Mafube Coal Mine Water Irrigation Project

Subtitle: From the Environmental Coordinator's View

By

Ingrid Sithole

01 April 2026

Transforming mine water into a sustainable asset and mine closure water management

The Background to the Project

The research history

1980's	Preliminary International Evaluation of Mine Water Irrigation Potential (Israel @ Arnot Colliery); ▪ Early international expert assessments, including site evaluations and institutional engagement, indicating the long-term suitability of mine water for agricultural irrigation.
1993-2007	Experimental Investigation and Environmental Impact Assessment; ▪ A sustained phase of laboratory, glasshouse, and field-based irrigation trials across selected coalfield sites, accompanied by comprehensive Water Research Commission (WRC) studies assessing environmental sustainability and groundwater impacts.
2013-2014	Feasibility Analysis within a Regional Acid Mine Drainage Management Framework; ▪ Detailed feasibility study examining irrigation with treated mine water as a component of a long-term, basin-scale neutralised acid mine drainage management strategy in the Vaal Basin.
2016	Operational-Scale Demonstration of Mine Water Irrigation; ▪ Field demonstration validating the technical and agronomic viability of the mine water irrigation concept under operational conditions at Mafube Colliery.
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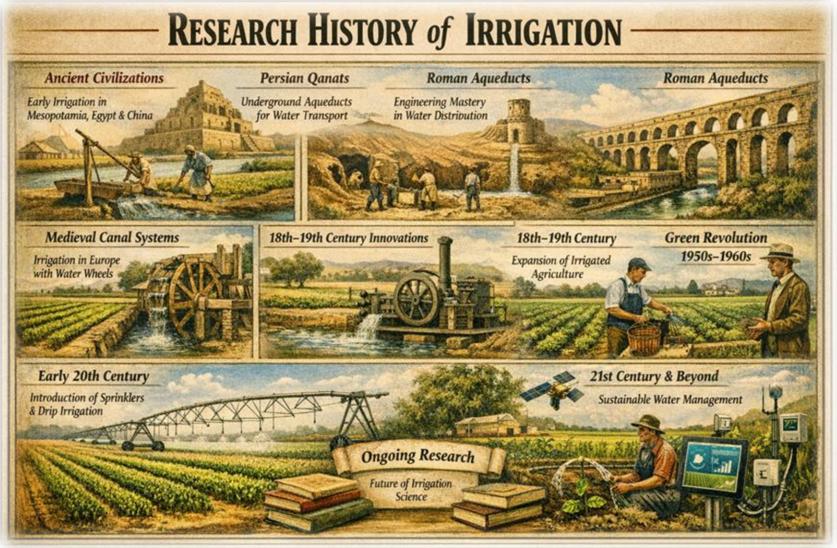
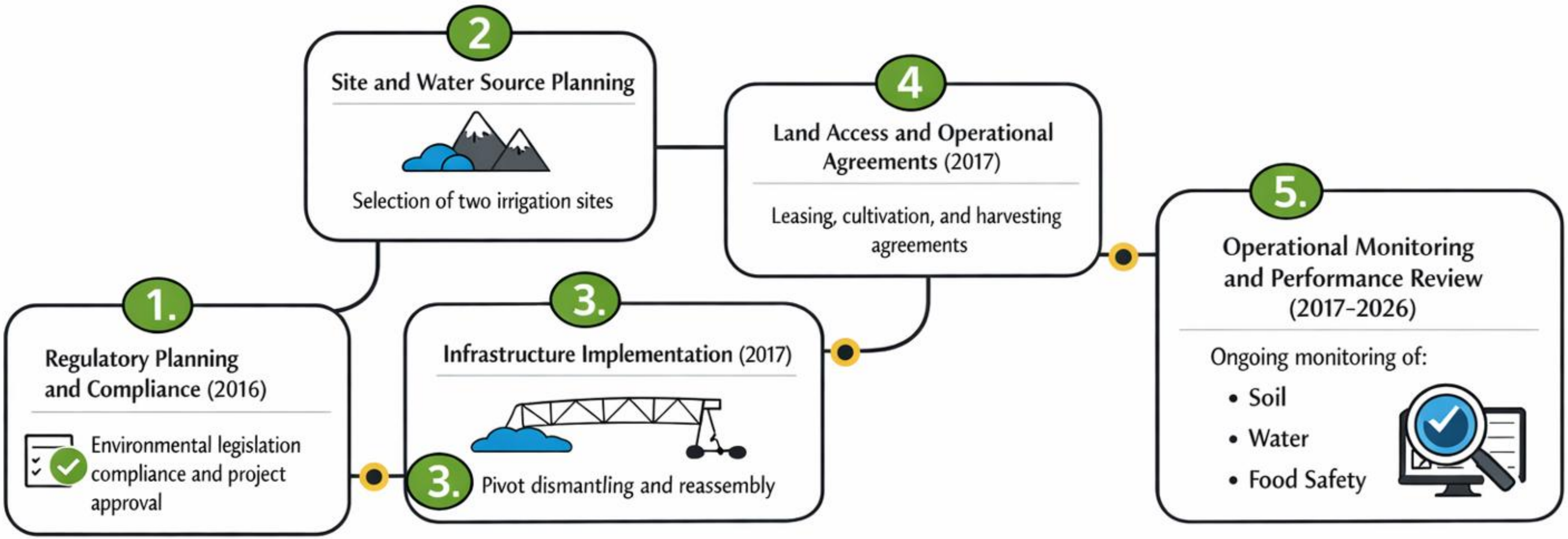
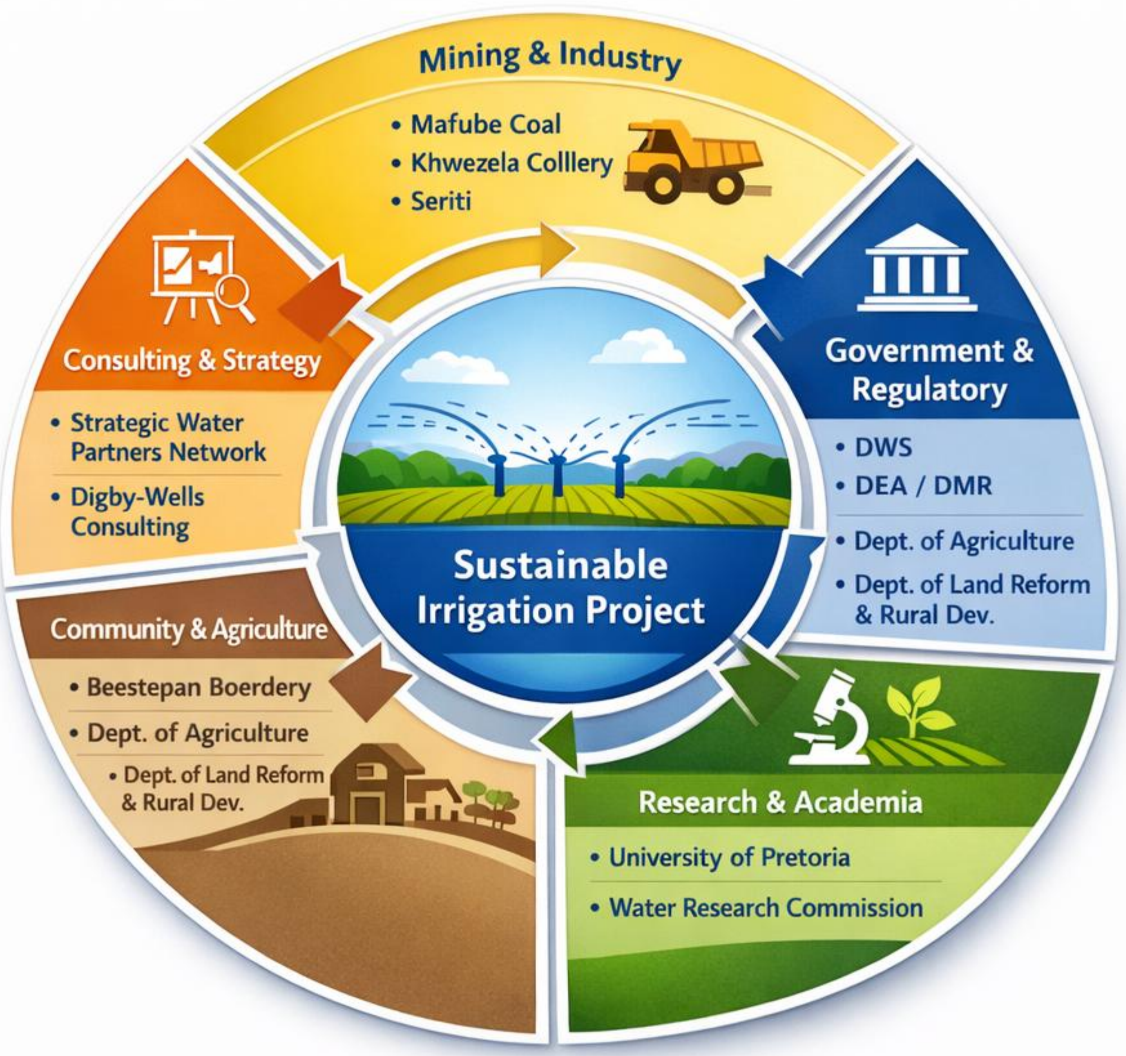


The Background to the Project

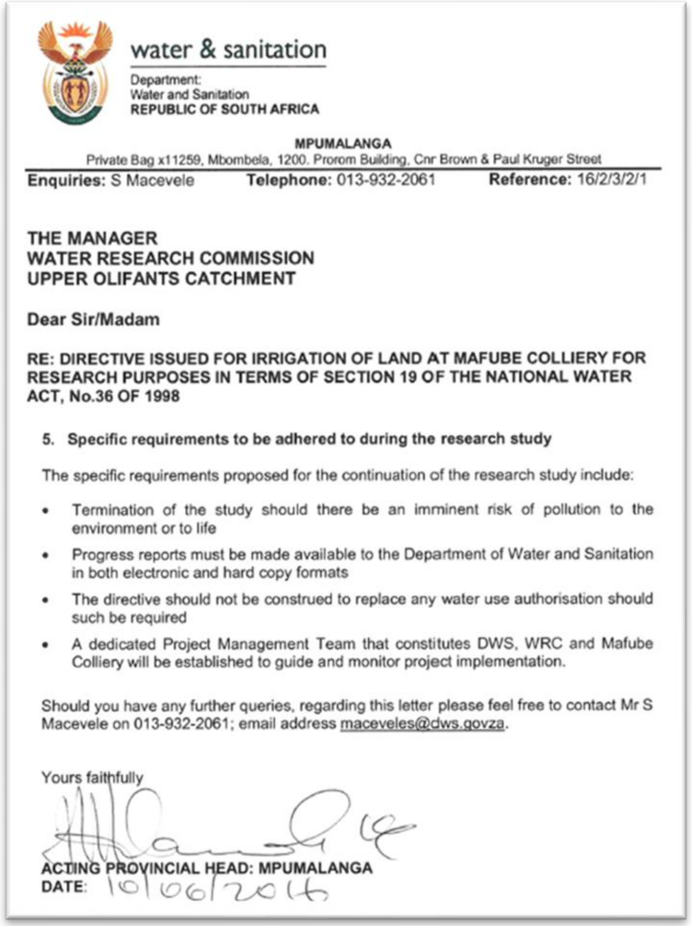
Planning and Implementation: Irrigation Project



Innovative Collaboration: Irrigation Project Partners



The Innovative Collaboration



water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

MPUMALANGA
Private Bag x11259, Mbombela, 1200. Prorom Building, Cnr Brown & Paul Kruger Street

Enquiries: S Macevele **Telephone:** 013-932-2061 **Reference:** 16/2/3/2/1

THE MANAGER
WATER RESEARCH COMMISSION
UPPER OLIFANTS CATCHMENT

Dear Sir/Madam

RE: DIRECTIVE ISSUED FOR IRRIGATION OF LAND AT MAFUBE COLLIERY FOR RESEARCH PURPOSES IN TERMS OF SECTION 19 OF THE NATIONAL WATER ACT, No.36 OF 1998

5. Specific requirements to be adhered to during the research study

The specific requirements proposed for the continuation of the research study include:

- Termination of the study should there be an imminent risk of pollution to the environment or to life
- Progress reports must be made available to the Department of Water and Sanitation in both electronic and hard copy formats
- The directive should not be construed to replace any water use authorisation should such be required
- A dedicated Project Management Team that constitutes DWS, WRC and Mafube Colliery will be established to guide and monitor project implementation.

Should you have any further queries, regarding this letter please feel free to contact Mr S Macevele on 013-932-2061; email address maceveles@dws.govza.

Yours faithfully

ACTING PROVINCIAL HEAD: MPUMALANGA
DATE: 10/06/2016

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

Directorate Water Use and Irrigation Development, Private Bag X515, SILVERTON 0127, 141 Creswell Road, SILVERTON, 0127, Tel: 012- 846 8569, Fax: 012-846 8576

Enquiries: Ms M.J. Gabriel

The Research Manager
Water Research Commission
Bloukrans Building
4 Daventry Street
Lynnwood Manor
PRETORIA

Dear Dr. Burgess and Mr. Martin

MAFUBE MINE WATER IRRIGATION PILOT AND DEMONSTRATION PROJECT

The Department of Agriculture Forestry and Fisheries (DAFF) acknowledges that irrigated agriculture has reached its threshold from a water allocation point of view and that new avenues of ensuring availability of water for irrigation have to be sought, of which the use of treated mine water for irrigation has been identified as one of the listed options which still need to be further explored.

DAFF has also taken note of the Feasibility Study Report and the Project Proposal attached and is therefore in support of this proposed Pilot Project (WRC Contract Number K5/2564//3) to be undertaken at Mafube, provided that measures to monitor and prevent long term impacts on soil will be implemented.

Yours faithfully

MS. P.N. MJADU
ACTING DIRECTOR: WATER USE AND IRRIGATION DEVELOPMENT
DATE: -11- 16

CONFIDENTIAL

Leslie Martin
General Manager

Tel no: 013 246 9410
Fax No: 0866 905 228

Mine Environmental, Research and Sustainable Development (MERSD)
Department of Mineral Resources
Tel: 012 444 3831

Attention: Mr Molefe Morokane

Request for continuation of the proposed Irrigation Project at Mafube Coal Mining Limited

Activity background

Mafube Coal (Pty) Ltd is a joint venture between Anglo American Coal South Africa and Exxaro Resources. Mafube has been operational since 2004, with the addition of the coal washing plant and the linear infrastructure in 2008. The current Life of Mine (LOM) of the operation is that of 2018

Mafube Coal is situated in South Africa, within the Mpumalanga Province, approximately 17km north of Arnot power Station and 25 km east of the town of Middelburg. The mine is located within the Steve Tshwete Local Municipality with the main section of coal reserves on the farm Springboklaagte 416-JS with small portions of coal reserves located across the farms Kleinfontein 432-JS and Elandsfontein 344-JS farms.

Mafube is located in the Middelburg Dam sub-catchment, which is part of the Loskop Dam catchment and within quaternary sub-catchment B12C of the Limpopo-Olifants primary drainage region.

1.1 Motivation

In addition to water scarcity issues, the exposure of sulfide minerals in mine voids to oxidising conditions and water results in acidity which may be neutralised naturally by alkaline strata or treated using lime, but results in a highly saline solution which may not be directly discharged into rivers in many ways. Vermeulen et al. (2008) estimated that eventually 20 000ha can be irrigated with coal mine water in Mpumalanga. Degradation of river water quality has already been observed in Mpumalanga, and is at least partly attributed to mining activities in the Crocodile and Olifants River Catchments.

The Irrigation of Gypsiferous Mine water to sustainably produce a range of crops and reduce mine water salt loads through gypsum precipitation in the root zone has been well-researched for Coal mine water in South Africa. In the Mpumalanga Region, irrigation can play an important role in reducing the risk of yield reduction during dry spells, and will also make winter production possible.

- **The Directive is addressed to the WRC; Mafube is the test site.**
- **Liability lies with the WRC.**

The Background to the Project

2017 Source water qualities vs targeted crops

Parameter	Unit	Void Water	Raw Water Dam	Arnot Water	Crop Suitability
pH	–	7.7	7.8	7.7	All
Electronic Conductivity (EC)	mS/m	208	229	558	V & RW
Calcium (Ca)	mg/L	241	268	526	V & RW
Magnesium (Mg)	mg/L	151	176	585	V & RW
Sodium (Na)	mg/L	103	56	108	V & RW
Potassium (K)	mg/L	35	30	72	V & RW
Chloride (Cl)	mg/L	28	23	21	All
Sulphate (SO_4)	mg/L	1 065	1 414	3 580	V

SA guideline for irrigation water

Parameter	Unit	SA Guideline – Suitable	Marginal	Unsuitable
pH	–	6.5 – 8.4	5.5 – <6.5 or >8.4 – 9.0	<5.5 or >9.0
EC	mS/m	< 40	40 – 90	> 90
Calcium (Ca)	mg/L	< 200	200 – 400	> 400
Magnesium (Mg)	mg/L	< 60	60 – 120	> 120
Sodium (Na^+)	mg/L	< 100	100 – 200	> 200
Potassium (K)	mg/L	< 10	10 – 20	> 20
Chloride (Cl^-)	mg/L	< 100	100 – 350	> 350
Sulphate (SO_4^{2-})	mg/L	< 250	250 – 500	> 500

Water Source	Salinity Risk	Sodicity Risk	Long-Term Soil Risk
Void Water	Moderate	Moderate	Moderate degradation risk
Raw Water Dam	Moderate	Low	Moderate degradation risk
Arnot	High	Moderate	High degradation risk

Criteria for water source selection

- Suitable – No restriction
- Marginal – Moderate restriction (management required)
- Unsuitable – Severe restriction (only salt-tolerant crops)

The Background to the Project

2017 Source water qualities vs targeted crops

Crop	Salinity Tolerance (ECe mS/m)	Suitability
Soybean	- 500	Marginal
Maize	- 170	Suitable
Wheat	- 600	Suitable
Barley	- 800	Suitable
Sorghum	- 680	Highly suitable
Stooling rye	- 1140	Highly suitable
Lucerne / pasture	- Moderate–high	Highly suitable

- Three possible water sources were chosen from the mine, with void 3 being the most preferred source (Quantity, quality, location, area management - controlled by Mafube, no production impact, and cost-effective – pipes distance).
- The water quality from the site was appropriate for the project, as the water will be taken up by the roots, and
- concentrated salt precipitation of Gypsum in the soil profile exported via irrigation return flows.

Science Stability – The Proven Theory

Soil, water qualities = Food safety

Soil Risk Classification and Soil Risk Categories		
Risk Driver	Evidence in Report (WRC, 2024)	Risk Category
Salinity	EC mostly < 300 mS/m in irrigation water; soil ECe < crop threshold	Moderate
Sodicity	Low Na and low SAR; high Ca mitigates dispersion	Low
Soil structure	Stable on unmined land; compaction impact & ponding on rehabilitated land	– Variable
Sulphate loading	High SO_4 loads (>30 t/ha over 7 seasons)	Managed
Trace elements	Slow accumulation (>200 yrs for most metals)	Low

Irrigation water quality monitored at Mafube and Beestepan pivots consistently complied with the South African Irrigation Water Quality Guidelines (DWAF, 1996) for salinity, sodicity, and food safety. Although electrical conductivity and sulphate concentrations were elevated, the Ca–SO_4-dominated nature of the water promotes gypsum precipitation, thereby reducing effective salinity and limiting adverse soil chemical impacts.

The Evolving Process

Key agricultural results and gains

Observed Yields

Maize (Unmined Pivot):

- Irrigated: 12–14 t/ha grain
- Dryland: 5–9 t/ha grain
- No declining trend over 7 consecutive seasons
- Shifted from R5,400/ha loss to R6,000/ha profit (2017).

Rehabilitated Land (Pasture/Weeds):

Yield varies 1.3–7.4 t/ha, driven by:

- Compaction
- Ponding
- Root depth restrictions
- Low P and K

The Evolving Process

Environmental Benefits and Water Stewardship

- The Mafube project advances water stewardship by reducing reliance on scarce freshwater and promoting beneficial reuse of mine-affected water. Diverting mine water to irrigation lessens uncontrolled discharge risks and reduces abstraction from surface or groundwater in the water-stressed Olifants Catchment.
- Avoiding energy-intensive treatment plants cuts ongoing energy and chemical inputs, lowering operational costs and greenhouse gas emissions. Irrigation reuse represents a lower-energy pathway aligned with resource efficiency and circular economy principles.
- Robust environmental monitoring remains essential to manage soil salinity and nutrient accumulation within acceptable thresholds, demonstrating that environmental protection and productive use can coexist when guided by science.
- Responsibly implemented, mine water reuse can form part of an integrated environmental management strategy rather than a compromise solution.
- Employment and Skills Pathways: Profitable agriculture enables jobs, on-farm training, and knowledge transfer led by a local farmer.
- Community Resilience & Food Security: Increased local production strengthens food security and buffers supply shocks and price volatility.
- Just Transition Alignment: Viable post-mining land uses raise the productive value of land and water, softening closure impacts.
- Social Accountability: Engagement with unions and regulators ensures community interests and long-term regional stability.

Cost Management During the Initial Phase ✅

Stakeholder	Total Contribution (R)	% of Overall Project Spend
Mafube Colliery	1 132 706.70	9.1%
WRC	11 263 900.00	90.9%
Overall Project Total	12 396 606.70	100%

Mafube 's internal Spend

- Pivot Installation – largest share
- Monitoring Borehole Drilling
- Water Pipeline – core water supply infrastructure
- Electrical Cable & Fencing – site access, safety, and connectivity
- Pump Testing – operational commissioning

Mafube 's 8yrs spend = 4,389,165.98

WRC Spend

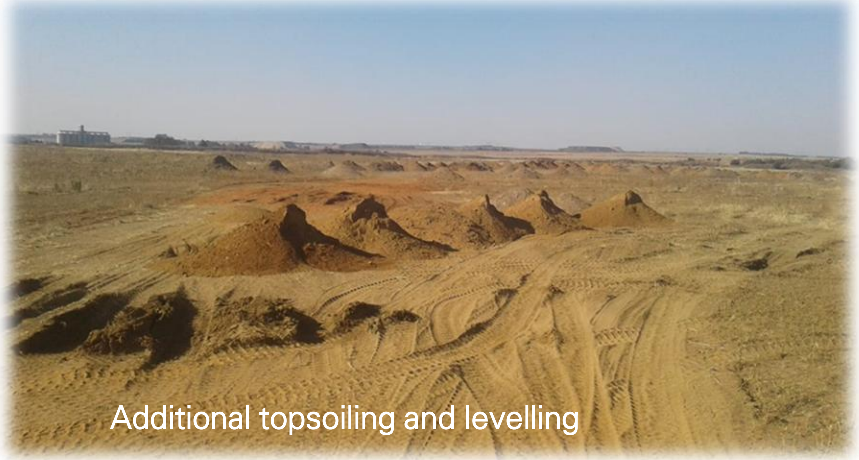
- Human Resources (dominant share)
- University of Pretoria and University of the Free State professors
- Postgraduate students
- WRC officials and technical specialists
- Laboratory analyses
- Casual labour
- Field campaigns
- Data loggers
- Weather station(s)
- Minor Expenses
- Reporting
- Computer programming and data processing

Mafube Spend on community training relating to the agricultural project

Project	Total Budget	2014 Spend	2015 Spend	2016 Spend	2017 Spend	2018 YTD Spend	Total Spend	Variance
Agricultural Project (Irrigation)	R 3,000,000.00	R –	R –	R 39,455.32	R 57,804.00	R 251,273.95	R 348,533.27	R 2,651,466.73

The Evolving Process

Operational Challenges

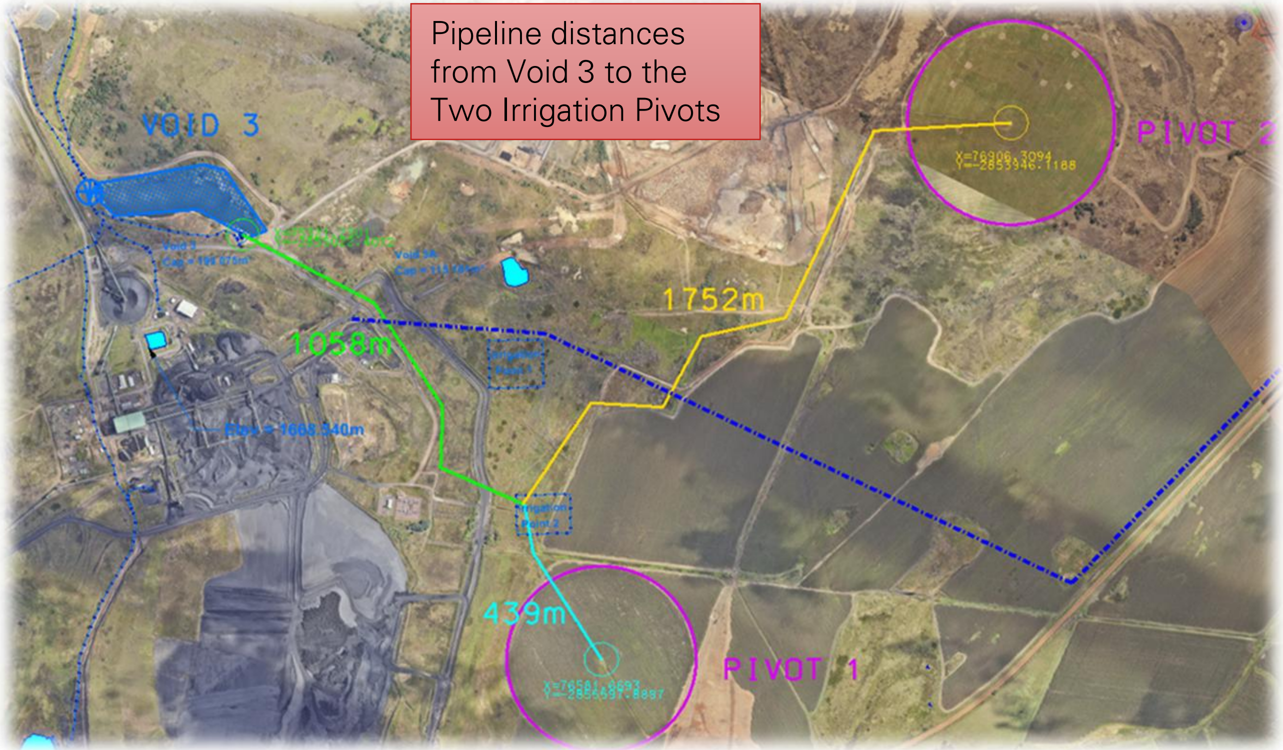


- Initial provision of costs that were not budgeted for
- Rehabbed area had different undulations – water not draining
- Machine availability for the Pivot area
- Delays in the actual Pivot re-assembly process
- Damaged parts placement
- Consistent monitoring – theft
- Subsequent Delays in planting the winter crop (initial stages)
- Structural failure (i.e., clogged sprayers and blockages)
- Dryer seasons – less water availability
- Electricity cuts – Pivot not completing its revolution
- Permitting – Directive expired, and 21(g) & (e)+ is underway **(Flagship for national mine water irrigation guidance)**

Note: Permitting process in progress – Mr. S. Macevele to cover the DWS progress

Conclusion: From Liability to National Asset

Mine closure Liability – AMD responsibility reduced



Once mining is fully ceased, water source will be from the decant scavenger boreholes as projected below

Pipeline Route	Pipeline Distance	Timeline for operational cost
Scavenger Borehole 1 to Collection Point	1 700	50 years
Scavenger Borehole 2 to Collection Point	300	50 years
Scavenger Borehole 3 to Collection Point	150	50 years
Pan Boreholes to Collection Point	Not specified	50 years
Collection Point to Pivots	49	100 years (end of reporting timeline)

From Risk to Resource

Mine-affected water becomes a productive input delivering environmental, economic, and social value.

Integrated Sustainability

Partnerships, rigorous monitoring, and adaptive management enable success.

Evidence for Policy

Robust results challenge assumptions and inform replication and policy development.

Scalable Just Transitions

A practical pathway for water-scarce regions to align food security and stewardship.

Scalable Just Transitions

A practical pathway for water-scarce regions to align food security and stewardship.

Video

2020 for Anglo American – Project warn first prize


THANK YOU