REFINERY EFFLUENT WATER REDUCTION AND TREATMENT

RESHAPING VALUE

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16 OCTOBER 2024

RAND REFINERY

AGENDA

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02 Why & How

03 Primary Scrubber Solution Testwork

04 Effluent Reduction Testwork

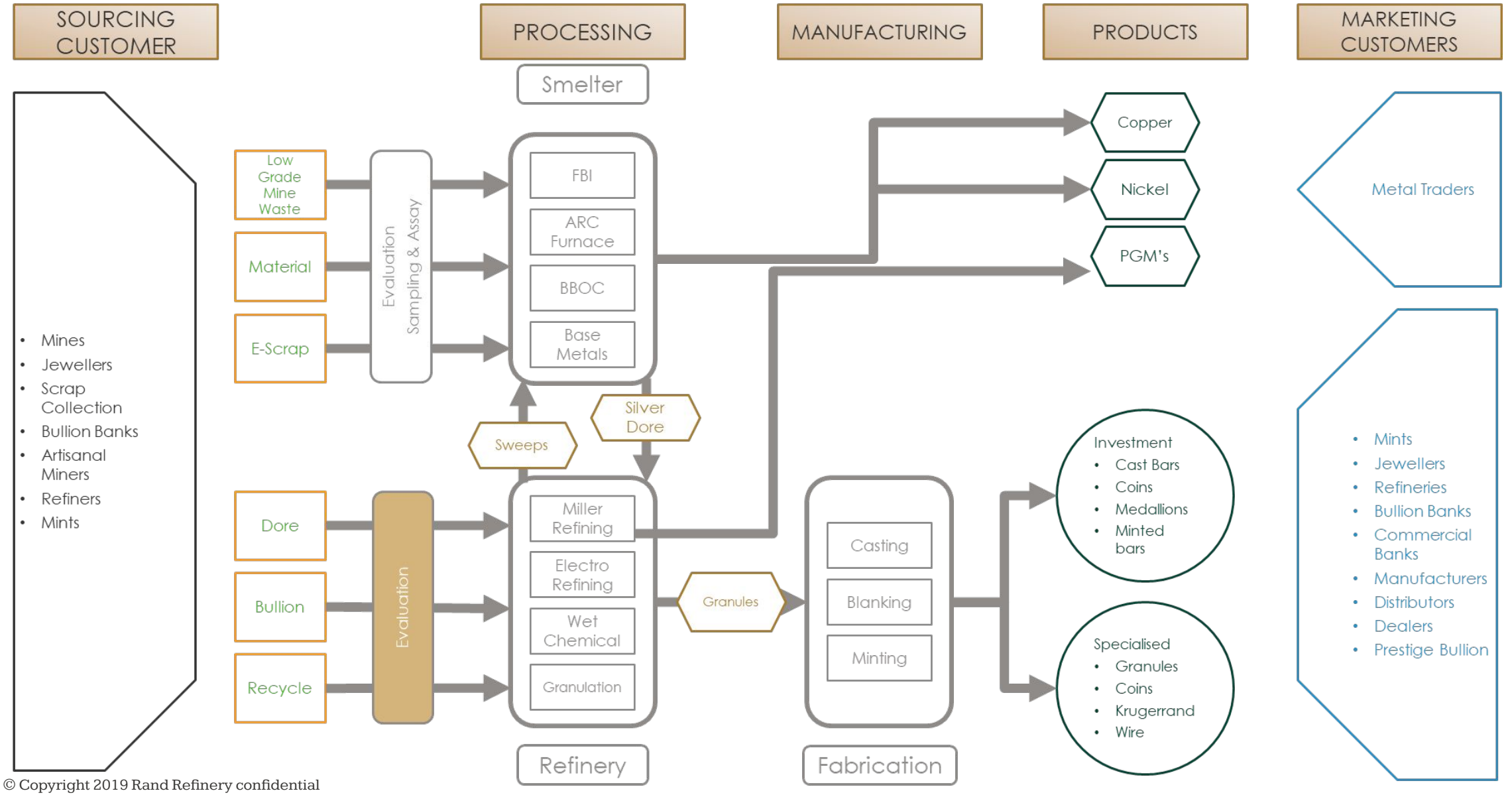
05 Silver Leach Stoichiometric Addition

06 Vibratory Shear Enhanced Processing Techniques

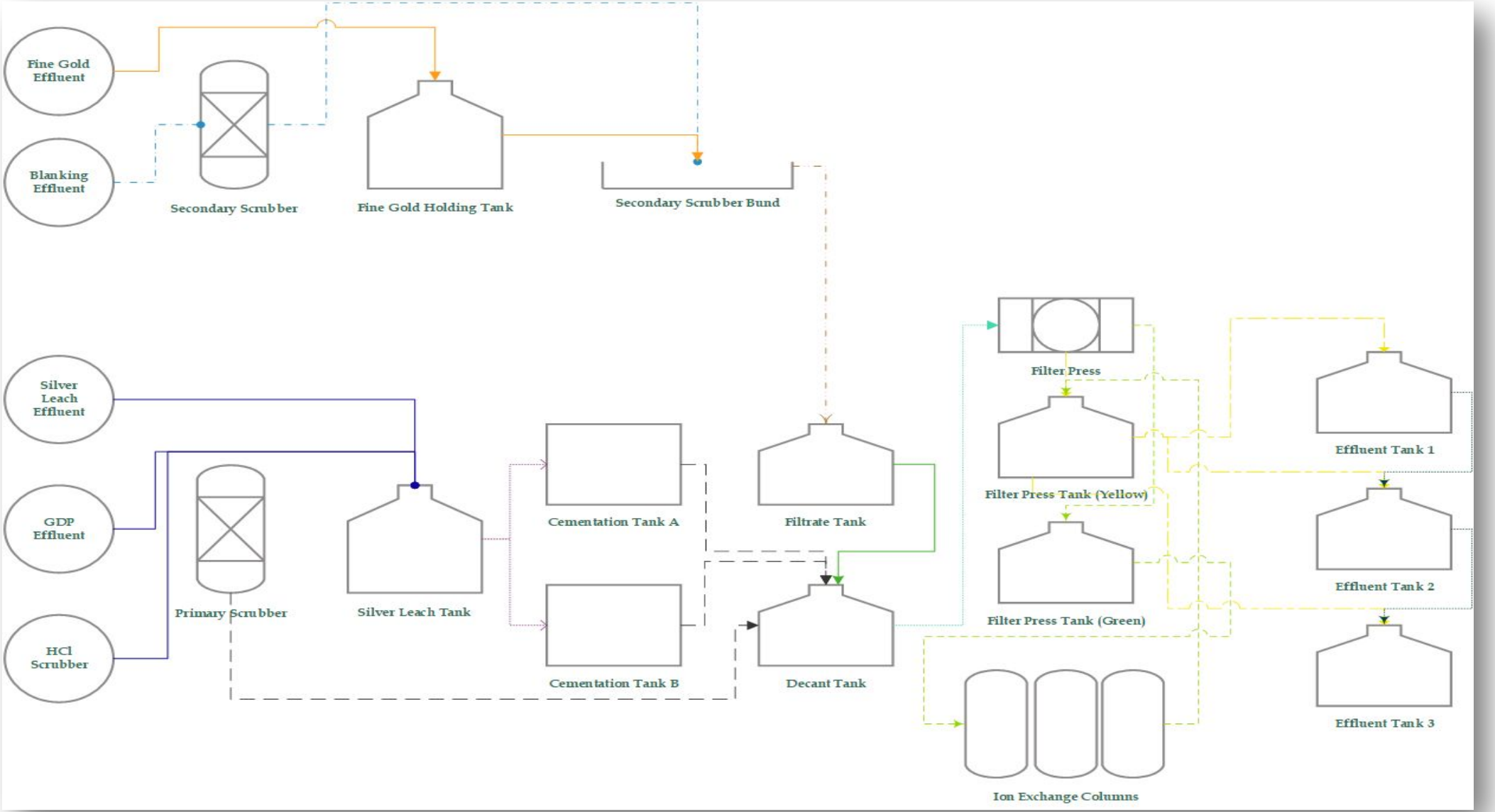
07 Conclusion and Future Initiatives

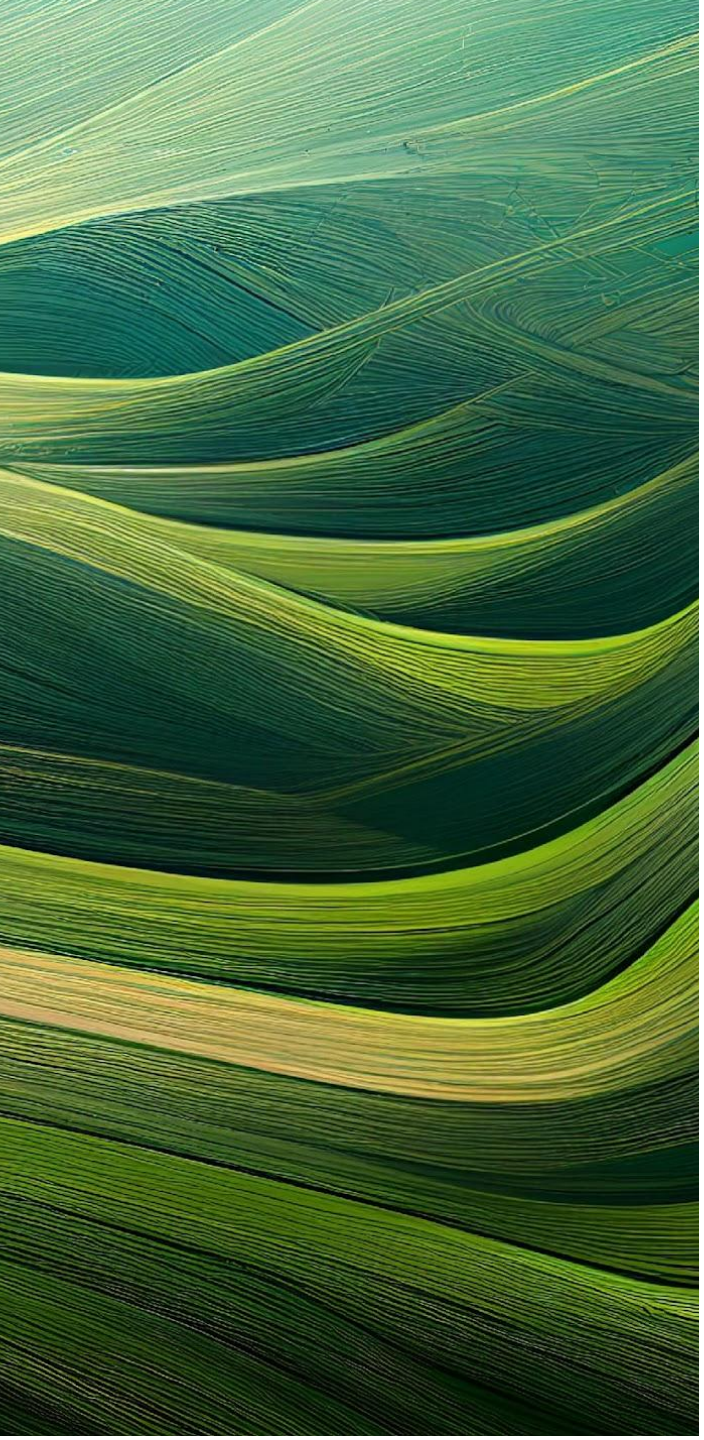
INTRODUCTION

RAND REFINERY PROCESS FLOW



EFFLUENT PROCESS FLOW





WHY & HOW

OBJECTIVES

Effluent Reduction

- Reduce effluent generation
- Rand water consumption
- Disposal cost

Effluent Treatment

- Increase metal recovery
- Inhouse treatment for disposal

ESG Compliance

- Align with ESG regulations
- Reduce water consumption from 72000 kl to 55 000kl
- Reducing effluent by 22%
- Reducing Rand Water by 25%

PROJECTS COMPLETED

Primary Scrubber Solution Testwork

Filtration Testwork

Granulation Water Recycling Testwork

Measure effluent and analysis

Silver Leach Stoichiometric Addition

Determine Cu content and stoichiometric addition of reagents

Vibratory Shear Enhanced Processing Techniques

Pilot plant study

PRIMARY SCRUBBER SOLUTION TESTWORK

PRIMARY SCRUBBER SOLUTION TESTWORK

EFFLUENT REDUCTION

Objective

- Determine the filtration characteristics of the scrubber solution under pressure filtration conditions to enable recirculation of the effluent back to the scrubber.

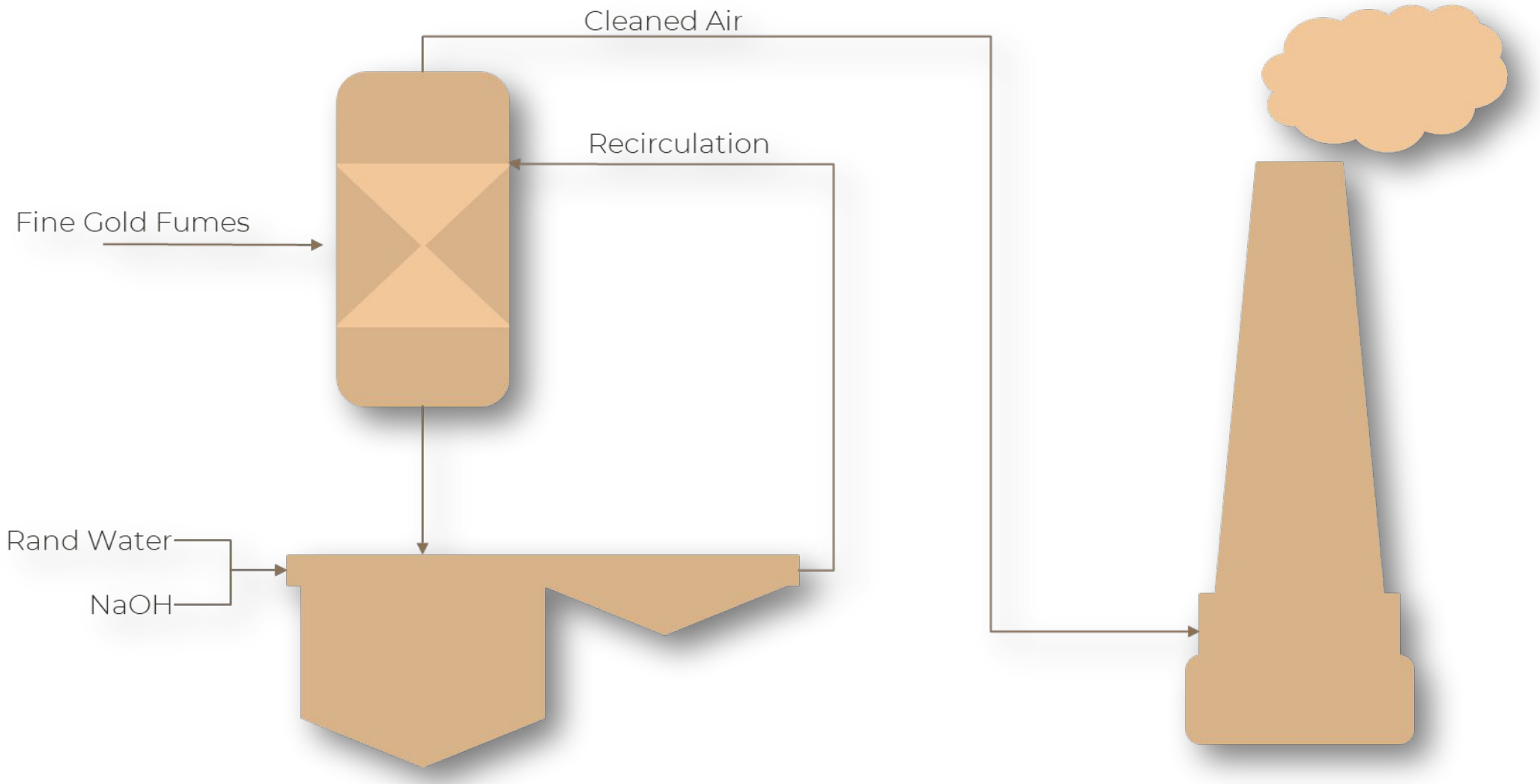
Sample Collection

- Scrubber solution samples were collected and analyzed for slurry density, feed solids, pH, particle size distribution (PSD), and temperature.

Process

- Fed agitated slurry into the filter press, recorded cake formation time and cumulative mass of discharged filtrate.
- Applied membrane squeeze, measured wet mass and thickness of the cake, then oven-dried to determine moisture content.

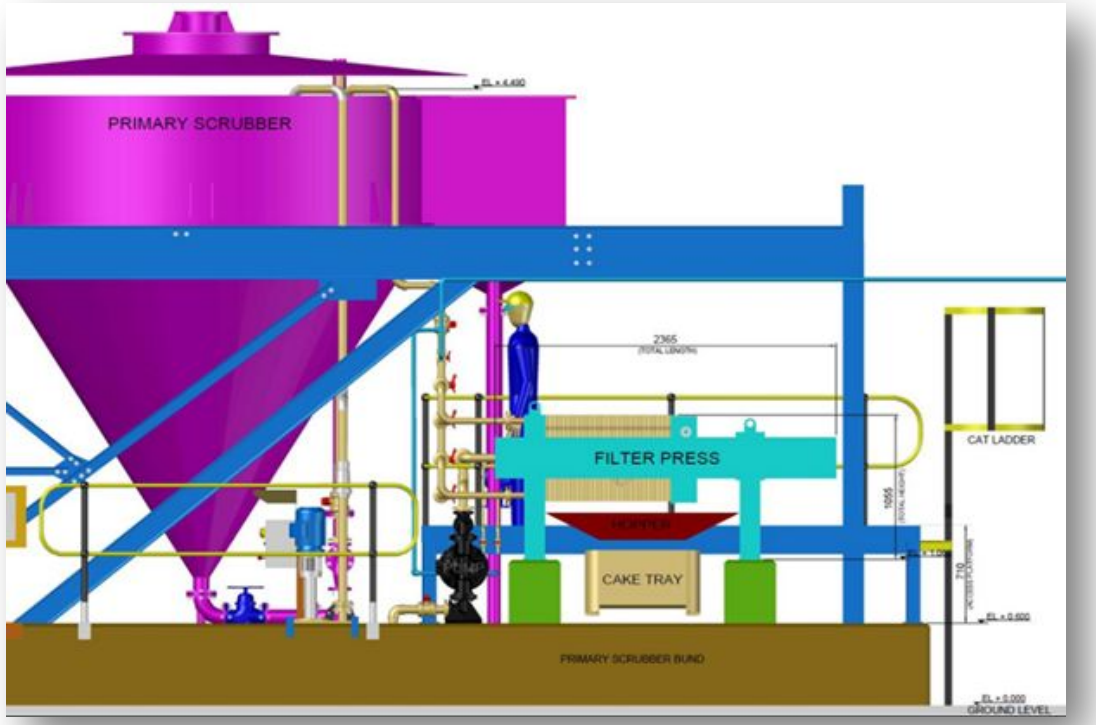
PRIMARY SCRUBBER PROCESS FLOW

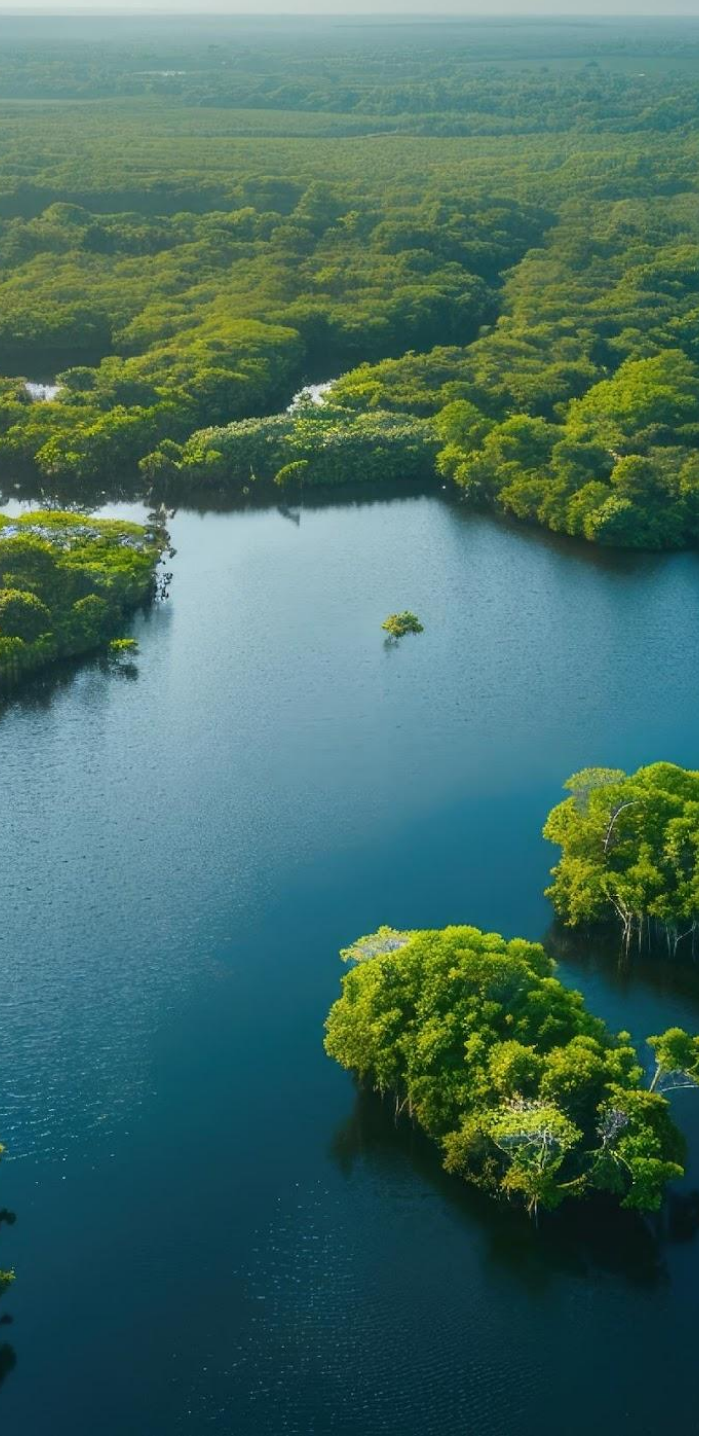


PRIMARY SCRUBBER SOLUTION TESTWORK

EFFLUENT REDUCTION

- Limited recycling options led to 20 m^3 of effluent being disposed of monthly, requiring freshwater additions.
- Installed a dedicated filter press to recycle scrubber filtrate back into the primary scrubber.
- Reduced handling and treatment of effluent, saving about 160m3.
- Continuous filtration and recovery of metal particles, improving daily metal accounting.
- Enhanced scrubber efficiency with ongoing removal of metal particles, increasing the solid loading capacity.
- Saving treatment cost ±R500 000.00





EFFLUENT REDUCTION TESTWORK

GRANULATION WATER RECYCLING TESTWORK

EFFLUENT REDUCTION

Objective

- Quantify effluent produced during the refinery process and explore recycling options..

Sample Collection

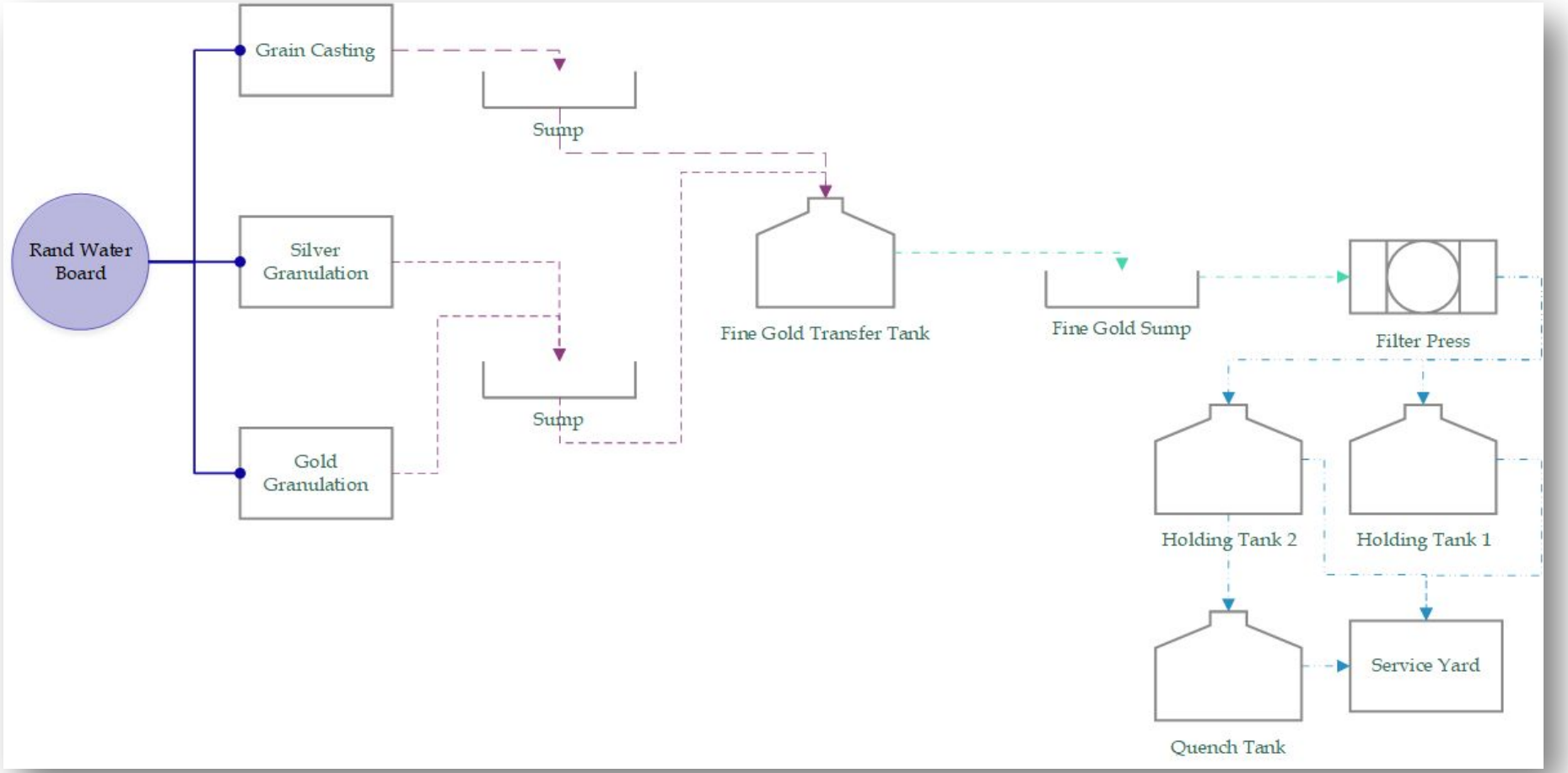
- Collected samples from various effluent streams and analyzed their properties and pH levels.

Process

- Conducted pH analysis and determined trace elements in the effluent using ICP-OES and titration methods.
- Installed a 5000-litre tank and filter housings to recycle water for various tasks like washing scrap and silver chloride quenching.

GRANULATION WATER RECYCLING TESTWORK

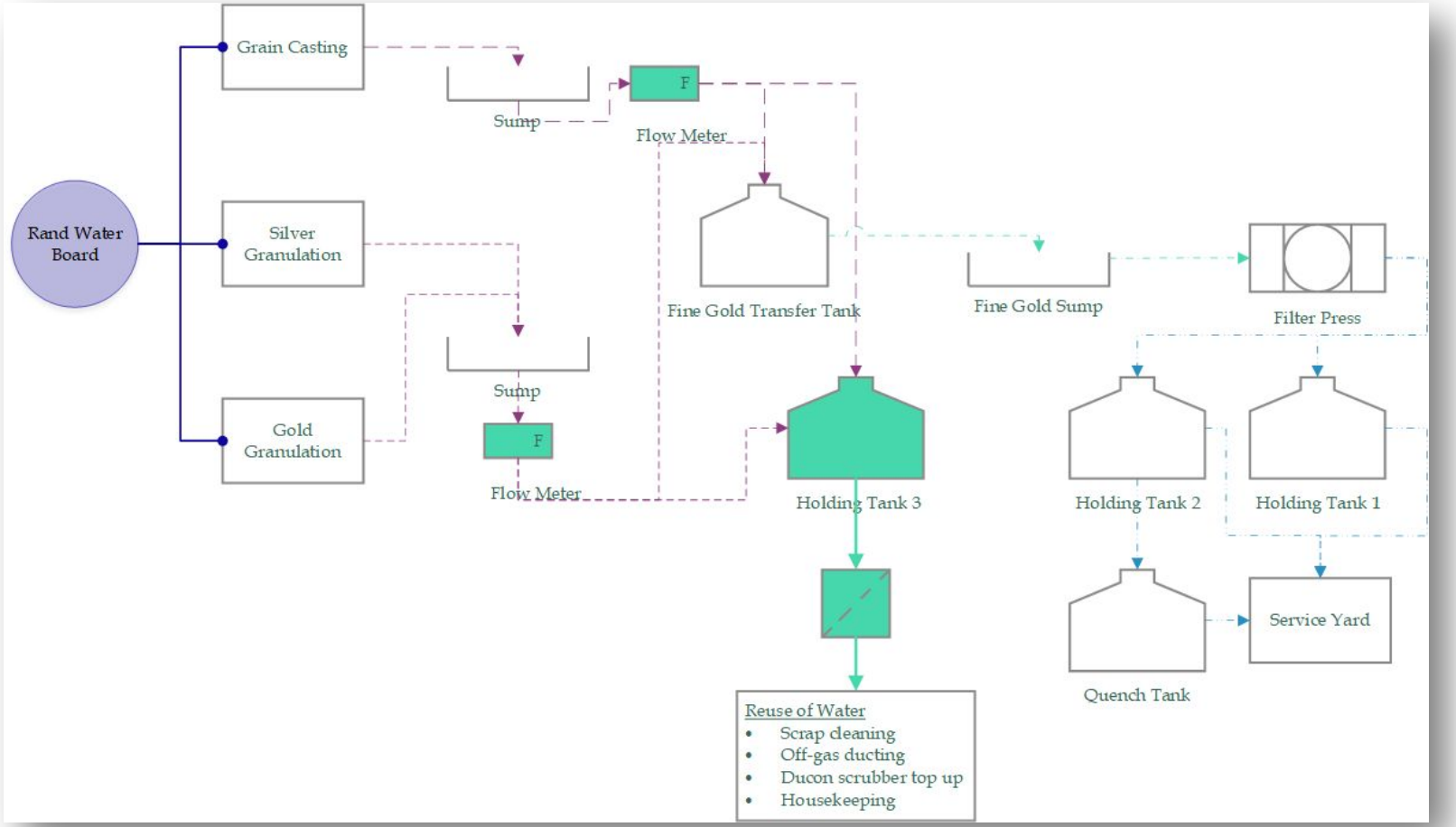
EFFLUENT REDUCTION



Before

GRANULATION WATER RECYCLING TESTWORK

EFFLUENT REDUCTION



After

- Identified clean process water stream (granulation water) as a replacement for potable water to reduce effluent.
- Installed a granulation water recycle plant with a 5000 L tank, pump, filter housing, and distribution pipes for various uses:
  - Scrap washing: Ensures capture of gold contaminants and clean scrap removal.
  - Fine gold fumes ducting washing: Releases material captured in ducting for collection and treatment.
  - Quenching of silver chlorides: Prepares silver chlorides before transfer to silver leach reactors.
  - Ducon scrubber top up.

GRANULATION WATER RECYCLING TESTWORK

EFFLUENT REDUCTION

- The refinery has effectively installed and commissioned a granulation water recycling system.
- The project was fully operational by 29 July 2023, marking significant milestones like the successful cleaning of fine gold fumes ducting, efficient scrap metal management, silver chloride quenching, Ducon scrubber top and housekeeping improvements.
- Reduced effluent volumes by 205 m^3 compared to FY22.
- Achieved cost savings of approximately half a million rand in effluent treatment expenses.

SILVER LEACH STOICHIOMETRIC ADDITION

SILVER LEACH STOICHIOMETRIC ADDITION

EFFLUENT REDUCTION

Objective

- Examine the feasibility and impact of total oxidation in silver leach operations by incorporating stoichiometric amounts of HCl and NaClO3.

Sample Collection

- No sample collection, since it was a calculations

Process

- Added HCl and NaClO3 to transform CuCl into soluble CuCl2, ensuring complete oxidation and minimizing HCl wash stages.
- Optimized copper concentration before the silver leach process to safely introduce the required reagents.

SILVER LEACH STOICHIOMETRIC ADDITION

EFFLUENT REDUCTION

Gold Refining Process in Miller Furnaces

- Byproducts: Silver and base metal chlorides generated during gold refining with chlorine.
- Quenching: Molten chlorides transferred into a water-filled tank to form chloride slurry.

Silver Leach Reactors

- Slurry directed to reactors containing copper chloride and other soluble base metal chlorides.
- Hydrochloric acid (HCl) and sodium chlorate ($NaClO_3$) added based on copper content.

Leaching Reaction

- Converts slightly soluble copper(I)chloride (CuCl) into soluble copper(II)chloride ($CuCl_2$).
- Reaction: $6CuCl(s) + 6HCl(aq) + NaClO_3(s) \rightarrow 6CuCl_2(s) + NaCl(aq) + 3H_2O(l)$

Exothermic Reaction

- Releases energy, increasing solution temperature.
- Side reaction: $2NaClO_3 + 4HCl(aq) \rightarrow 2ClO_2(g) + NaCl(aq) + H_2O(l)$

SILVER LEACH STOICHIOMETRIC ADDITION

EFFLUENT REDUCTION

- Reactor loaded with 1050 liters of solution (450 liters of chlorides, 600 liters of water).
- Consumes 2400 liters of fresh water for four washes per batch.
- Post-leaching, reactor prepared for zinc reduction phase with 600 liters of fresh water.
- Each batch uses 3600 liters of water; 20 batches monthly total 72,000 liters.
- To reduce water consumption:
  - Implement stoichiometric addition of HCl and $NaClO_3$ in a controlled environment.
  - Optimize operational approach for precise pH and temperature regulation.
  - Utilize supplementary effluent drainage to extract copper from the solution.

SILVER LEACH STOICHIOMETRIC ADDITION

EFFLUENT REDUCTION

- Optimized operational approach enabled precise regulation of pH and temperature, ensuring safe and efficient leaching reactions.
- Decreased water usage in the silver leach process by 1800 liters per batch, reducing total water usage by 36,000 liters per month.
- Reduced effluent by 266 cubic meters between FY22 and FY24, contributing to cost savings and improved environmental sustainability.

VIBRATORY SHEAR ENHANCED PROCESSING TECHNIQUES

VIBRATORY SHEAR ENHANCED PROCESSING TECHNIQUES

EFFLUENT TREATMENT

Objective

- Assess the potential for removing and concentrating solid mineral particles of gold and silver using VSEP in batch operation.

Sample Collection

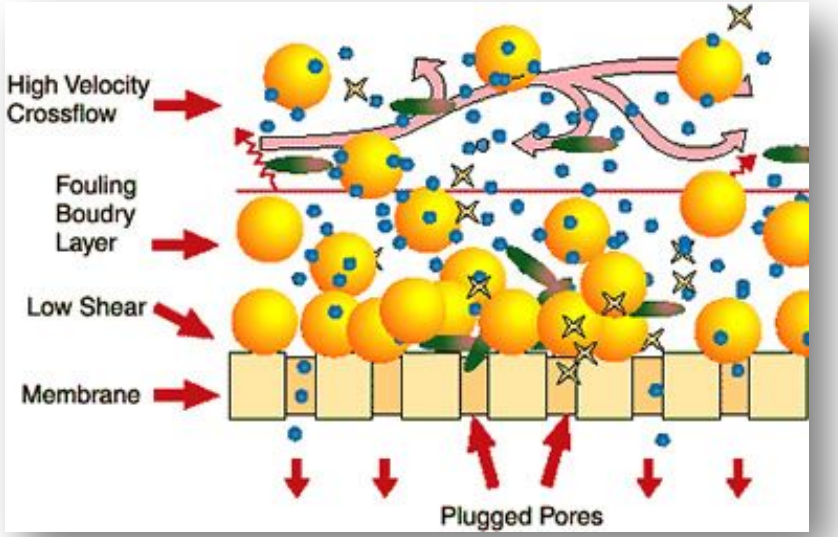
- Silver effluent stream
- Fine gold effluent stream
- Primary scrubber effluent stream

Process

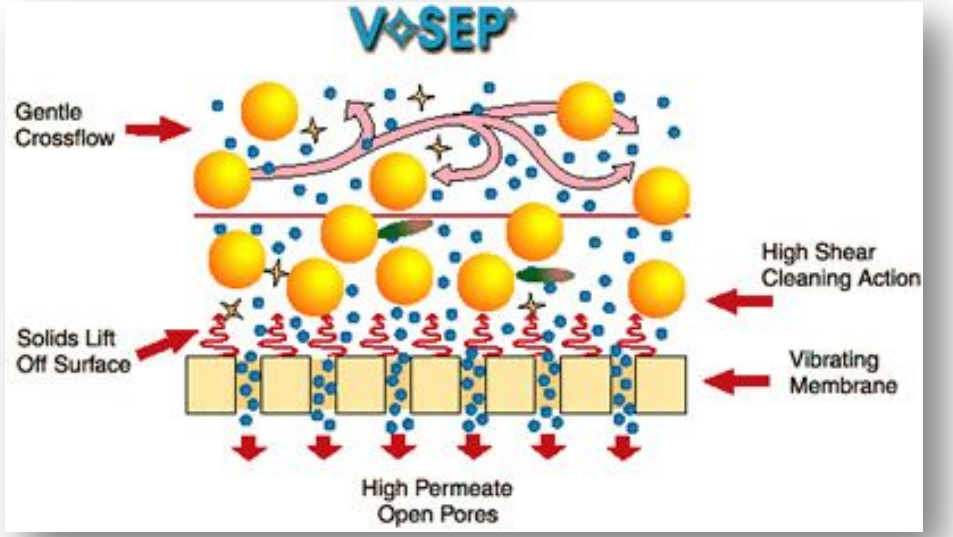
- Fed slurry into the pilot plant
- Conducted pressure studies by starting the system at 50 psi and increasing to 110 psi, measuring permeate flow rate at timed intervals.
- Cleaned the system using chemicals and water flushes after each run.

VIBRATORY SHEAR ENHANCED PROCESSING TECHNIQUES

INTRODUCTION



- Membrane-based technology is over 20 years available
- Has one disadvantage i.e. Fouling
- Due primarily to the formation of a boundary layer that builds up naturally on the surface of the membrane during the filtration process.
- No ability to handle the build up which acts as a secondary membrane layer.



- An alternative method for producing intense shear waves on the face of a membrane.
- The technique is called Vibratory Shear Enhanced Processing (VSEP).
- In a VSEP System, the feed slurry remains nearly stationary, moving in a leisurely
- The shear waves produced cause solids and foulants to be lifted off the membrane surface and remixed with the bulk material flowing through the membrane stack.

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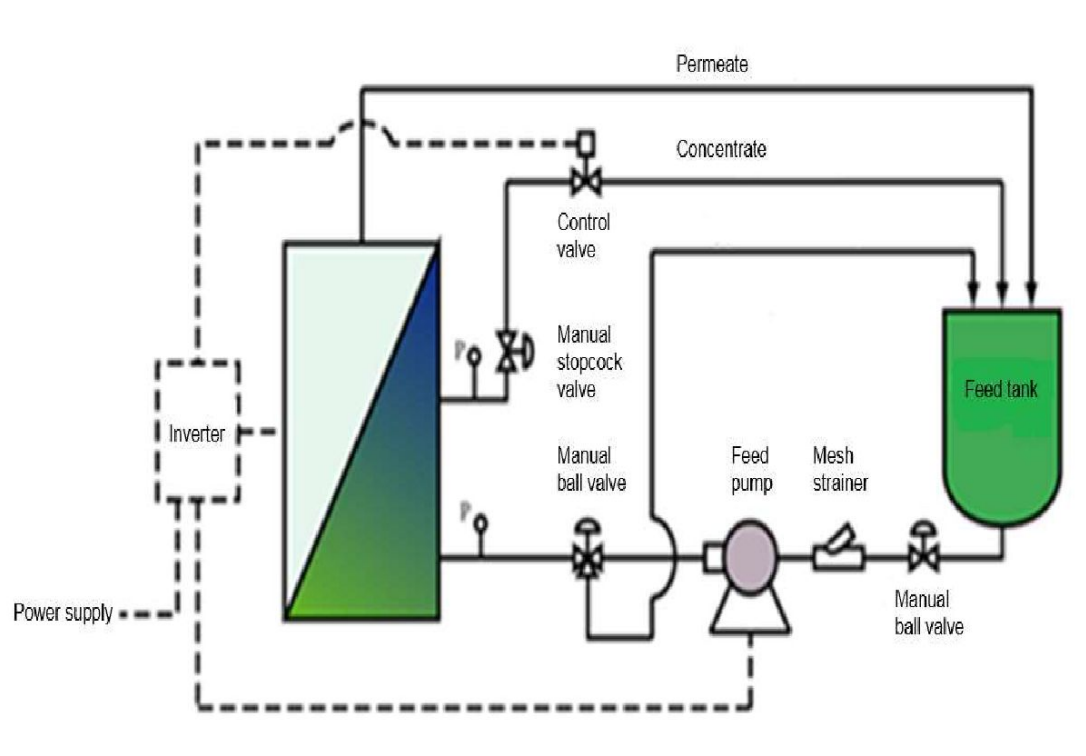
VIBRATORY SHEAR ENHANCED PROCESSING TECHNIQUES

PLANT SET UP



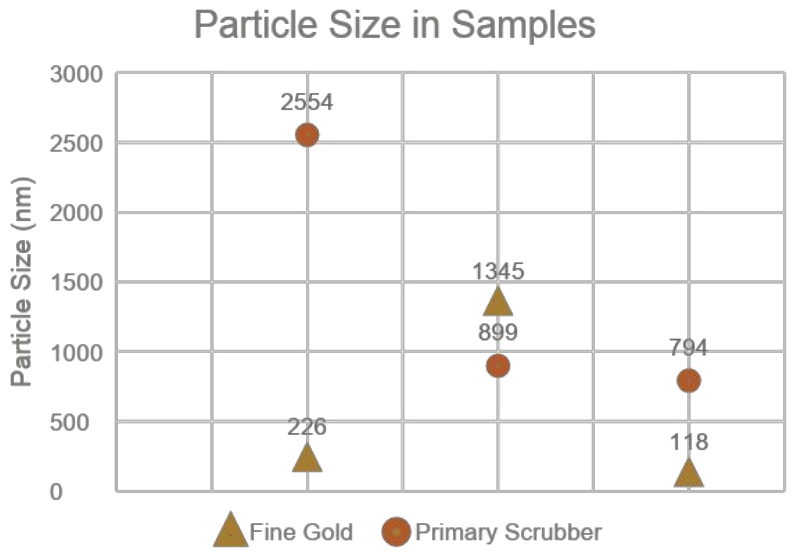
Basic Flowsheet

Pilot Plant Set Up

VIBRATORY SHEAR ENHANCED PROCESSING TECHNIQUES

RESULTS

- Particles measured in the various streams were between 118 to 2554 nanometer
- There was a clear distinguished products produced which indicates solid recovery
- The silver stream trials yielded results that are inconclusive due to the membrane malfunction
- This stream had to low TSS <348ppm and subsequently low gold recovery potential
- The primary scrubber stream is viable for gold recovery via VSEP with 3.5 and 2.4 times gold concentration for runs 1 and 2 respectively
- The fine gold stream run 1 concentrated gold up 11 times and as such has potential for gold recovery using VSEP



CONCLUSION & FUTURE INITIATIVES

CONCLUSION

Effluent reduction and treatment initiatives at Rand Refinery have significantly decreased freshwater usage and effluent generation..

Successful launch of the granulation water recycle plant and improvements to the silver leach process have lowered effluent volumes and treatment expenses.

VSEP trial yielded encouraging outcomes for gold recovery from wastewater; additional trials and other treatment methods are suggested

Water savings tracked using flow meters integrated with SCADA	Effluent reduced to 2676 m^3 in FY23 with granulation effluent recycling
	Further reduced to 2083 m^3 in FY24 with HCl and NaClO3 addition
	Cumulative reduction of 590 m^3 between FY23 and FY24, saving R560,500

Initiatives support Rand Refinery's commitment to ESG compliance, emphasizing resource conservation and waste management.

Projects promote environmental sustainability and offer valuable staff training in process engineering and effluent management.

Rand Refinery's proactive stance on reducing and treating effluent highlights its commitment to sustainable practices and corporate responsibility, ensuring long-term success and positive environmental and societal impact.

REFINERY WATER REDUCTION INITIATIVES

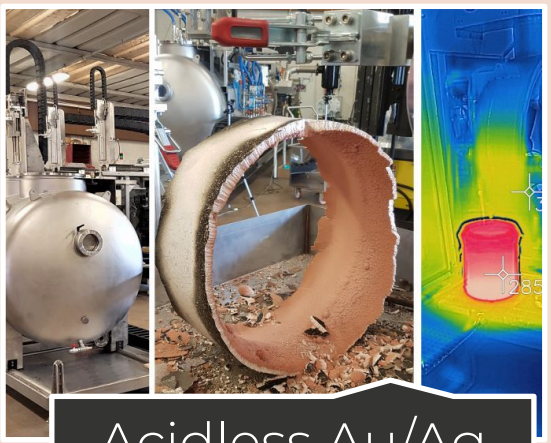
Current initiatives

Recycling Water Tank

Resin Installation

Future initiatives

Reverse Osmosis



Acidless Au/Ag Separation

ACKNOWLEDGEMENTS

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RAND REFINERY

THANK YOU