IMPLEMENTING INNOVATION

Session 2

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Business
Cooperative Research Centres Program

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AGENDA

- Strategy
- Model
- Key success factors
- Execution
- Leverage of CRC Ore, Amira P420 and Amira P9
  - Way points:
    - Sunrise Dam
    - La Colosa
    - Iduapriem
    - Quebradona
  - Where to next

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STRATEGY

- Value-add through participation in collaborative research thereby leveraging AGA contribution with other peer companies; while benchmarking for best practise
- Maximising participation of AGA in boards, technical committee's etc. in an effort to steer research.
- Selected themes in focus areas for value creation;
- Participation in general research for the sustainability of the Company
- Technology transfer through maximum involvement of AGA personnel
- Developing young professionals

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MODEL FOR IMPLEMENTATION

The Four I's

- Identification and evaluation of opportunity
- Identification of site
- Identification of Champion
- Implementation plan

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KEY SUCCESS FACTORS

- Top level support – organisation design
- Multi-tiered support – steering committee
- Multi-disciplinary teams – central technical support
- Business case - clear value statement
- Internal “sales process” – Intranet
- Independent financial support – central budgetary support

EXECUTION

- Planning – need to be flexible and adaptive
- Defined scope – baby steps
- Be on the look out for value adding opportunities
- Be prepared to fail – close out and move on
- Clear understanding of accountability
- Communication strategy

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LEVERAGE OF CRC ORE AND AMIRA P9 AND P420:

Strategy to extract value-add and develop methodology

Represent current flow sheet on platform

Collect required amount of plant input and responses through measurement.

Conduct grind curves at various inputs

Simulate, mass balance, and model fit plant

Predict plant outcomes in simulation and measure to validate

Create scenarios (that optimize the Portfolio) from simple to elaborate and conduct detailed analyses of technical and economic consequences

Train Regional. Project and Operational Mets and Engineers to apply strategy

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EXAMPLES

4 examples projects

- Sunrise Dam (1st IES Plant implementation)
- La Colosa (Geomet modelling: Comminution and Flotation)
- Iduapriem (Capability modelling and optimisation)
- Quebradona (Design check)
- Others...... Cuiaba, Corrego do Sitio, Kopanang etc.

WAY POINT 1: SUNRISE DAM (WITH JKMRC AND AMIRA P9)

Context: *Drastic throughput drop due to Ore hardness changes*

Work Performed

Initial Observations, sampling, mass balancing, modelling, simulation, recommendations

Outcomes:

1. Observation report

2. Recommendations from Simulation work

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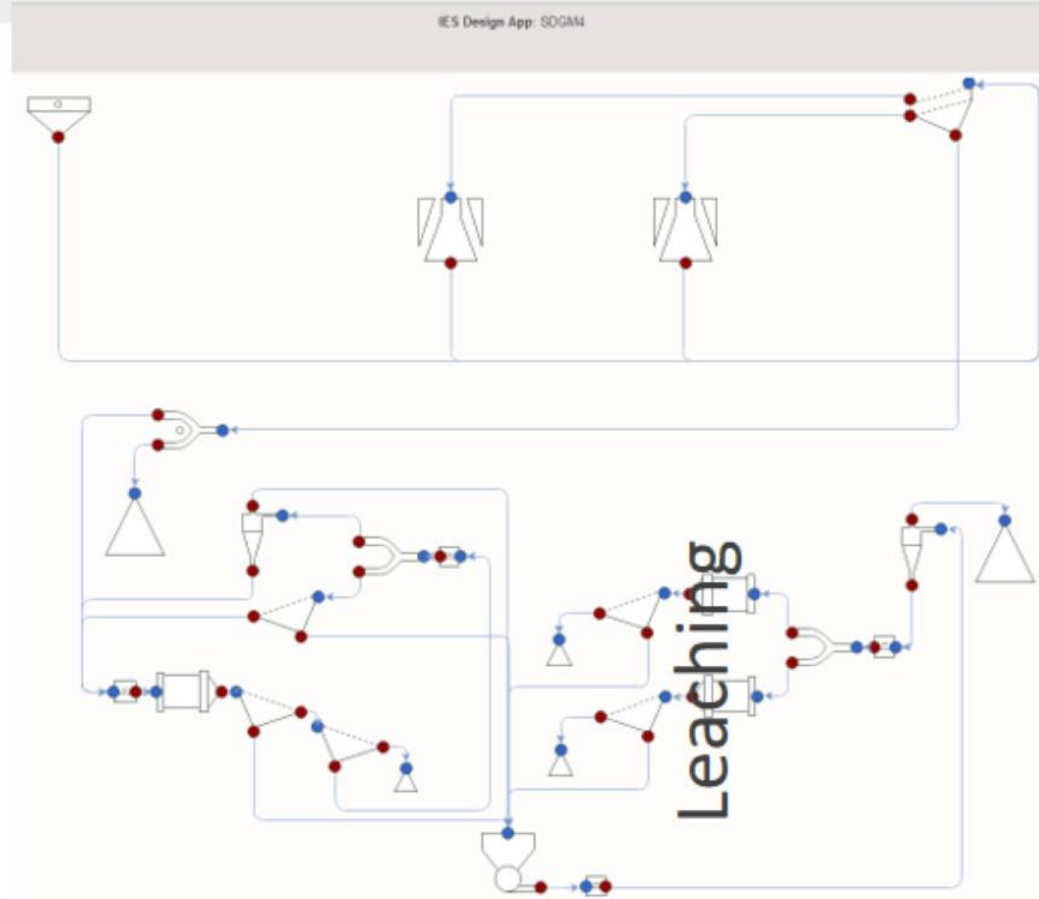
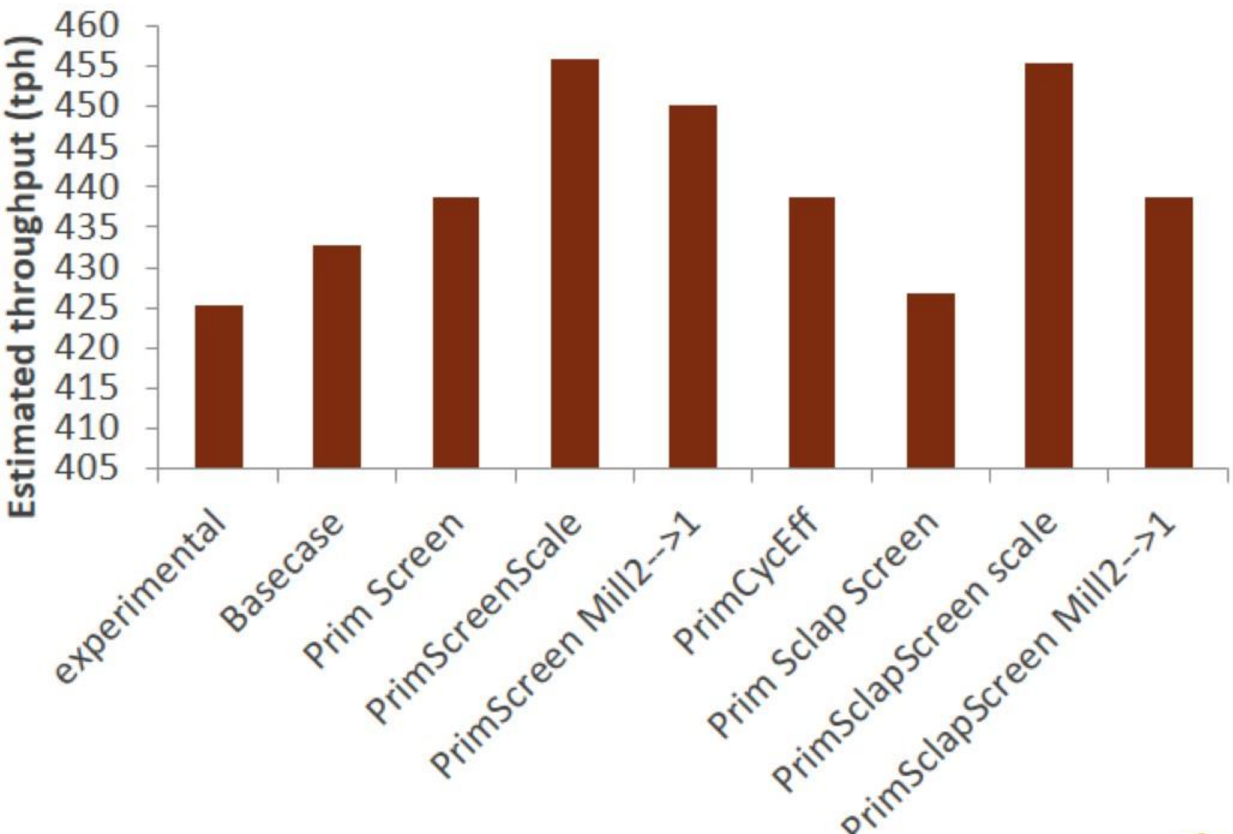
IES

Mining



Leaching

THROUGHPUT RESULTS



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RECOMMENDATIONS

Scalping screen:

screen capacity measurements on current sample
re-survey mill to get rates at lower solids loading

Crusher utilisation:

chamber design, Chalmers modelling
high frequency analysis

Secondary cyclones:

cyclone tests at lower % solids and lower cone ratio
increased cyclone diameter to achieve sharp, coarse separation

Reassess ball size requirements

WAY POINT 2: LA COLOSA DESIGN THROUGHPUT CHECK

Description	Unit	Base Case	Scenario 1	Scenario 2	Scenario 3
Number of SAG Mill	#	1	1	1	1
Number of Ball Mill	#	2	2	2	2
F80 size	mm	146	146	146	146
T80 size	µm	1,700	3,300	4,900	6,600
P80 size	**µm**	**75**	**105**	**150**	**212**
SAG mill power draw	kW	29,689	29,689	29,689	29,689
SAG mill power installed	kW	33,000	33,000	33,000	33,000
SAG specific energy	kWh/t	9.8	8.6	7.8	7.3
Ball mill power draw	kW	20,867	20,859	20,860	20,859
Ball mill power installed	kW	22,000	22,000	22,000	22,000
Ball mill specific energy	kWh/t	13.8	12.1	11.0	10.2
Total specific energy	**kWh/t**	**23.6**	**20.7**	**18.8**	**17.5**
Design throughput	t/h	3,030	3,445	3,807	4,090
Design throughput	**Mtpy**	**24.15**	**27.46**	**30.35**	**32.60**
Design factor	°/1	1.05	1.05	1.05	1.05
Nominal throughput	**Mtpy**	**23.00**	**26.15**	**28.90**	**31.05**

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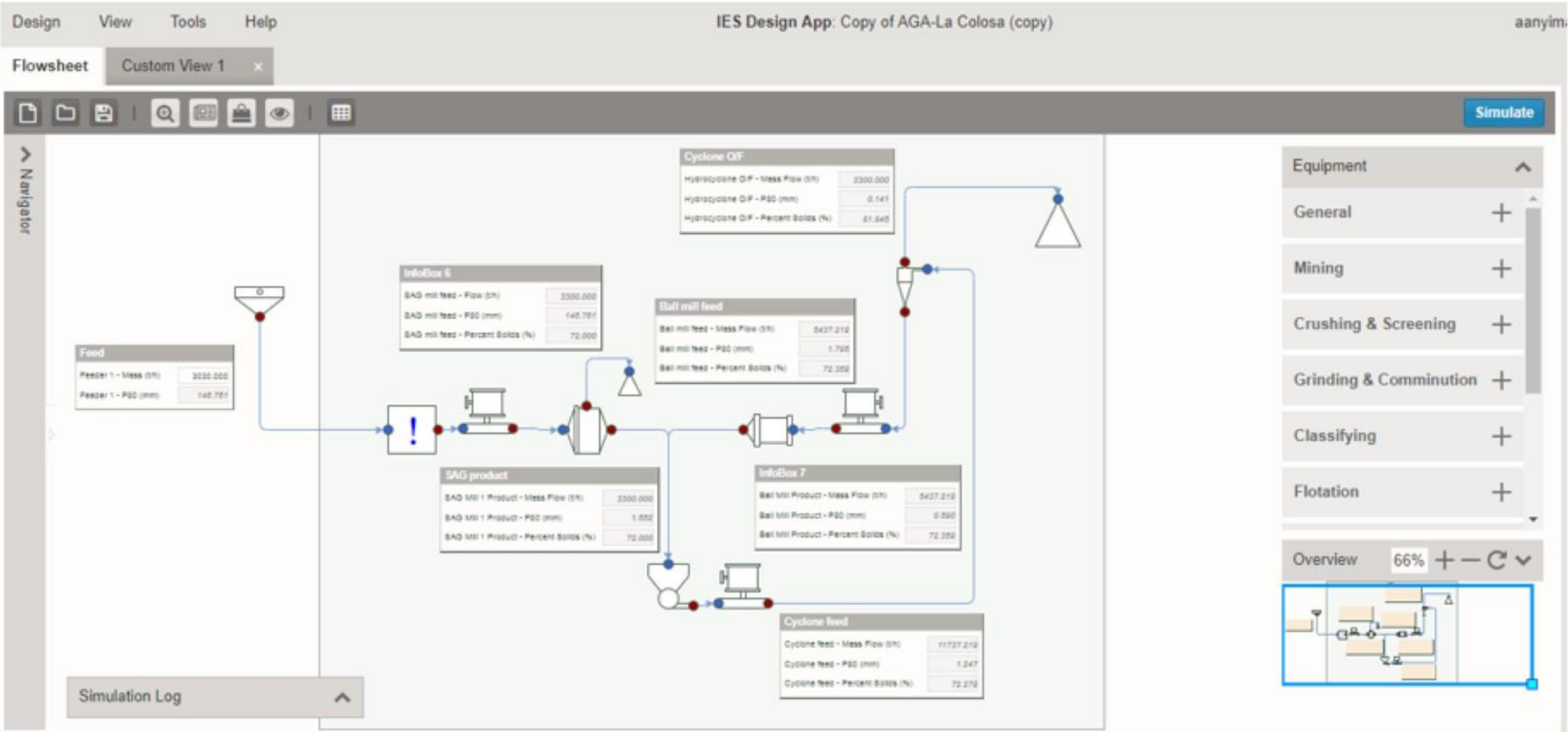
LA COLOSA GEOMET THROUGHPUT CHECK



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LA COLOSA GEOMET FLOTATION:

Varied responses to same flotation conditions

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CONCLUSION FROM FLOTATION RECOVERY MODELLING

Varied responses to both grinding and flotation response and froth behaviour. – potential to exploit geo-metallurgy

All flotation kinetics mapped to the individual cores tested

Photographic records of every single flotation froth behaviour.

Optimisation opportunities in flotation include:

- Most of the samples will benefit from a conditioning tank
- After 7 minutes of flotation, froth needs to be energised – more energy input down the bank, rather than traditional stage addition of reagents
- The dark material (presumed carbonaceous) will need a good froth washing of the sticky concentrate
- Some estimated design criteria needs to be assessed to benefit from some findings from the flotation (and subsequent leach) work

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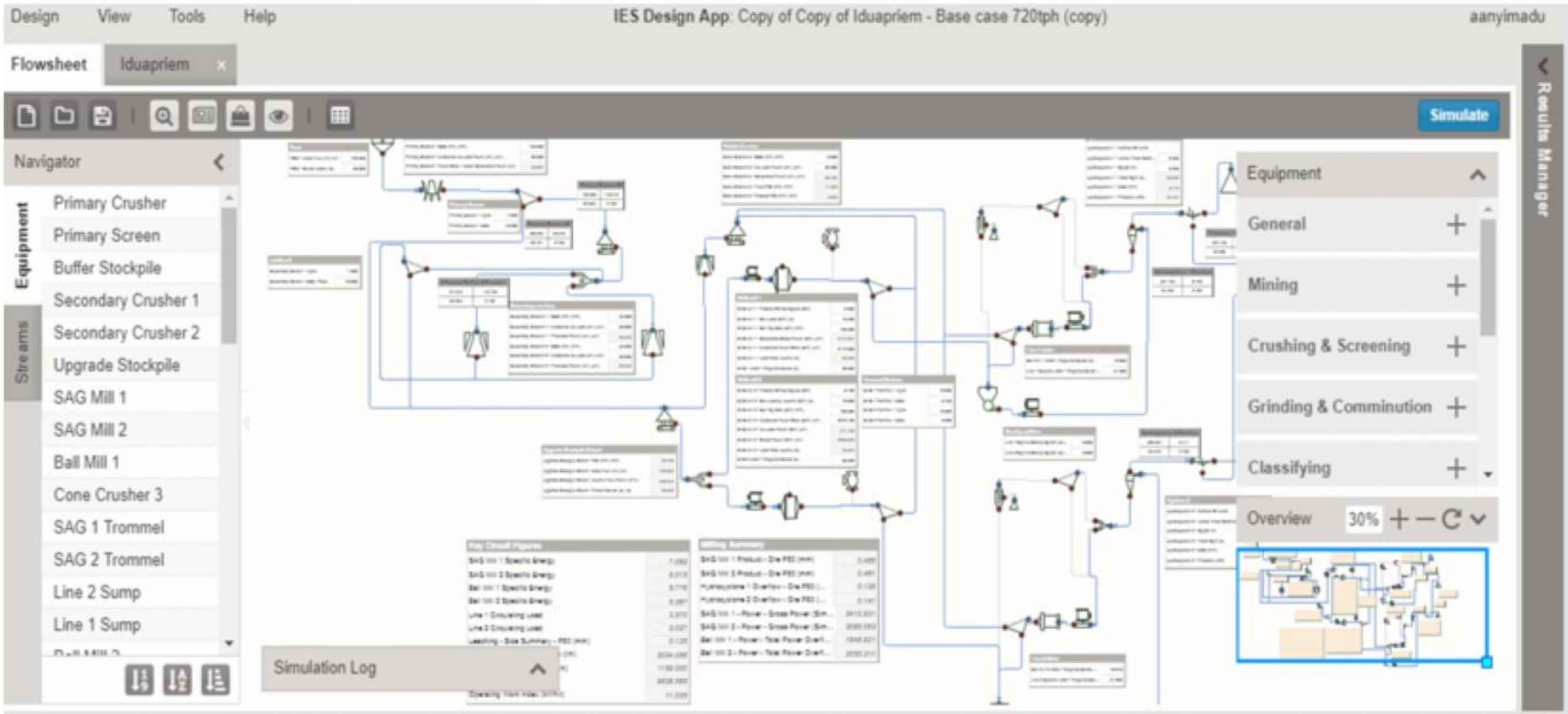
WAY POINT3: IDUAPRIEM

Context: Throughput improvement initiatives



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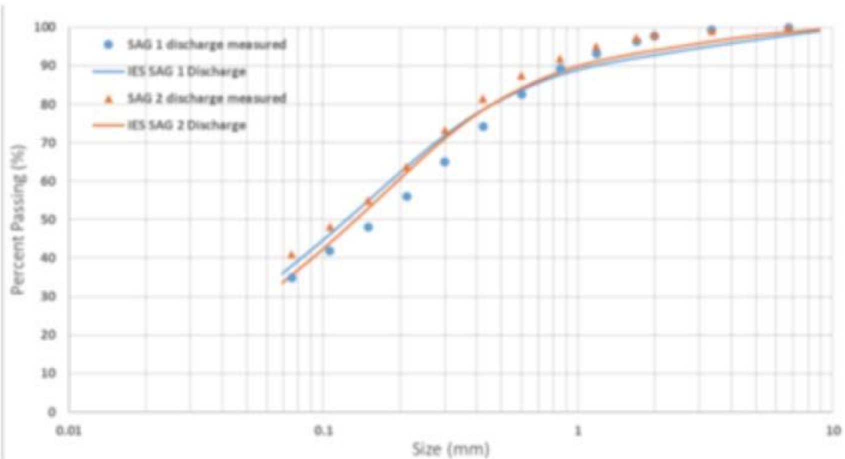
Base Case modelled to predict current performance

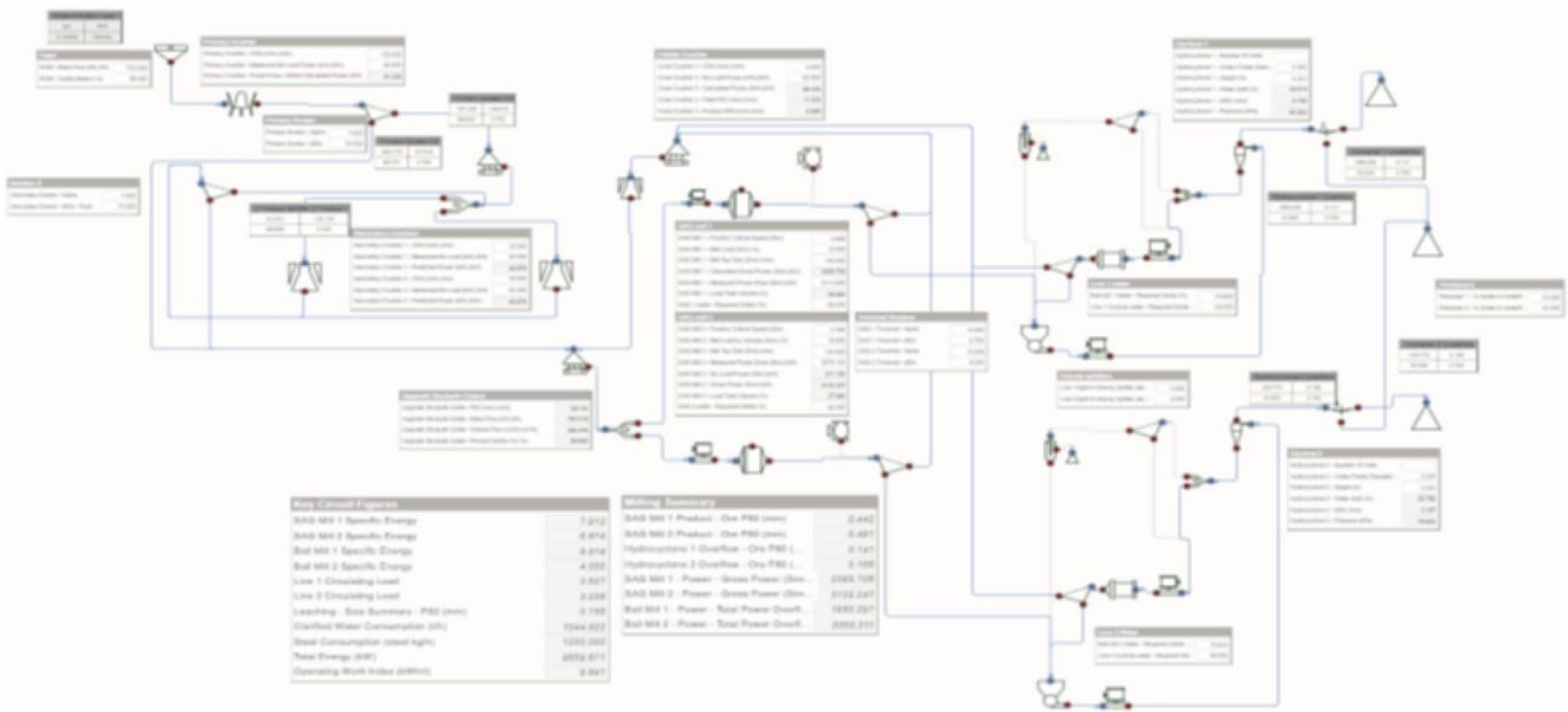
Table 4: Comparison of Key operating data for the base case simulation of Iduapriem circuit and PI data

	Feed		SAG Mill 1		SAG Mill 2		Ball Mill 1		Ball Mill 2	
	Feed rate (t/h)	Annual throughput (Mt)	Feed Rate (t/h)	Specific Energy (kWh/t)	Feed Rate (t/h)	Specific Energy (kWh/t)	Specific Energy (kWh/t)	Cyclone OF P80 (µm)	Specific Energy (kWh/t)	Cyclone OF P80 (µm)
PI Data	717	5.97	338	7.5	379	8.1	6.1	144	5.2	144
Base case model	720	5.99	341	7.06	385	8.01	5.78	128	5.37	141



IDUAPRIEM

THEN SIMULATE LOOKING FOR INCREASED THROUGHPUT CONDITIONS



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IDUAPRIEM

DOABLE OPTIMISED CASE WITHIN THE CURRENT INSTALLED CAPACITY!

	Feed		SAG Mill 1		SAG Mill 2		Ball Mill 1		Ball Mill 2	
	Feed rate (t/h)	Annual throughput (Mt)	Feed Rate (t/h)	Specific Energy (kWh/t)	Feed Rate (t/h)	Specific Energy (kWh/t)	Specific Energy (kWh/t)	Cyclone OF P80 (µm)	Specific Energy (kWh/t)	Cyclone OF P80 (µm)
Base case model	720	5.99	341	7.06	385	8.01	5.78	128	5.37	141
Optimisation scenario 1	750	6.24	300	7.912	454	6.87	6.52	141	4.56	166

Key circuit information which is simulated are as follows:

- Ball mill 1 circulating load 362%
- Ball mill 2 circulating load 304%
- Cyclone 1 nest pressure 82.29 kPa
- Cyclone 2 nest pressure 79.923 kPa

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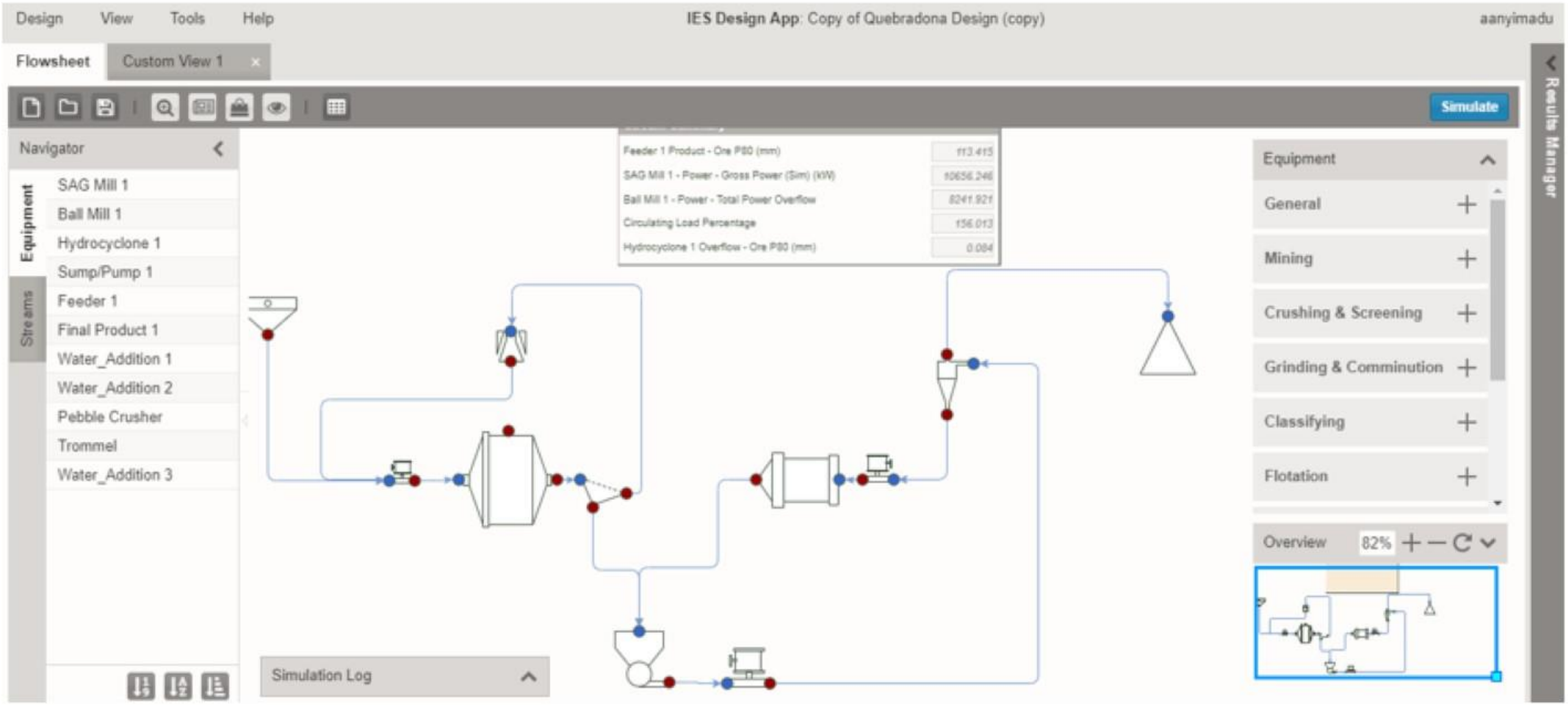
QUEBRADONA DESIGN CHECK



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TECHNOLOGY TRANSFER

- The very first plant application of IES at Sunrise Dam, trained Tropicana and Sunrise Dam (in conjunction with JKMRC and Metskill)
- South and West Africa Tech Transfer (with AMIRA P9 and UCT- 2015)
- AGA Leach/Adsorption leach application in IES (with Chalmers University)
- South America P420 Tech Transfer; and site visits (with AMIRA P420, Curtin University)
- South America 2-Week AMIRA P9 Workshop; Cuiaba and Corrego do Sitio Sampling, Survey and IES implementation programme (Led by UCT, with UFRG, Chalmers, JK. Hacetteppe – 20 AGA professional trained)
- La Colosa modelling and IES conversion check of Comminution Design; and Geomet (with JKMRC, IES team)
- Iduapriem plant Optimisation and Options Study Review (with JK)
- Remote seminars on IES (over 30 AGA Mets trained in 2018)

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TECHNOLOGY TRANSFER




40 metallurgical professionals trained to use IES to model their circuits

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WHERE TO NEXT?

- Full plant simulation – including "Black boxes", CIL/CIP, flotation.

  Key requirement will be developing models for the "black boxes"
- Move back into the mine:

  Blasting

  Stockpiling

  Blending

  Geometallurgy

  Sorting
- Ultimate aim: Drill bit to gold bar model – Digital Twin

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