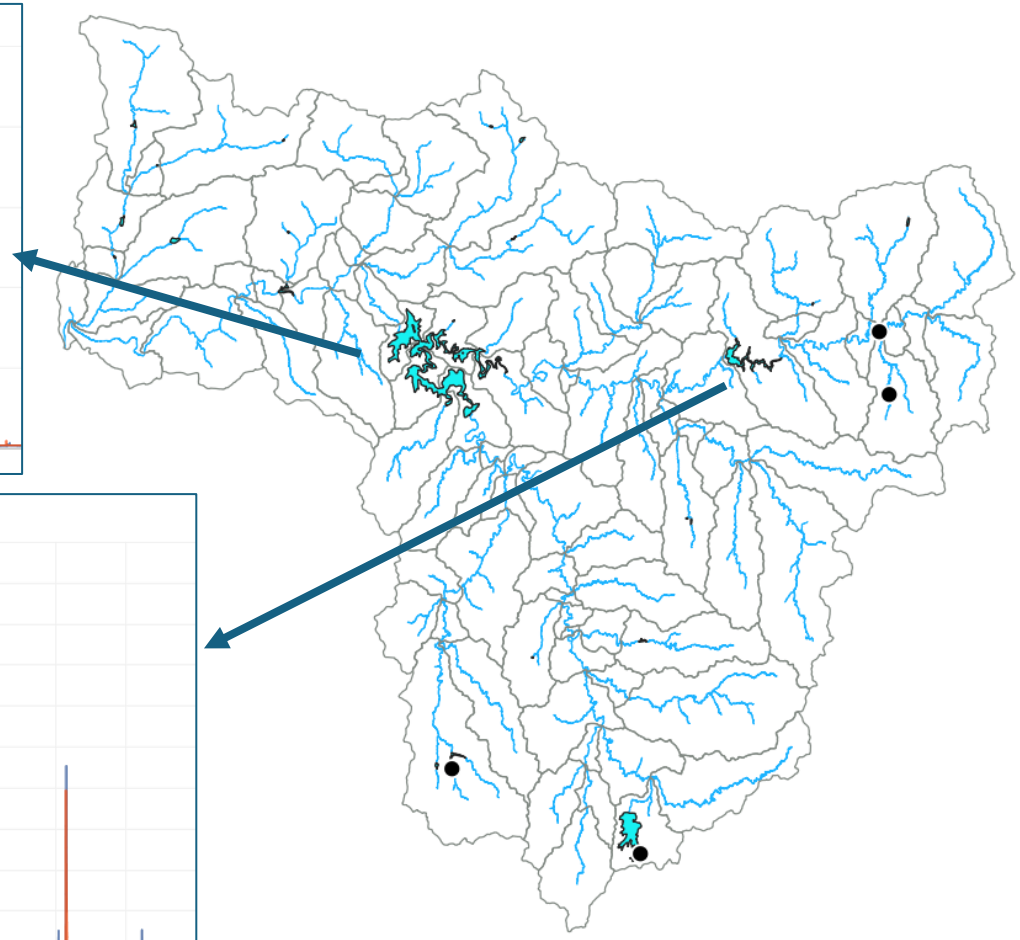




Results: Controlled Releases





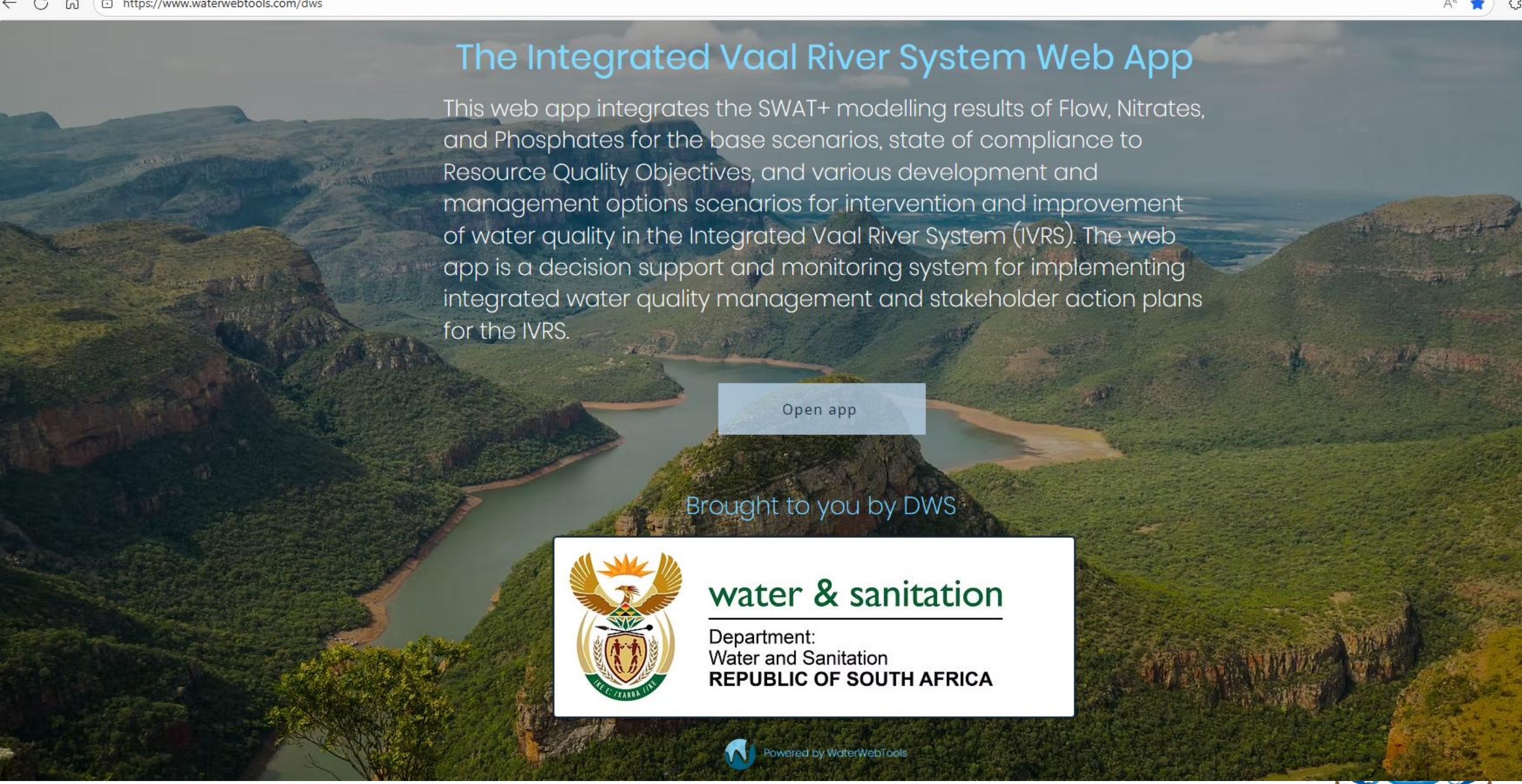


Key Messages

- The new SWAT+ water allocation module and decision tables for incorporation of management action has **produced plausible results** for the IVRS system.

- The IVRS SWAT+ model can now be used for **annual operation analysis** and future predictions for **management actions and interventions** for water quality management

- This study contributes to enhancing water quality monitoring systems, where the **spatial and temporal limitations in water quality monitoring data** should be augmented by predictions using hydrologic water quality models incorporating management action (system operating rules).


https://www.waterwebtools.com/dws
The Integrated Vaal River System Web App
This web app integrates the SWAT+ modelling results of Flow, Nitrates, and Phosphates for the base scenarios, state of compliance to Resource Quality Objectives, and various development and management options scenarios for intervention and improvement of water quality in the Integrated Vaal River System (IVRS). The web app is a decision support and monitoring system for implementing integrated water quality management and stakeholder action plans for the IVRS.
Open app
Brought to you by DWS
water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA
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Menu

WaterWebTools

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Layers View

- Lakes and reservoirs
- Landscape units
- Other
- Point sources
- Stations
- Streams
- Subbasins

Report View

About | Landscapes | Reservoirs | Point Sources | Scenarios | RQO | Performance

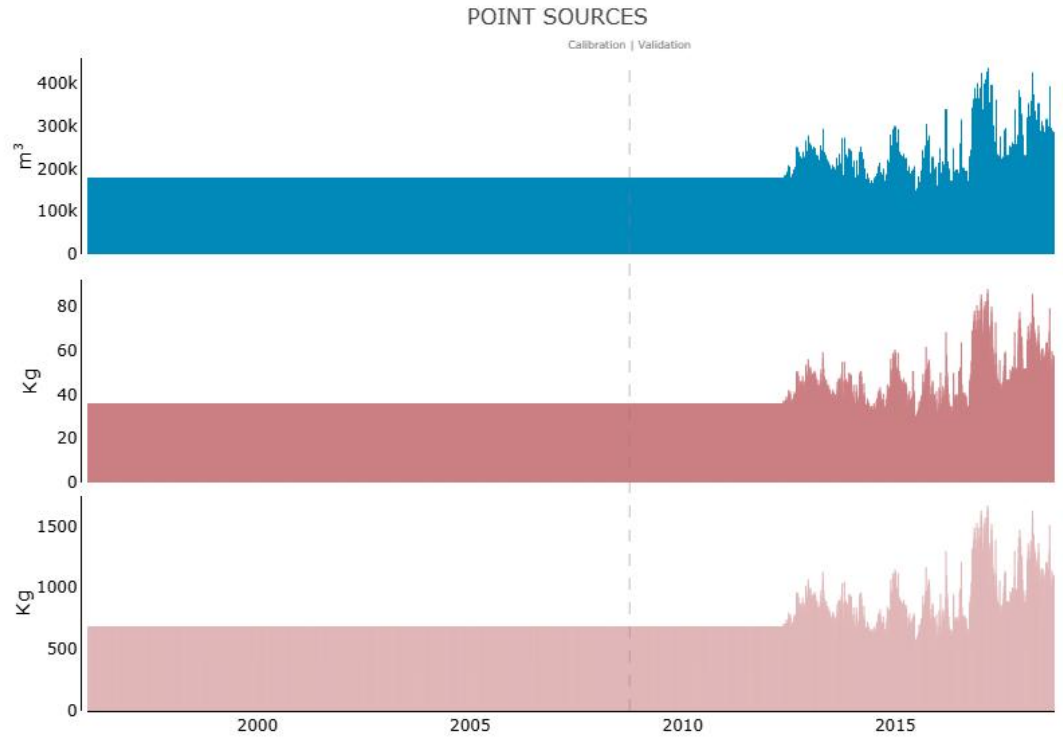
Select temporal resolution

Daily

SWAT model

Point source Id = 167

Name = Waterval (Midvaal LM)



Layers View

- Lakes and reservoirs
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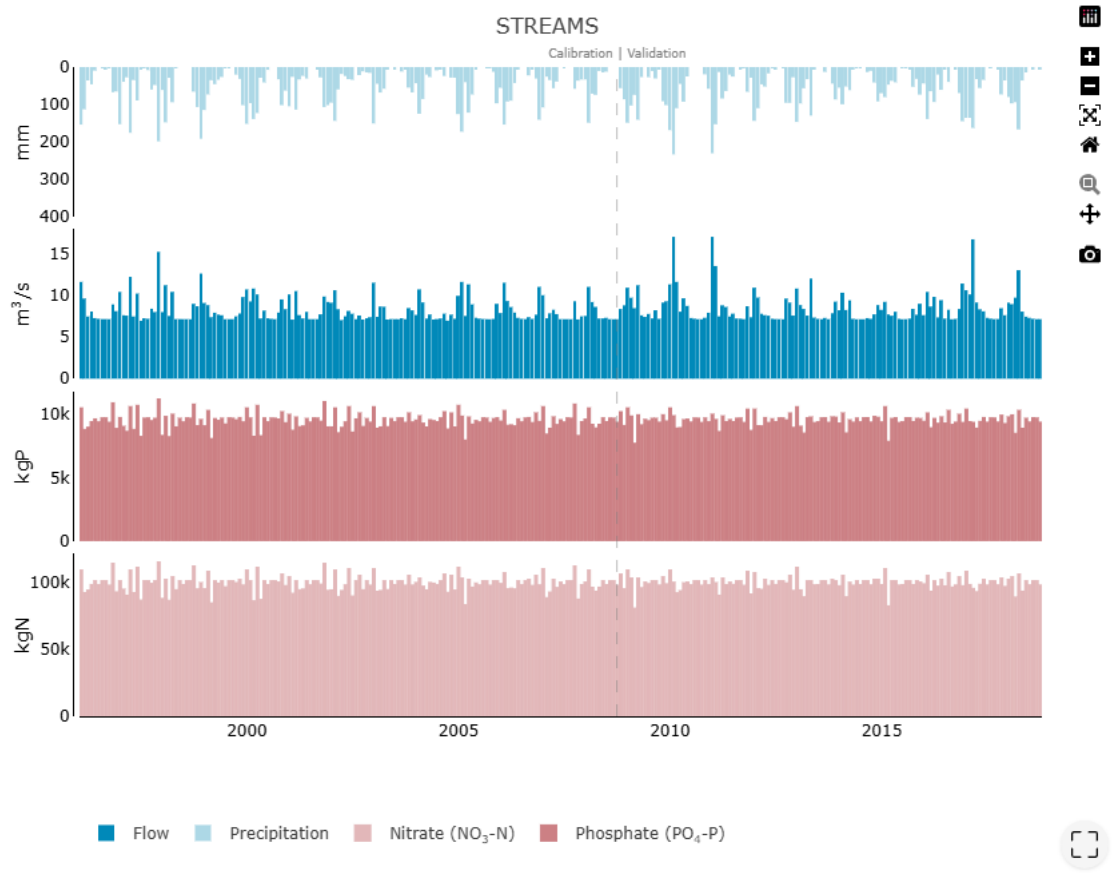
- Other
- Point sources
- Stations
- Streams
- Subbasins

Report View

SWAT model

Channel Id = 31
Aquifer Id = 40
LSU Id = 310



Menu

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Layers View

- [x] Lakes and reservoirs
- [ ] Landscape units
- [x] Other
  - [x] RQO
- [x] Point sources
- [x] Stations
- [x] Streams
- [x] Subbasins

Report View

chemical, and biological characteristics of the water (c) character and condition of the instream and riparian habitat; and (d) characteristics, condition and distribution of the aquatic biota.

Select EWR station

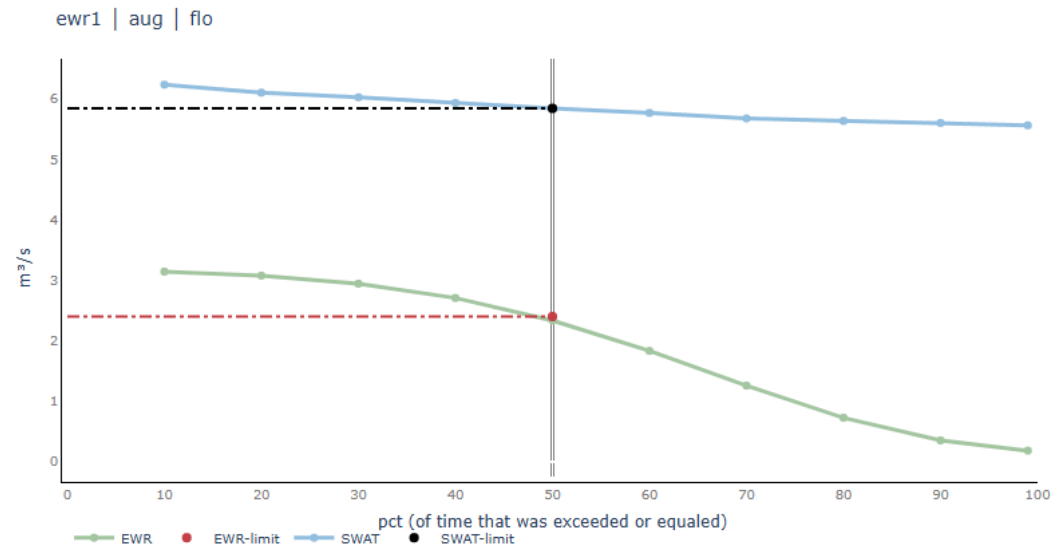
EWR 1

Select month

Aug

Select variable

Flow



Kriel
Bethal
Secunda
Breyten
Ermelo
Morgenzon
Standerton
Amersfoort
Daggakraal
Cornelia
Volksrust
Wakkerstroom
Louwsburg

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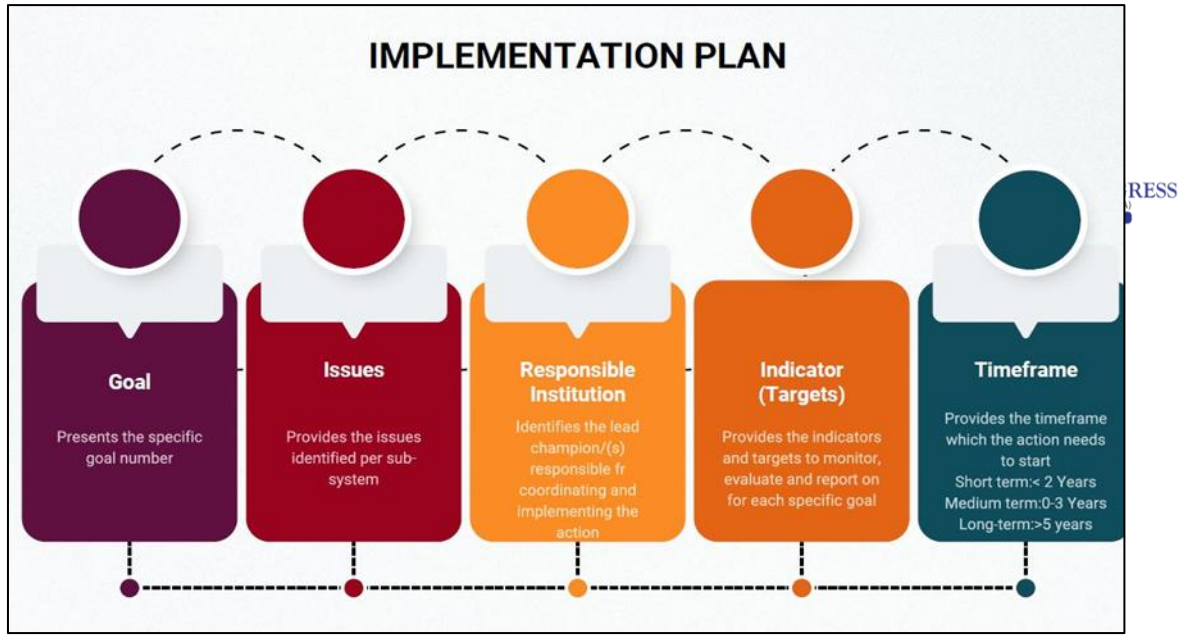
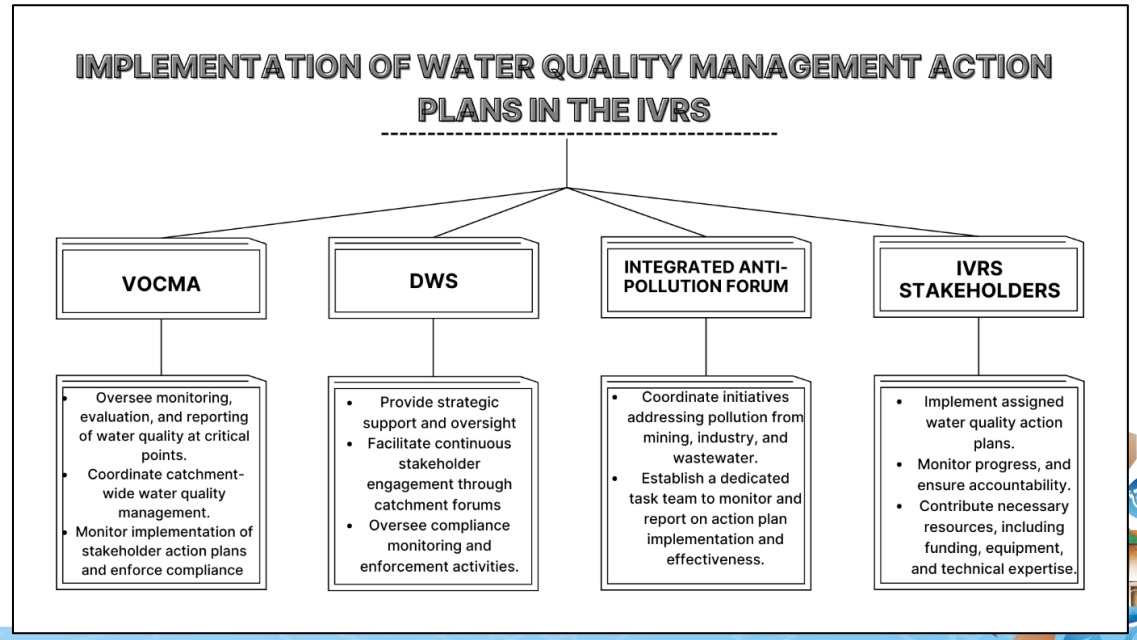
IWQMPs


1
Ensure Compliance with Resource Quality Objectives (RQOs)
2
Reduction in catchment nutrient and salt load and improve effluent compliance
3
Improve flow and Water Quality Monitoring and Information Management System
4
Improved Institutional Governance
5
Infrastructure Development and Maintenance: Water Sanitation Services and Improved Storm Water Management
6
Improve Solid Waste Management and Awareness
7
Water Conservation
Water Demand Management
8
Capacity Building
9
Research, Development and Innovation


IMPLEMENTATION PLAN
Goal
Presents the specific goal number
Issues
Provides the issues identified per sub-system
Responsible Institution
Identifies the lead champion/(s) responsible fr coordinating and implementing the action
Indicator (Targets)
Provides the indicators and targets to monitor, evaluate and report on for each specific goal
Timeframe
Provides the timeframe which the action needs to start
Short term:< 2 Years
Medium term:0-3 Years
Long-term:>5 years


IMPLEMENTATION OF WATER QUALITY MANAGEMENT ACTION PLANS IN THE IVRS
VOCMA
Oversee monitoring, evaluation, and reporting of water quality at critical points.
Coordinate catchment-wide water quality management.
Monitor implementation of stakeholder action plans and enforce compliance
DWS
Provide strategic support and oversight
Facilitate continuous stakeholder engagement through catchment forums
Oversee compliance monitoring and enforcement activities.
INTEGRATED ANTI-POLLUTION FORUM
Coordinate initiatives addressing pollution from mining, industry, and wastewater.
Establish a dedicated task team to monitor and report on action plan implementation and effectiveness.
IVRS STAKEHOLDERS
Implement assigned water quality action plans.
Monitor progress, and ensure accountability.
Contribute necessary resources, including funding, equipment, and technical expertise.

Acknowledgements

- **PSC members: Chaired by:** Deborah Mochotlhi (DDG: WRM)
- **PMT members**
- **Project Leader:** Dr Moloko Matlala
- **Project Manager:** Nondumiso Mabe
- **Deputy Project Manager:** Andy Sambo
- **WRC**
- **Randwater**
- **VOCMA**
- **Aarhus University - Denmark:** Dr Katrin Bieger
- **North West University:** Dr Edward Smith

Study Team:

- Joshua Rasifudi
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- Mbali Dlamini
- Hulisani Mafenya
- Mirrander Ndhlovu
- James Berkland
- Anna Mamothe Ramothello
- Thandekile Mbili

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Thank you!

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