



STRATUM AI

# COPPER PORPHYRY CASE STUDY

AI-driven model improving leach grade modelling by 43% and reducing waste by 63%, [unlocking ~\\$35M in-situ value](#)

# CASE OVERVIEW

## CONTEXT & CHALLENGE

- Large copper porphyry deposit in the United States with over 45 years of production history.
- Extensive dataset including **~300,000 m of drillhole** assays, ~90,000 blastholes, and ~70,000 blastholes reserved for reconciliation.
- Low cutoff grades (0.17% Cu mill / 0.08% Cu leach) require precise differentiation between mill, leach, and waste material.

## AI APPROACH

Deep learning model trained on **~390,000 samples** from **historical drillholes and blastholes**. The model learns complex geological patterns to classify material into mill, leach, or waste, improving block-level and quarterly predictions of leach performance.

## VALUE DELIVERED

Improved quarterly mill tonnage reconciliation by 56%, enhanced leach grade modelling accuracy by 43%, and reduced waste misclassification within leach predictions by 63%. Reconciliation results identified **9.4 Mlbs Cu (~US\$35M)** of additional mill ore in zones previously classified as waste by Kriging.

## DEPOSIT OPEN PIT

Large Copper Porphyry in the United States

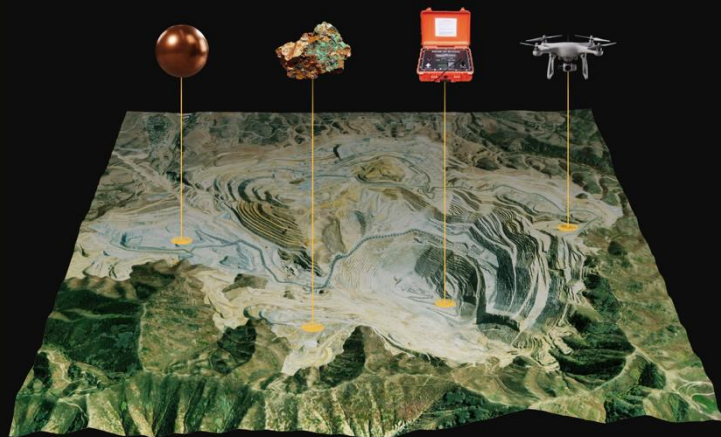


\*AI-driven modelling enabled the identification of **9.4 Mlbs (~\$35M)** of additional mill ore where kriging predicted waste.

# APPLIED METHODOLOGY

## 1 INPUT Existing data

Historical, multichannel, and other unstructured data



*We leverage all available data —such as metallurgy, geochemistry, geophysics, and sensor data— together with the full historical dataset of the mine*

## 2 PROCESSING Saige Deep Learning

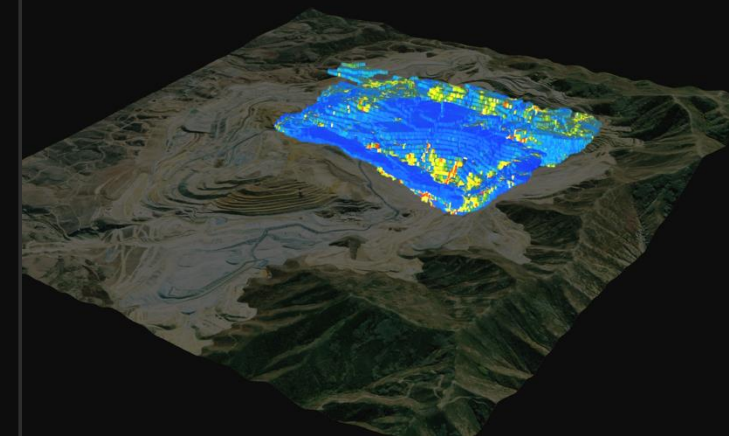
AI-driven analysis and integration of complex patterns



*Our AI model learns geological patterns from historical data, using a neural network trained on high-density datasets to model multivariate relationships in lower-density environments.*

## 3 OUTPUT AI predictive model

More accurate and comprehensive identification of mineral deposits



*Identifies previously unrecognized mineralized areas, improves definition in zones with low data density, and enables continuously updated resource models that guide companies toward the most profitable locations for mineral extraction.*

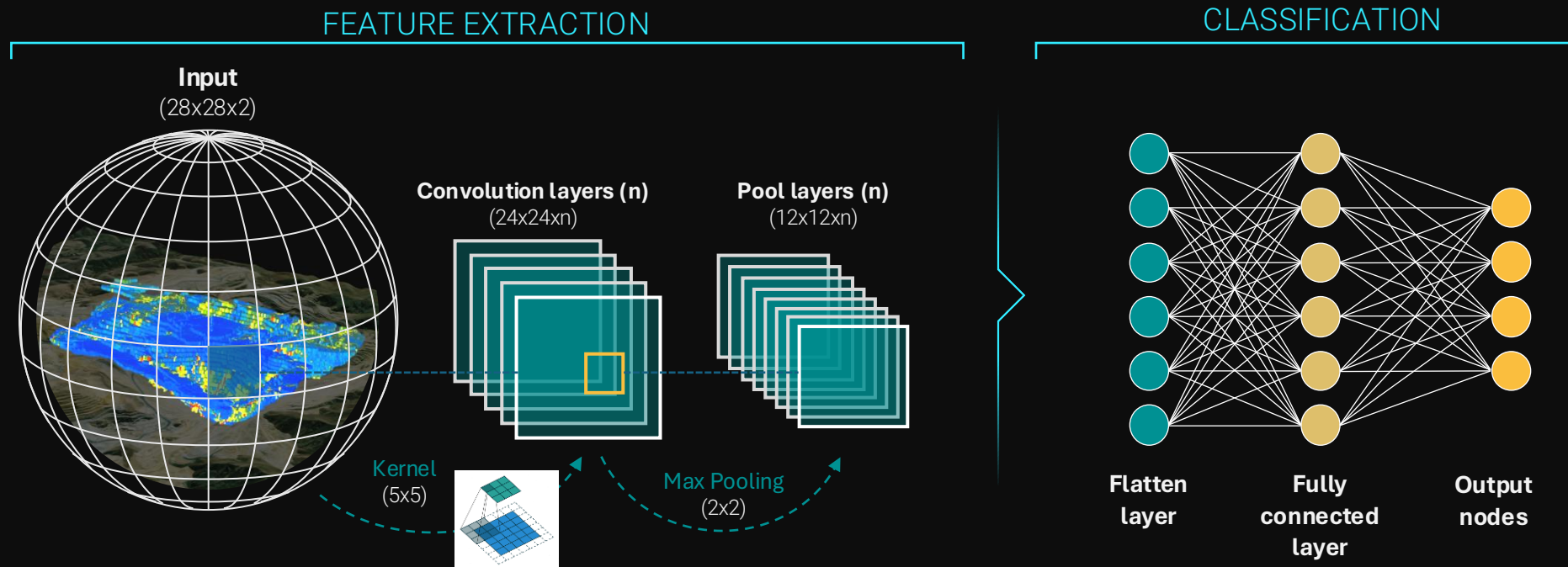
# CORE ARCHITECTURE

## SAIGE

Stratum AI  
Geospatial Estimator

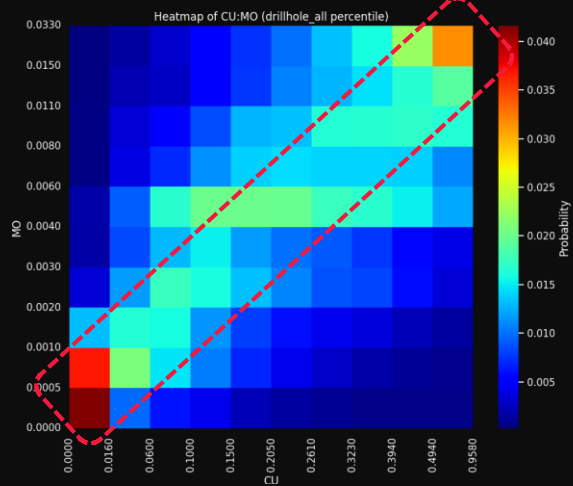
## CONVOLUTIONAL NEURAL NETWORK

Deep learning algorithm that successfully captures spatial dependencies in an image through the application of relevant filters. Stratum AI model is based on this architecture, adapting it to the unique challenges of mining data.

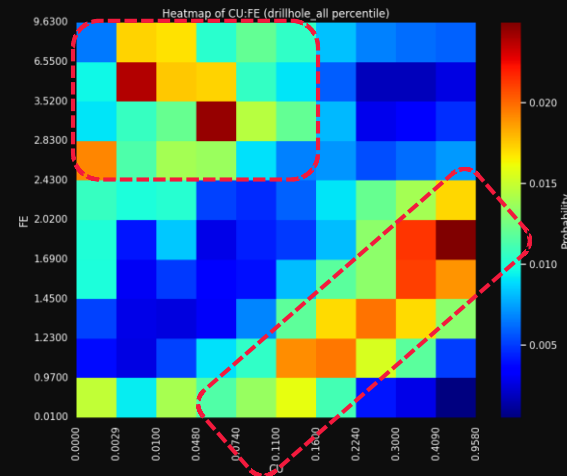


# DATA ANALYSIS

## PERCENTILE SCALING



COPPER & MOLYBDENUM (MO)

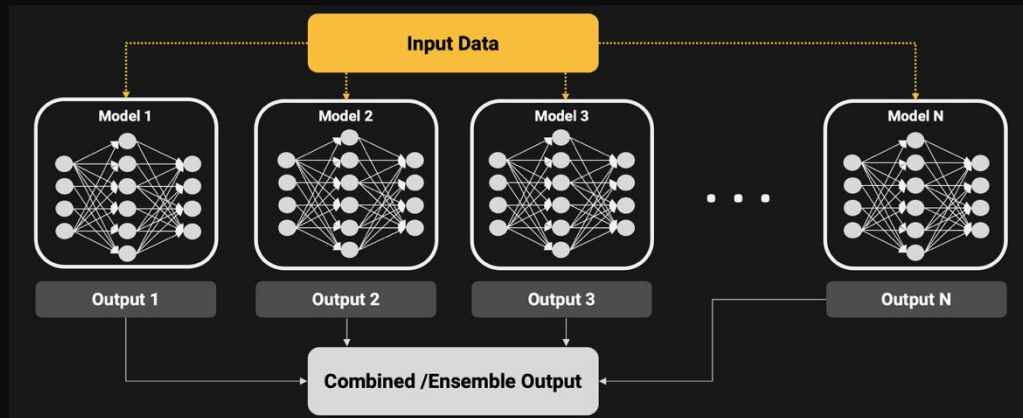


COPPER & IRON (FE)

- Spatial analysis reveals distinct mineralization domains (high Cu / low Mo, mid Cu / high Mo, etc.), highlighting non-linear behavior.
- **Mo assays add predictive value**, particularly around grade boundaries (0.06–0.20% Cu), improving detection of leach and mill ore
- **Fe inputs enhance high-grade targeting** (>0.45% Cu) and reduce false positives in HG zones
- Ensemble models combining **Cu, Mo, and Fe** improve targeting accuracy through consensus across multiple predictors

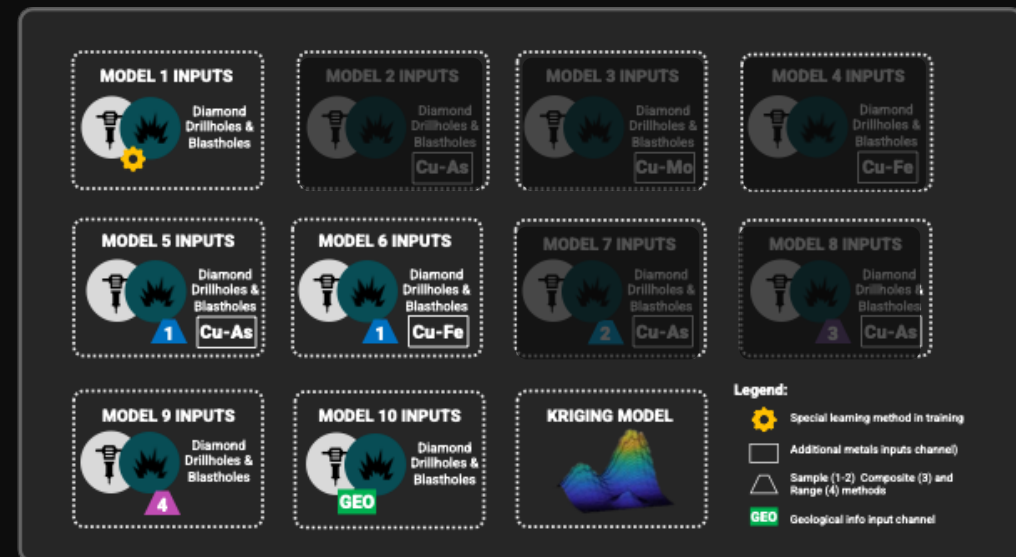
# COMBINATION OF MODELS

## ENSEMBLE NETWORKS



Combining the outputs of multiple AI models generally creates more accurate models. We create separate models from different data inputs and then combine them through an Ensemble Network. In this analysis, the Kriging model output can be included as well.

## Model used for reconciliation analysis: ENSEMBLE NETWORKS



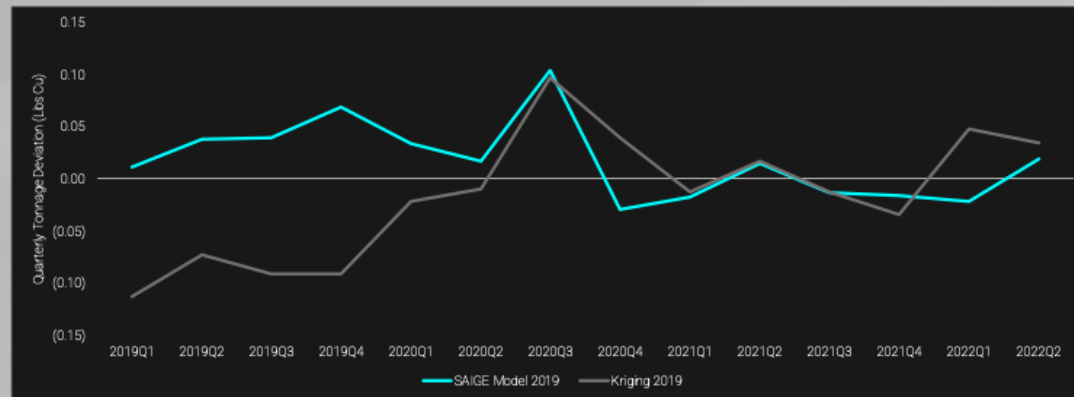
We build a unified ensemble of 10 AI models and the kriging baseline, selectively retaining only those that improve performance on target metrics

# SAIGE MODEL RESULTS

## QUARTERLY DEVIATION

Mill cutoff = 0.17% Leach cutoff = 0.08%

Quarterly Tonnage Deviation (Lbs Cu) *Kriging 4.97% vs SAIGE 3.16%*



### Methodology Notes

- Reconciliation analysis was performed across 14 consecutive quarters, from 2019 Q1 to 2022 Q2.
- Model validation was conducted using production blasthole data (BLHs), incorporating all available ICP and XRF assays throughout the evaluation period.
- ICP coverage was significantly expanded during 2021–2022, resulting in higher-resolution multi-element information across most production blocks.
- The reconciliation comparison used a block size of 50 × 50 × 45 ft.
- Copper metal calculations were normalized using an average specific density (SD) of 2.75.

### 2019 Models vs Blastholes 2019-2022

		Kriging 2019	SAIGE 2019
Quarterly Total Tonnage Deviation	All BLH (Cu lbs)	4.97%	3.16%
Quarterly Mill (>0.17% Cu) Tonnage Deviation	All BLH (Cu lbs)	9.28%	4.07%
	All BLH (MT ore)	7.70%	6.71%
Quarterly Leach (0.08% < Cu < 0.17%) Tonnage Deviation	All BLH (Cu lbs)	31.55%	17.97%
	All BLH (MT ore)	31.81%	19.11%

# SAIGE MODEL RESULTS

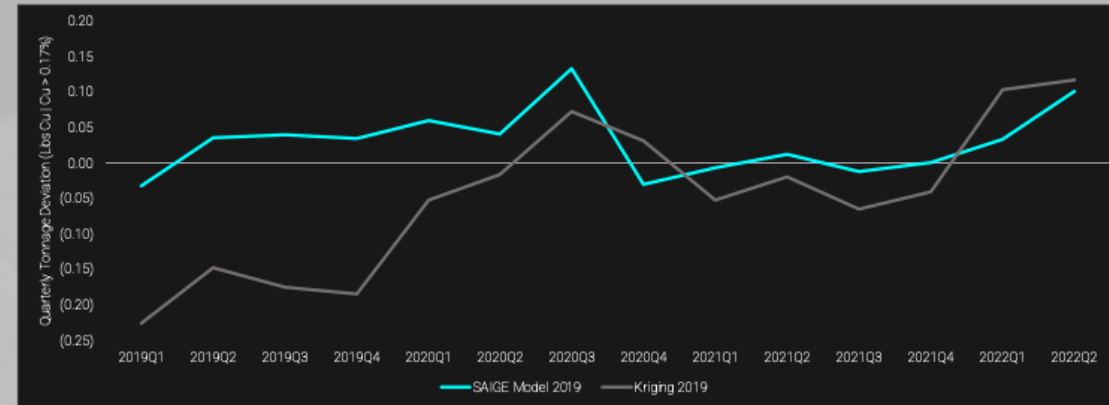
## QUARTERLY DEVIATION

Mill cutoff = 0.17% Leach cutoff = 0.08%

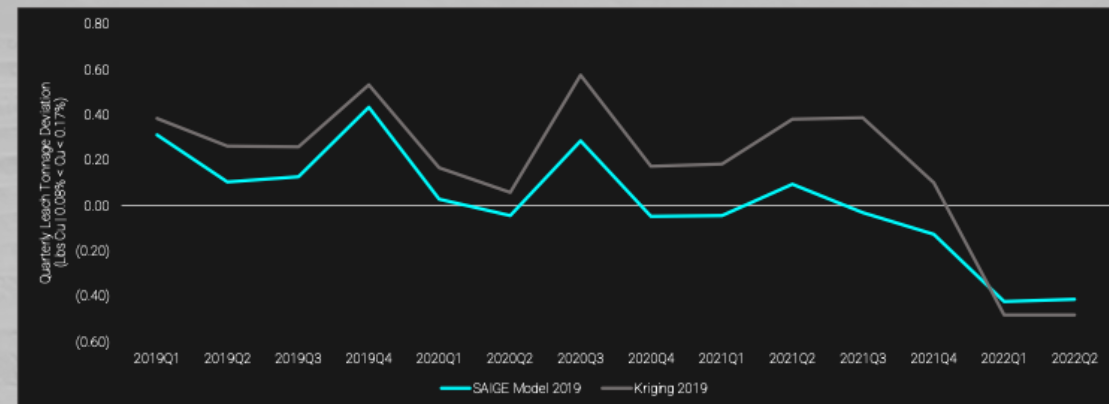
### Key Findings

- Ensemble models consistently outperformed standalone kriging across both mill and leach reconciliation metrics.
- The strongest relative improvement was observed in mill copper tonnage deviation (Cu lbs), where ensemble modelling reduced quarterly deviation from 9.28% to 4.07%. **(56% of relative improvement)**
- Significant improvements were also observed in leach reconciliation performance, suggesting better continuity capture in transitional-grade material. **(43% of relative improvement)**
- Results indicate that combining machine learning spatial pattern recognition with geological interpretation can materially improve production-scale reconciliation accuracy.

Quarterly Mill Tonnage Deviation (Lbs Cu | Cu > 0.17%) - Kriging 9.28% vs SAIGE 4.07%



Quarterly Leach Tonnage Deviation (Lbs Cu | 0.08% < Cu < 0.17%) - Kriging 31.55% vs SAIGE 17.97%



# SAIGE MODEL RESULTS

## BLOCK-WISE RESULTS

Mill cutoff = 0.17% Leach cutoff = 0.08%

2019 Models vs Blastholes 2019-2022		Kriging 2019	SAIGE 2019
Missed Mill Ore (mill ore predicted as leach or waste)	All BLH (Cu lbs)	38.47 Mlbs Cu	29.07 Mlbs Cu
	All BLH (MT ore)	8.08 MT	6.13 MT
False Positive Mill Ore (leach/waste predicted as mill ore)	All BLH (% waste/ leach)	12.11%	13.8%

The SAIGE model demonstrates a significantly stronger ability to identify mill-grade ore (>0.17% Cu) compared to standalone Kriging, correctly identifying an **additional 9.4 Mlbs Cu** of mill ore in zones where Kriging classified material as leach or waste, reducing missed mill ore from 38.47 Mlbs Cu to 29.07 Mlbs Cu.

While the model introduces a modest increase in false positive mill ore classification, the economic trade-off remains favorable for this operation, where recovering additional mill ore is more valuable than marginal reductions in waste movement.

2019 Models vs Blastholes 2019-2022		Kriging 2019	SAIGE 2019
Missed Leach Ore (leach ore predicted as waste)	ICP BLH (Cu lbs)	1.48 Mlbs Cu	2.40 Mlbs Cu
	ICP BLH (MT ore)	0.70 MT	1.13 MT
Waste In Leach Ore (Waste predicted as leach)	ICP BLH (% waste)	35.2%	13.0%

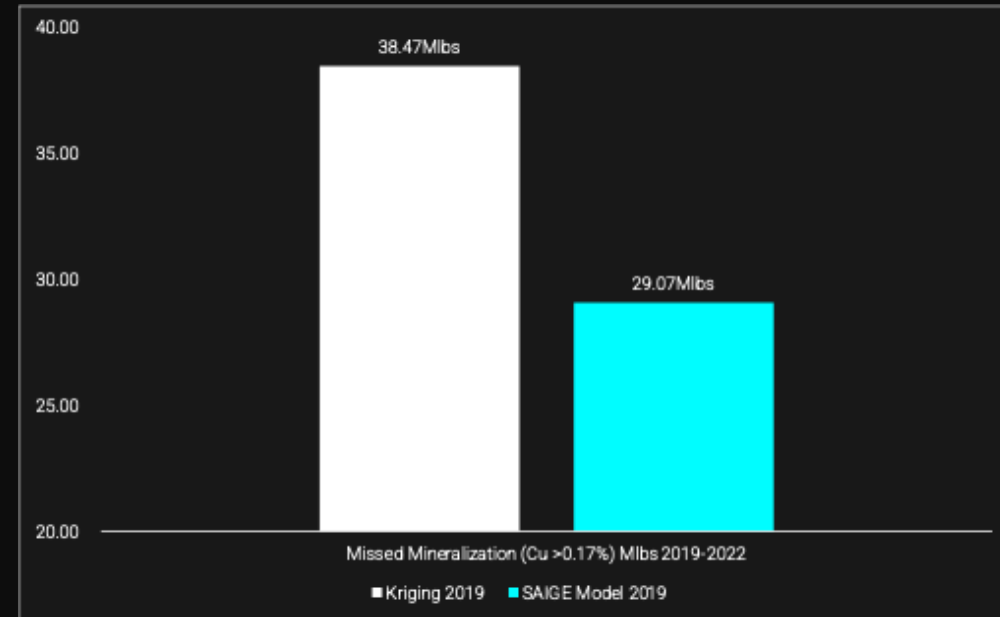
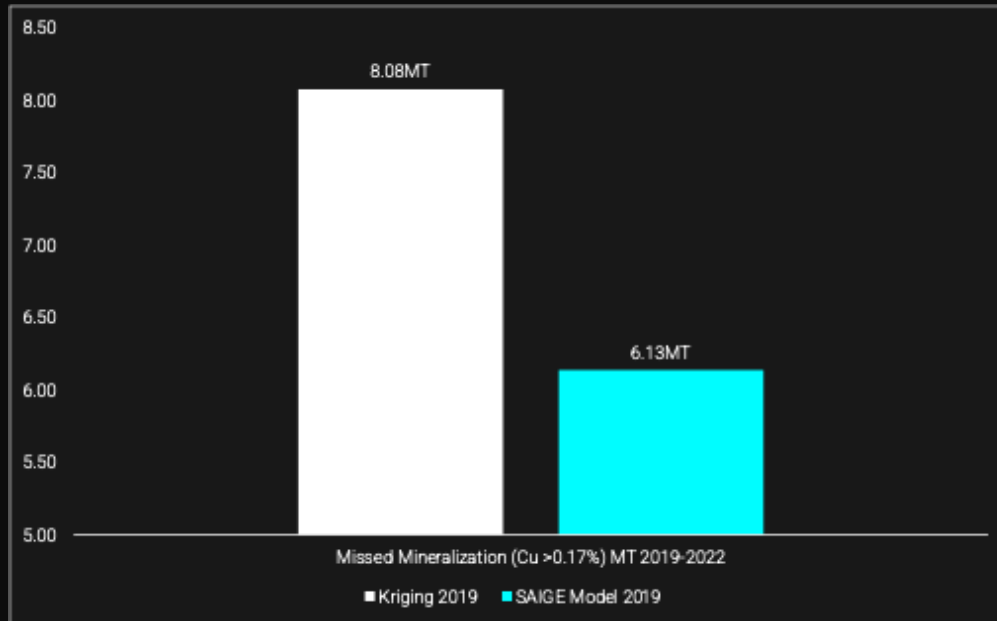
Leach reconciliation was evaluated using only ICP blasthole data due to the narrow grade range between waste and leach material (0.08%–0.17% Cu) and the higher analytical precision of ICP assays. In this domain, SAIGE behaved more conservatively, slightly increasing missed leach ore while substantially reducing waste dilution within predicted leach material. Only 13.0% of predicted leach reconciled as waste, compared to 35.2% under Kriging, representing a **63% relative reduction in waste dilution** and a significant improvement in leach feed quality. For this operation, where leach material is already marginal ore, maintaining cleaner leach classification is economically preferable to aggressively maximizing leach recovery.

# SAIGE MODEL RESULTS

## MISSED MILL ORE

Ore Mill predicted as Waste or Leach  
Mill cutoff = 0.17%

SAIGE demonstrated a materially stronger ability to identify economically recoverable mill-grade mineralization (>0.17% Cu) compared to the baseline Kriging model, improving recognition of zones that would otherwise be misclassified as waste or low-grade material. Over the 3.5-year reconciliation period (2019 Q1 – 2022 Q2), missed mill ore was reduced from 38.47 Mlbs Cu under Kriging to 29.07 Mlbs Cu under SAIGE, equivalent to **9.4 Mlbs Cu** of additional recovered mineralization and an approximate 24% relative reduction in missed ore.

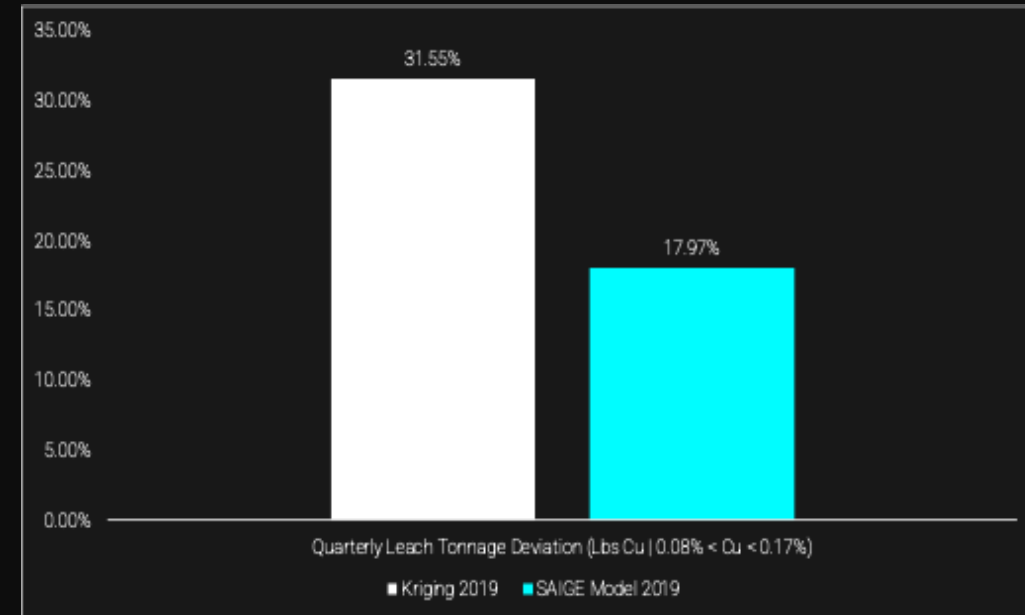
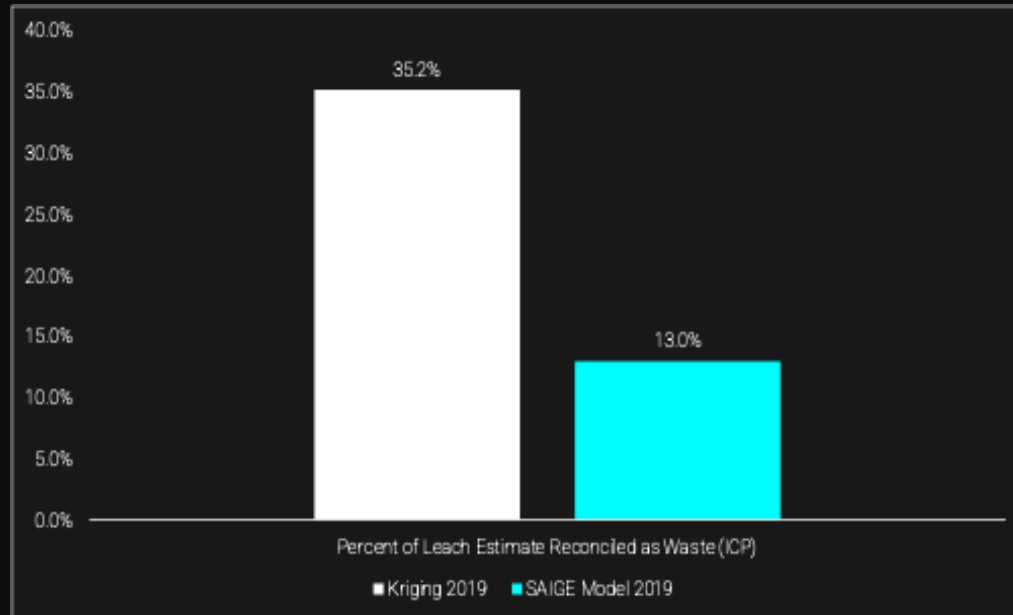


# SAIGE MODEL RESULTS

## WASTE IN LEACH ORE

Waste predicted as Leach Ore  
Leach cutoff = 0.08% < Cu < 0.17%

SAIGE demonstrates materially improved leach reconciliation performance relative to Kriging by producing more constrained and operationally reliable leach classifications. The model reduced waste reconciled within predicted leach material from 35.2% to 13.0%, representing a 63.08% relative reduction in waste dilution, while quarterly leach tonnage deviation improved from 31.55% to 17.97%, equivalent to a 43.03% relative improvement in reconciliation accuracy.

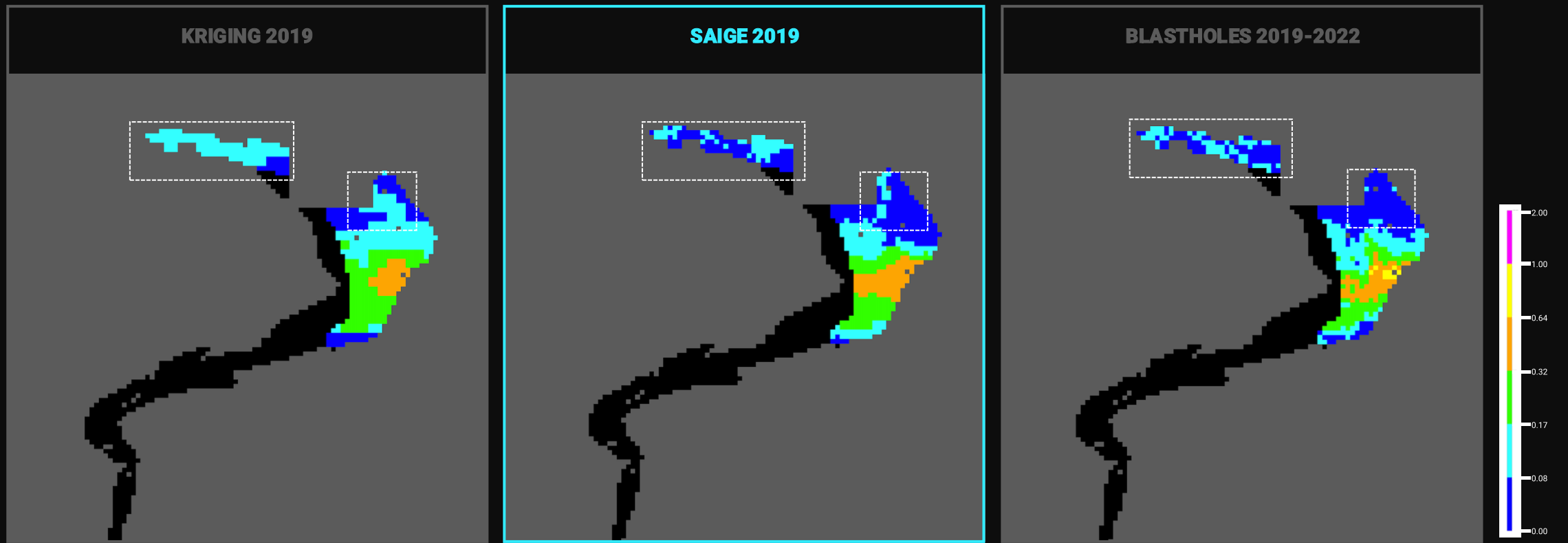


# BENCH VIEW

Z = 4010.8750 ft

SAIGE model identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and improves pit design as it should not have been mined in the first place (contains little to no ore in benches under it).

Block Size  
50ft x 50ft x 45ft

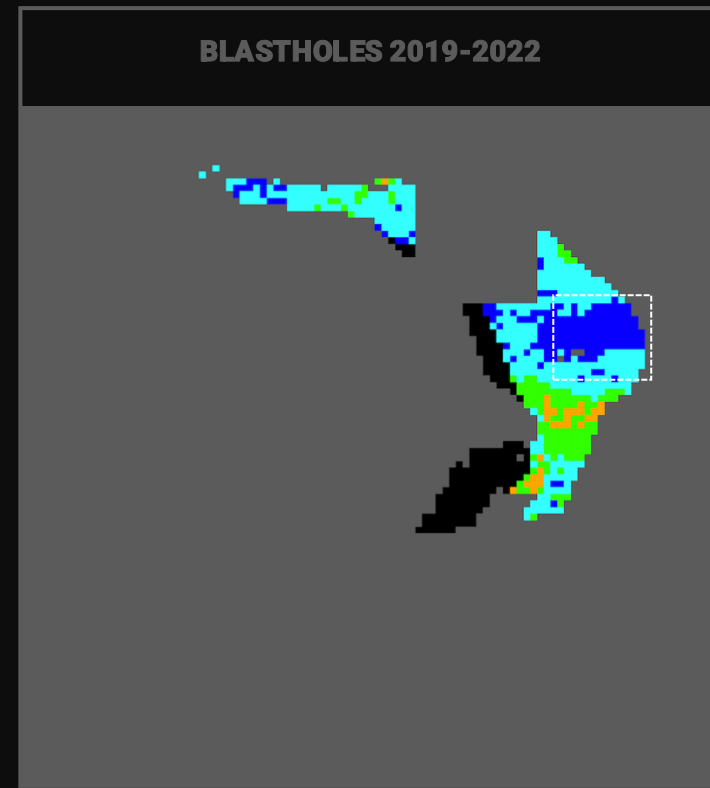
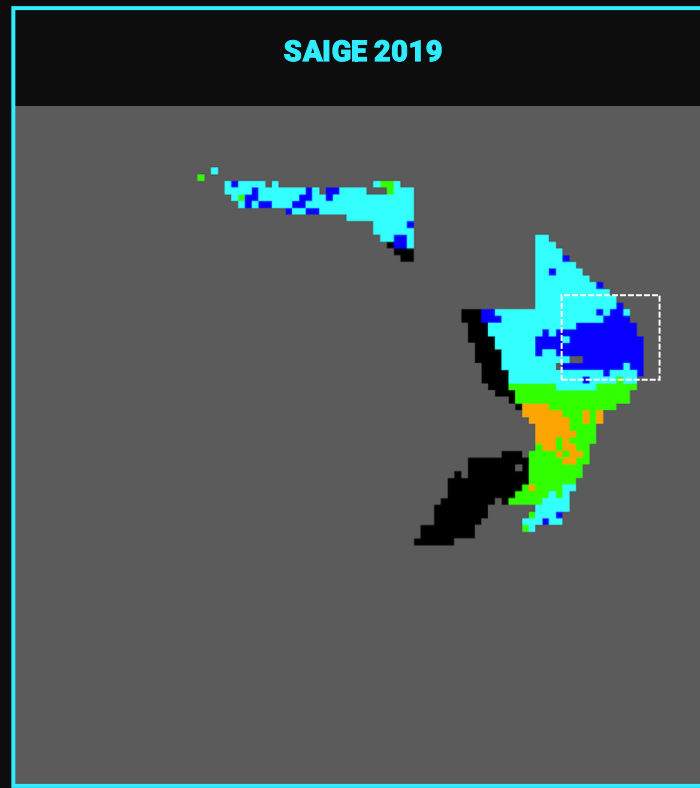
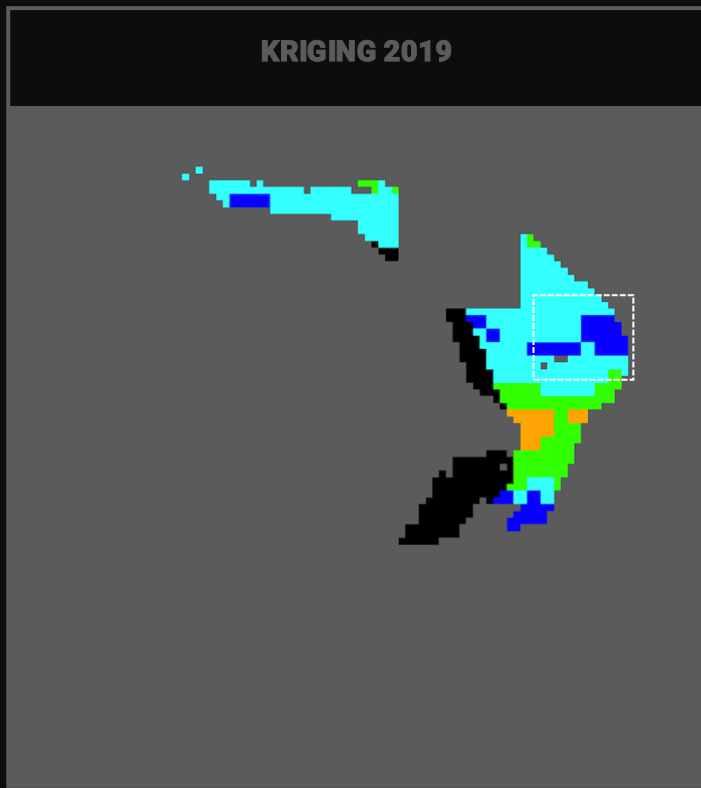


# BENCH VIEW

Z = 4145.8750 ft

SAIGE model identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and dilution (through blast shape delineation).

Block Size  
50ft x 50ft x 45ft

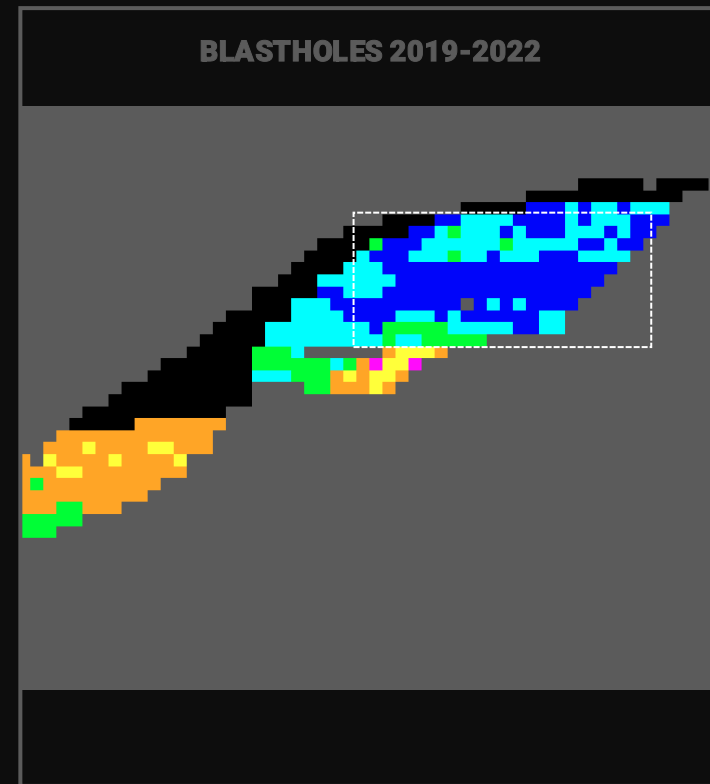
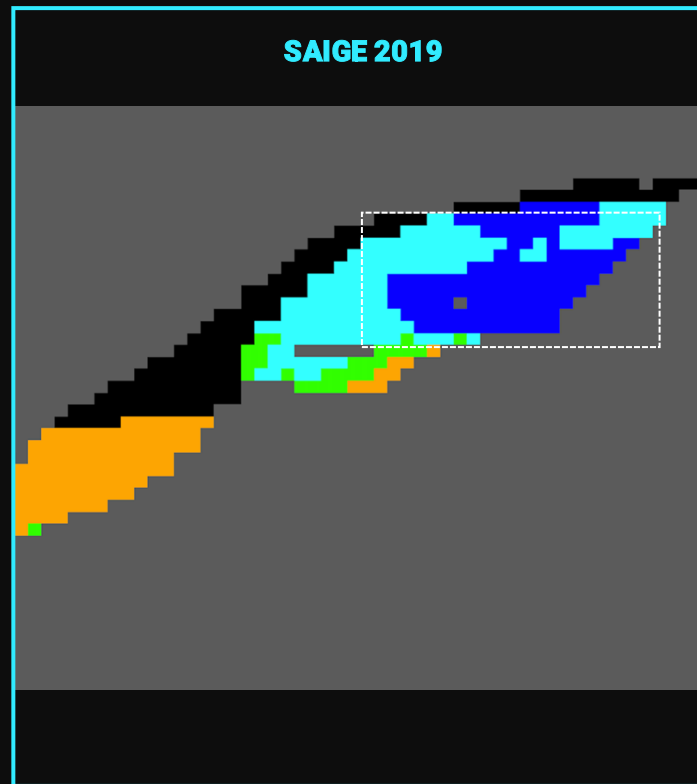
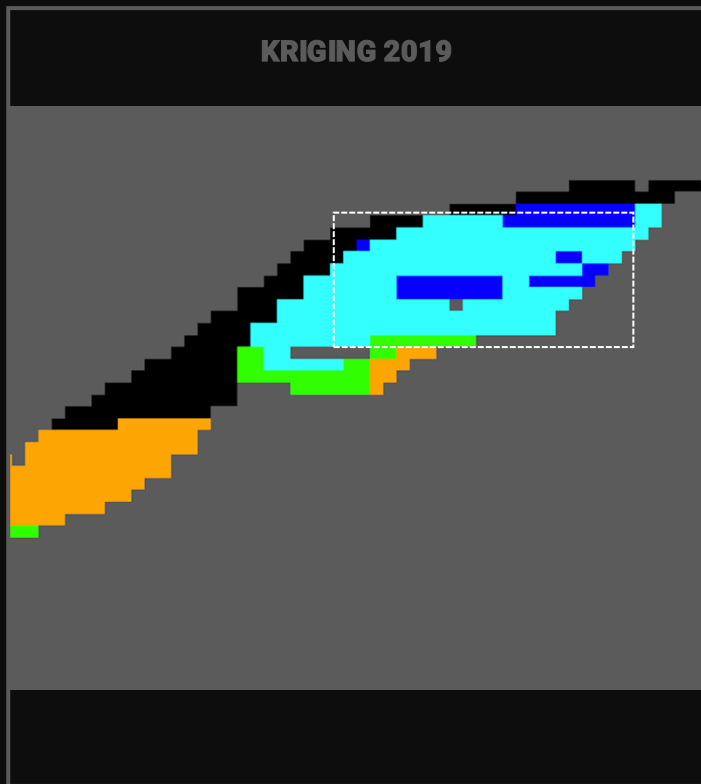


# BENCH VIEW

North = 6694.5700 ft

SAIGE model identifies waste area correctly where kriging predicts leach grade. This improves leach guidance and dilution (through blast shape delineation).

Block Size  
50ft x 50ft x 45ft

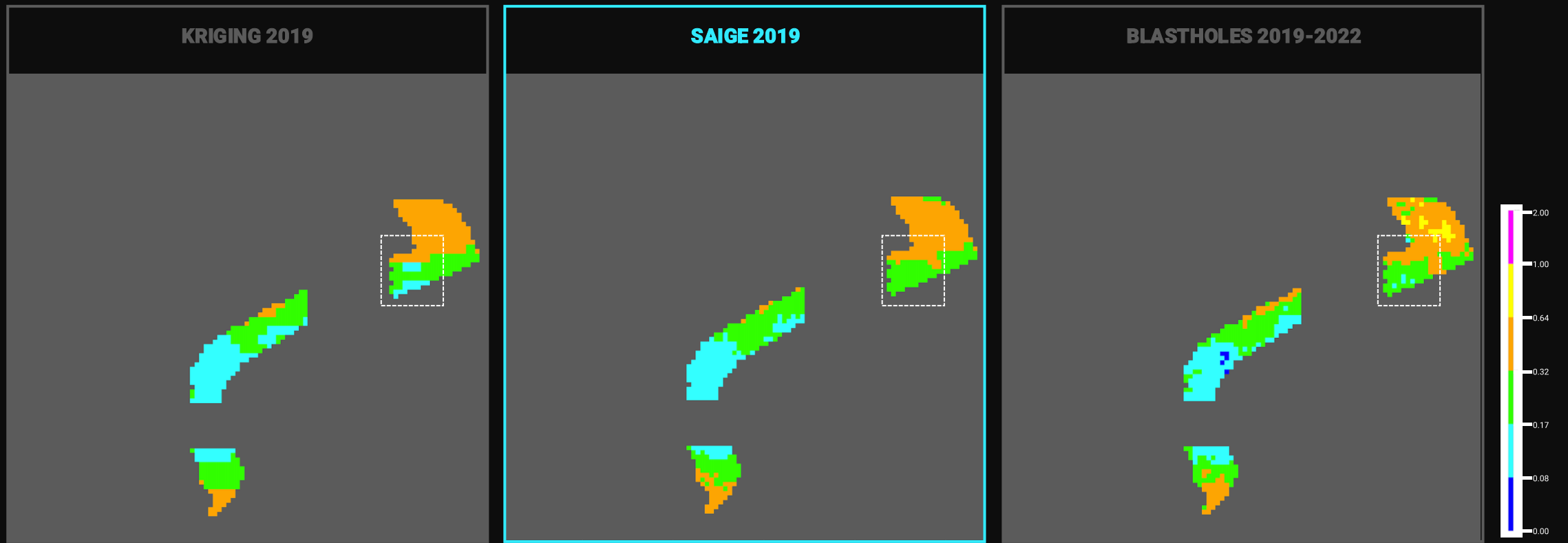


# BENCH VIEW

Z = 3515.8750 ft

SAIGE model identifies mill area correctly where kriging predicts waste/leach. Demonstrates ability of model in correctly identifying otherwise missed mineralization.

Block Size  
50ft x 50ft x 45ft



# SAIGE MODEL RESULTS - HG

## BLOCK-WISE RESULTS

HG cutoff = 0.45%

### HIGH GRADE ANALYSIS

2019 Models vs Blastholes 2019-2022		Kriging 2019	SAIGE 2019
Missed Mill Ore (mill ore predicted as leach or waste)	All BLH (Cu lbs)	85.15 Mlbs Cu	60.42 Mlbs Cu
	All BLH (MT ore)	7.15 MT	5.03 MT
False Positive Mill Ore (LG/waste predicted as mill ore)	All BLH (% waste/leach)	34.13%	31.03%

For high-grade mineralization (>0.45% Cu), SAIGE reduced missed copper from 85.15 Mlbs Cu under Kriging to 60.42 Mlbs Cu, equivalent to **24.73 Mlbs Cu of additional recovered mineralization** and a 29.04% relative reduction in missed HG ore.

Reconciliation results also indicate a **9.1% lower probability** that blocks predicted as high-grade reconcile as low-grade or waste when mined, demonstrating improved confidence and selectivity in HG classification.

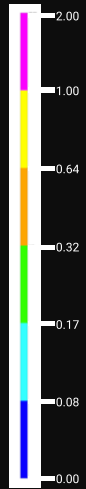
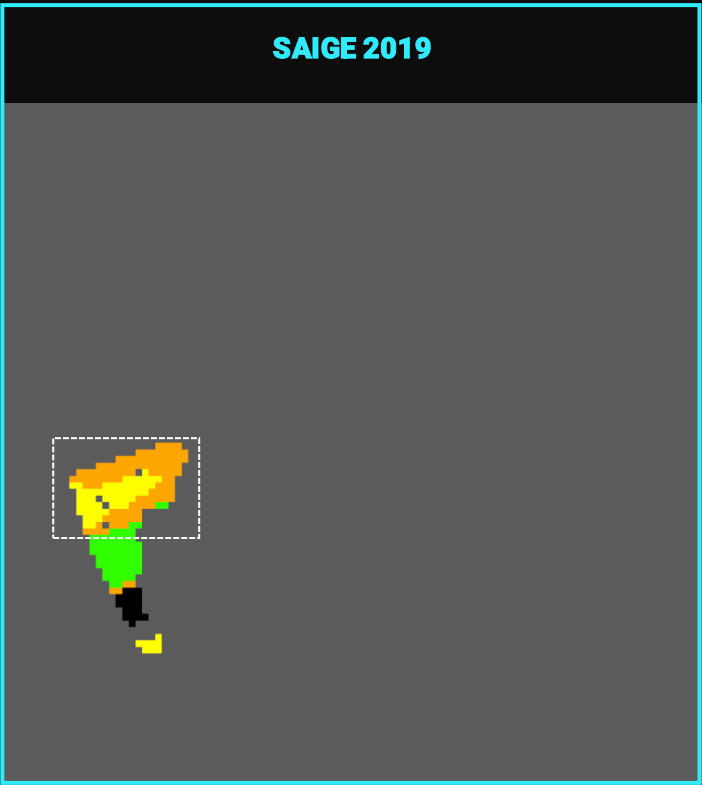
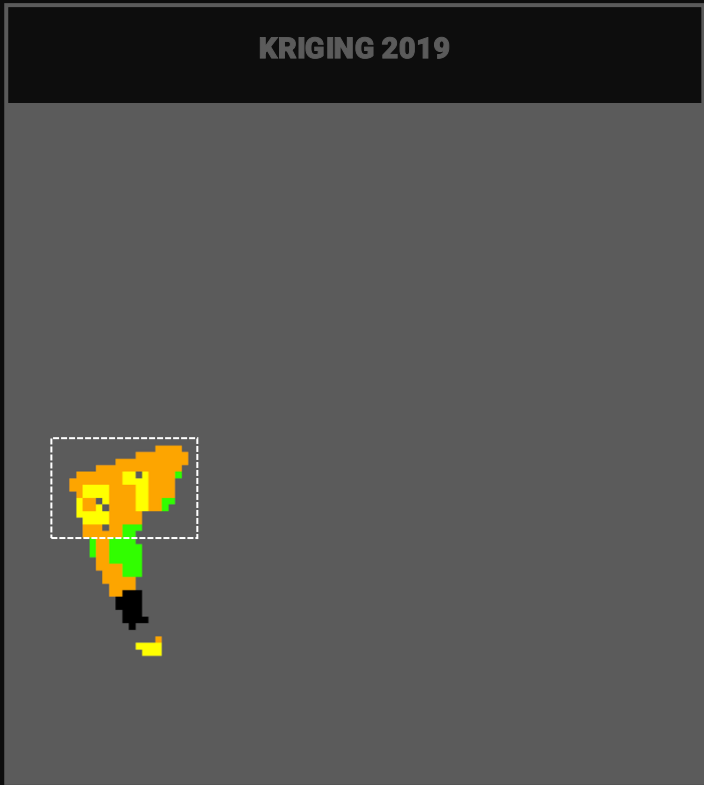
# BENCH VIEW

Z = 2750.8750 ft

HIGH GRADE ANALYSIS

SAIGE model successfully identifies large continuous HG region that should be heavily prioritized in the mine plan. Predicting this bench correctly earlier in mine life would improve realized NPV as it would prioritize mine design to reach it sooner.

Block Size  
50ft x 50ft x 45ft



# BENCH VIEW

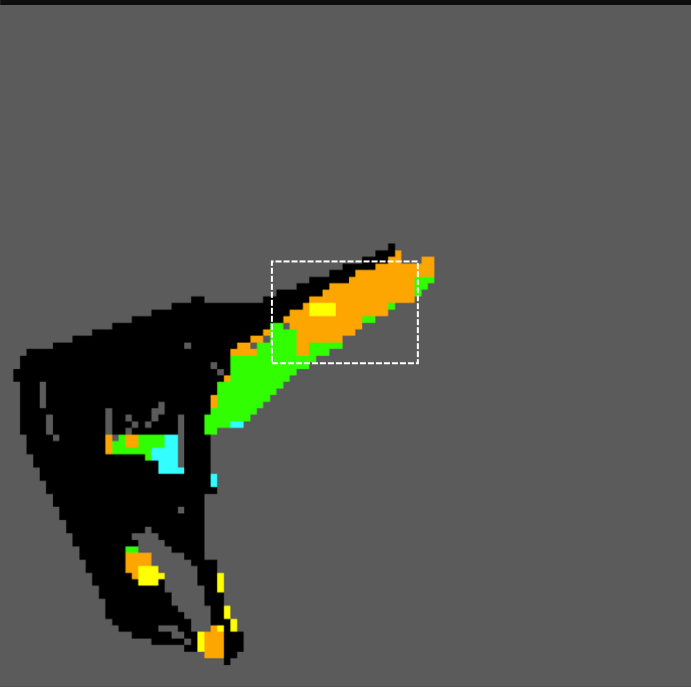
Z = 3110.8750 ft

HIGH GRADE ANALYSIS

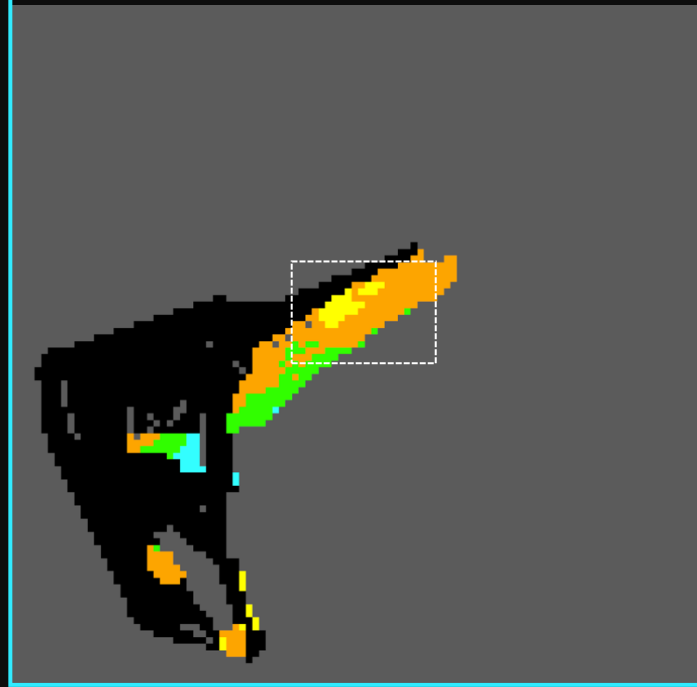
SAIGE model successfully identifies large continuous HG region that should be heavily prioritized in the mine plan. Predicting this bench correctly earlier in mine life would improve realized NPV as it would prioritize mine design to reach it sooner.

Block Size  
50ft x 50ft x 45ft

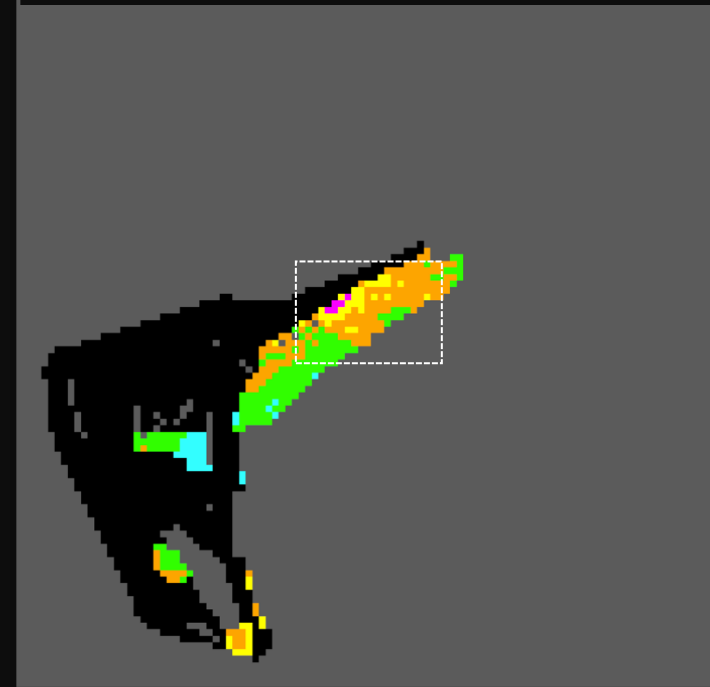
KRIGING 2019



SAIGE 2019



BLASTHOLES 2019-2022



# SAIGE MODEL RESULTS

## SUMMARY

SAIGE demonstrated improved operational reliability through more accurate ore/waste separation, reduced dilution risk within leach feed, and stronger alignment between model predictions and reconciled mining performance.

These improvements translated into cleaner material classification, more consistent guidance across production periods, and increased confidence in operational decision-making.

### IMPROVED PRODUCTION RECONCILIATION

**+56%**

Improvement in quarterly **mill** tonnage deviation

**+43%**

Improvement in quarterly **leach** tonnage deviation

### MILL ORE RECOVERY UPSIDE

**+9.4  
Mlbs**

Additional recoverable mill ore identified during reconciliation

### CLEANER LEACH CLASSIFICATION

**-63%**

Less waste reconciled where leach predicted

Improved leach guidance reliability and reduced dilution

### IMPROVED HG ORE RECOVERY (>0.45% CU)

**+23.7 Mlbs**

Mlbs less missed HG ore in reconciliation

**-9.1%**

lower probability of HG blocks reconciling as LG/W



STRATUM AI

# COPPER PORPHYRY CASE STUDY

AI-driven model improving leach grade modelling by 43% and reducing waste by 63%, [unlocking ~\\$35M in-situ value](#)