Managing Multiple Indicator Kriging Models

This article details how to work with a multiple indicator kriging model (MIK) effectively and efficiently using multi-ore percent modeling. Similar reporting techniques can be also used for uniform conditioning (UC) models.

MineSight Tools for MIK Reserves and Planning

Let's assume the block (Figure 1) has items CUIK1, CUIK2, CUIK3 and CRPB1, CRPB2, CRPB3 that correspond to grade and percentage of block above grades of 0.0, 0.4 and 0.6 respectively.

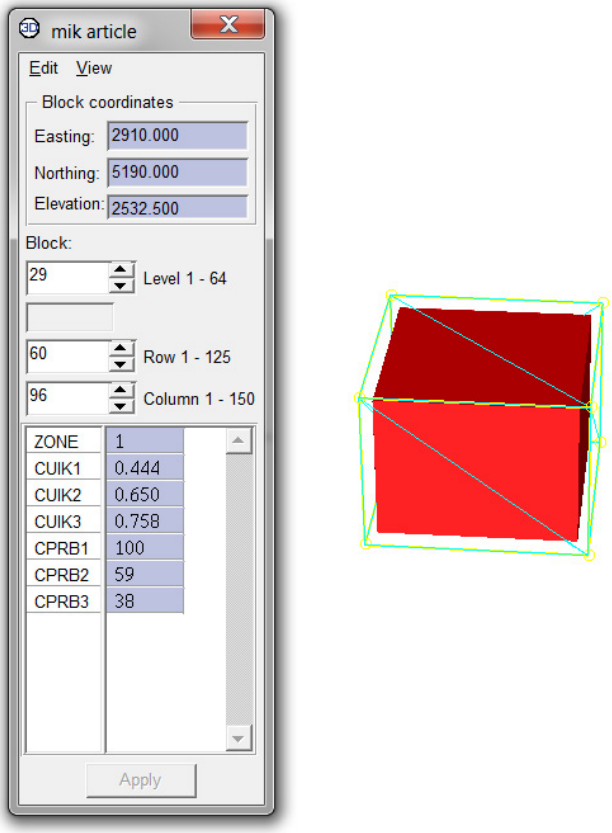


Figure 1. *A block with grade and percentage above grade items.*

To run reserves on such a MIK model, use any of the following methods.

1. Use procedure SMURES.DAT (Report Reserves from Block %).

Set up an SMU table to associate each zone item with the sequence in which material is accumulated. You need a zone item in the model (even just a "dummy" item with a constant value of 1).

For example, in the picture/block shown in Figure 2 for zone 1, the sequence of accumulation is 1-2-3.

```
0 1 2 3
1 1 2 3
```

```
smu.dat      Name of SMU Table File
test         Filename of output files (no extension) (RPT/SUM/SCD)
☐ Output MineSight Schedule file? (extension will be .scd)
                                        Title (** Reserves for ....)
```

Figure 2. *SMU table, showing zone and sequence of accumulation.*

Key panel in this procedure can be seen in Figure 3.

```
DETERMINE SMU RESERVES FROM PIT DESIGN OR OPTIMIZED PIT

*** The following items are on a whole block basis ***
zone      Name of zone/rock type item (SMU table is keyed to this item)
          Name of model ore density item (Leave blank if no Density item)

*** The following are for each SMU category  ***
3         Number of SMU categories per block (2-10)
cprb      Name of ore% item (Fill here or use next panel)
☐ Ore% and waste% items are a fraction. (Default=percentage)

cuik                                                  Grade items (or use next
                                                                      panel)
☐ Use the SMU table classification for MineSight Scheduling file?
If using the above option, cutoffs below would be the class #s and labels.
```

Figure 3. *The SMURES.DAT procedure.*

The reserves now are reported in incremental fashion (Figure 4). Zone 1 is for 0.0 to 0.4, zone 2 is for 0.4 to 0.6 and zone 3 is for above 0.6.

BENCH TOE	ZONE NAME	ZONE NO.	INSITU ORE (BCMS)	INSITU ORE (TONNES)	RUN OF MINE (TONNES)	INSITU GRADES CUIK
2525.0	1	1	2460.	6150.	6150.	0.1476
	2	2	1260.	3150.	3150.	0.4546
	3	3	2280.	5700.	5700.	0.7580
2525.0	SUMMARY		6000.	15000.	15000.	0.4440
	WASTE		0. (BCMS)	BENCH,CUM. ROM S/R=		0.00 0.00

Figure 4. *Reserves reported from SMURES.DAT procedure.*

2. Convert grades and proportions above cutoff to discrete grade and percentages.

Clone the MIK model if needed and add new items to calculate into. The number you add depends on the number of discrete bins you want in your model (from the ones you have already calculated in the MIK model). Choose the ones that match the mining material cutoffs. For example, waste, low grade, high grade, etc. In general, you will need three items per cutoff:

DP# - discrete percentage value

DG# - discrete grade value

ZN# - discrete zone item (needed for procedure PITRES.DAT and MineSight Interactive Planner - MSIP)

To transform from cutoff intervals to bins we apply the following formulas:

Discrete percentage is calculated as

lower cumulative percentage – upper cumulative percentage.

Pct (i) = Pct (i) – Pct (i+1)

Discrete grade is calculated as

(metal of lower bin – metal of upper bin)/discrete percentage value.

G(i) = (G(i)*Pct(i) – G(i+1)*Pct(i+1)) / (Pct (i) – Pct (i+1))

Last interval remains the same.

ZONE item is a requirement to use MSIP, so we'll assign an arbitrary integer number to each of the cutoff bins using the cp-ModelCalcTool.pyx procedure (Figure 5).

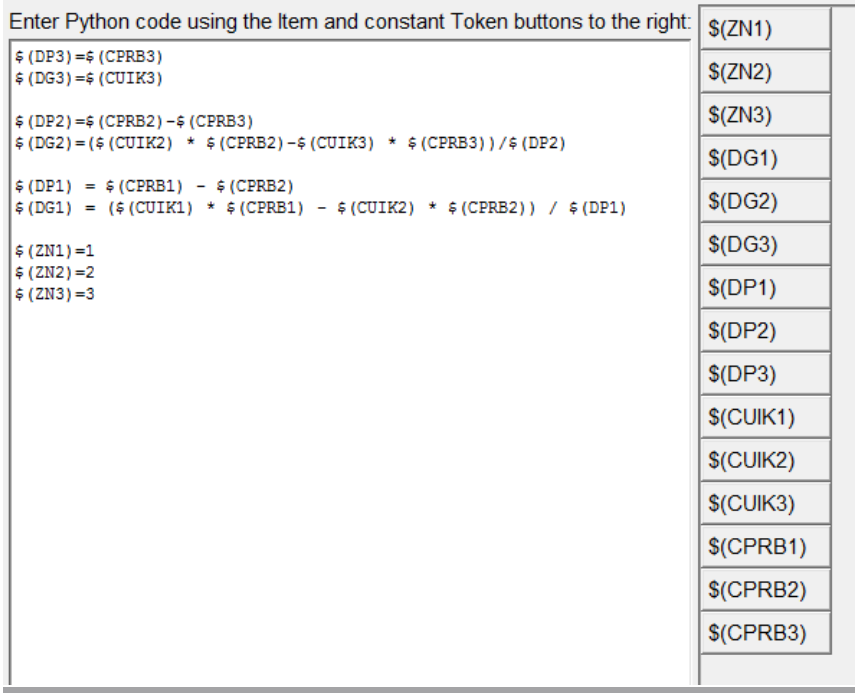


Figure 5. *Assign integer number to each of the cutoff bins.*

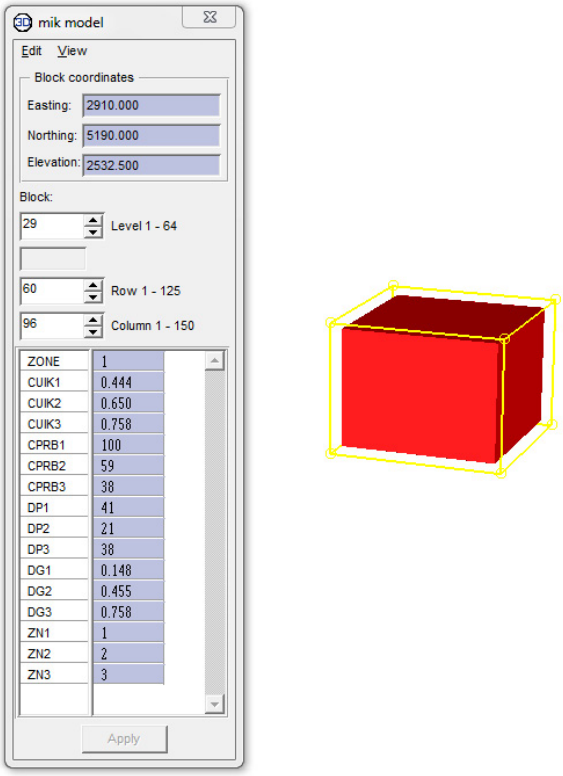


Figure 6. *Values in the block.*

3. Check reserves with PITRES.DAT (Report 3DBM Reserves) using discrete items (it should match procedure SMURES.DAT).

Key panel and results are shown in Figures 7 and 8.

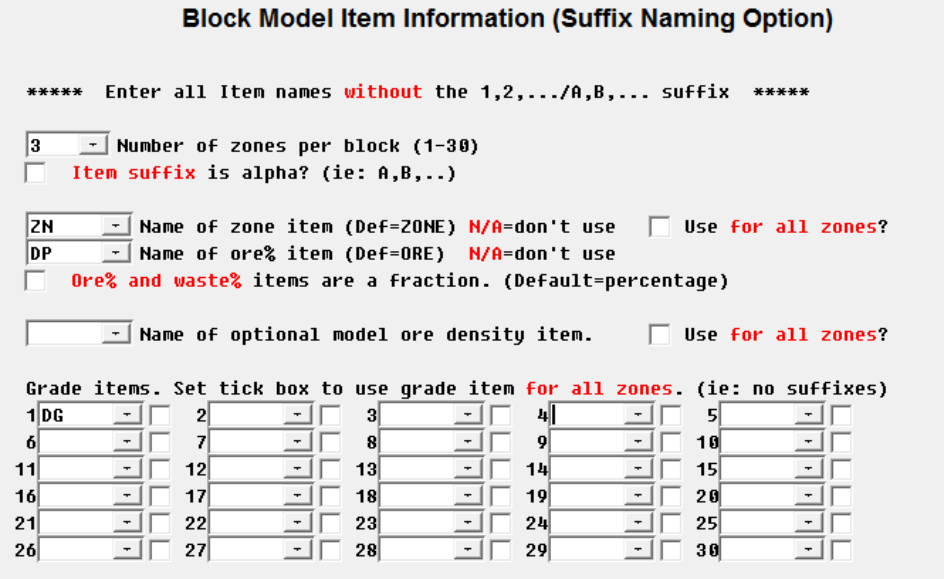


Figure 7. *PITRES.DAT panel information.*

BENCH TOE	ZONE NAME	ZONE NO.	INSITU ORE (BCMS)	INSITU ORE (TONNES)	RUN OF MINE (TONNES)	INSITU GRADES DG
2525.0	1	1	2460.	6150.	6150.	0.1480
	2	2	1260.	3150.	3150.	0.4550
	3	3	2280.	5700.	5700.	0.7580
2525.0	SUMMARY		6000.	15000.	15000.	0.4443
	WASTE		0. (BCMS)	BENCH,CUM. ROM S/R=		0.00 0.00

Figure 8. *PITRES.DAT results.*

4. Run MSIP with multiple ore% items.

To use the MIK model with MSIP set up a multiple ore% plan. Use the items/values as they were calculated from the model calculation script (discrete items).

The basic set up is displayed in Figures 9 through 11.

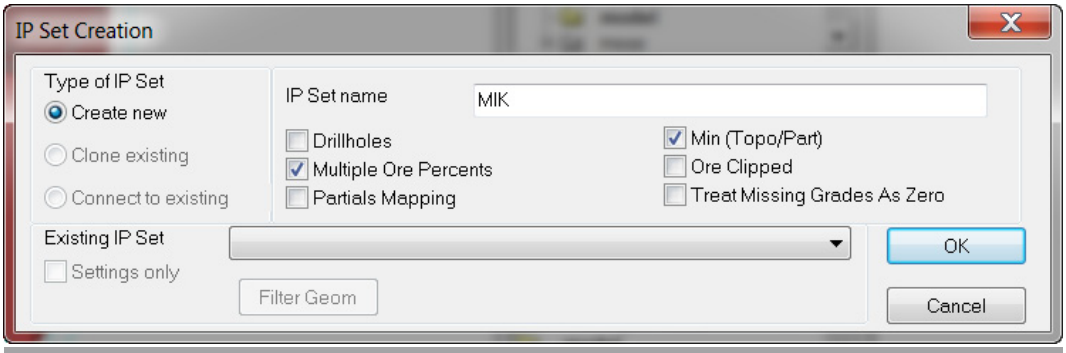


Figure 9. *Choose to use Multiple Ore Percents when setting up the IP object.*

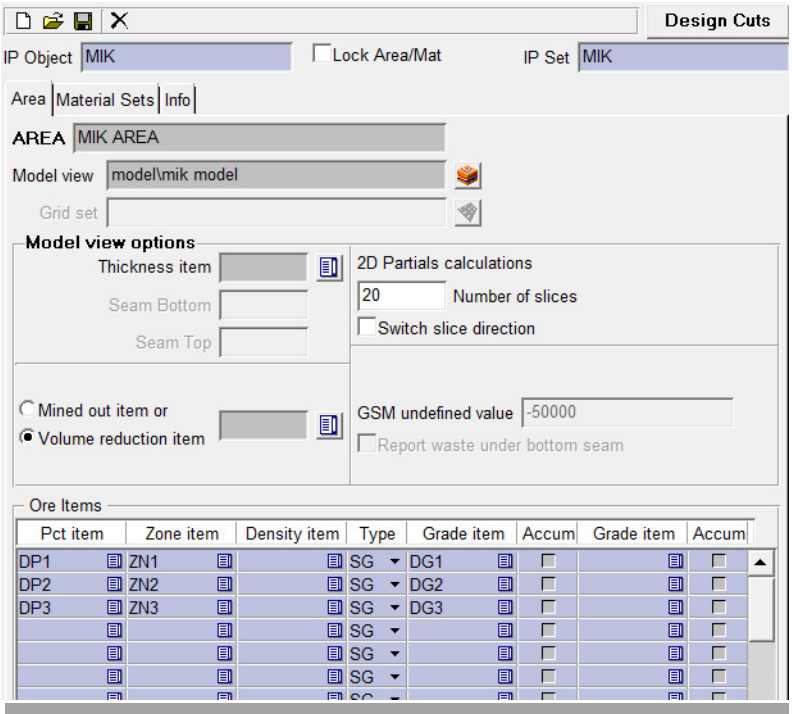
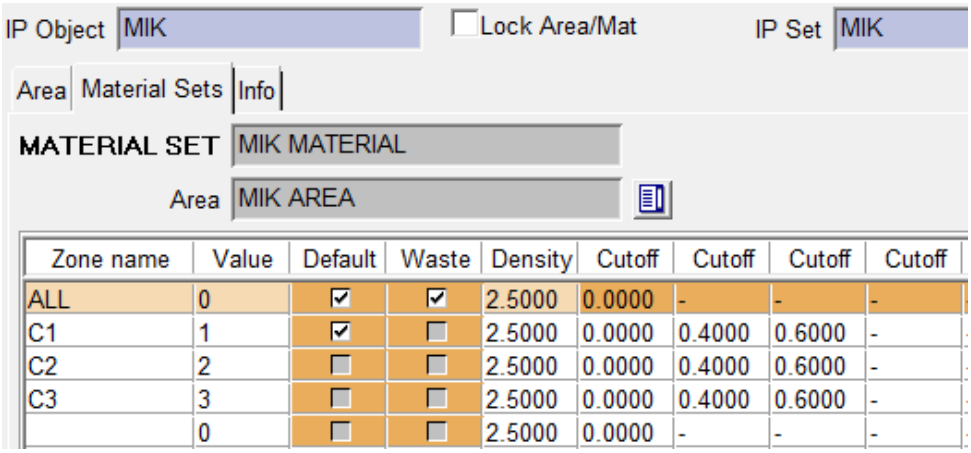


Figure 10. *Setup of the IP Area tab.*



Zone name	Value	Default	Waste	Density	Cutoff	Cutoff	Cutoff	Cutoff
ALL	0	☑	☑	2.5000	0.0000	-	-	-
C1	1	☑	☐	2.5000	0.0000	0.4000	0.6000	-
C2	2	☐	☐	2.5000	0.0000	0.4000	0.6000	-
C3	3	☐	☐	2.5000	0.0000	0.4000	0.6000	-
	0	☐	☐	2.5000	0.0000	-	-	-

Figure 11. Setup of the IP Material tab.

When you make a cut, you can now report reserves incrementally (Figure 12).

	A	B	C	D	E
1	Material:	C1			
2	Cutoff	0.00-0.40	0.40-0.60	>0.60	Totals
3	Tonnes	6150	0	0	6150
4	Volume (BCM	2460	0	0	2460
5	DG	0.148	0.000	0.000	0.148
6	Material:	C2			
7	Cutoff	0.00-0.40	0.40-0.60	>0.60	Totals
8	Tonnes	0	3150	0	3150
9	Volume (BCM	0	1260	0	1260
10	DG	0.000	0.455	0.000	0.455
11	Material:	C3			
12	Cutoff	0.00-0.40	0.40-0.60	>0.60	Totals
13	Tonnes	0	0	5700	5700
14	Volume (BCM	0	0	2280	2280
15	DG	0.000	0.000	0.758	0.758

Figure 12. Reserves reported incrementally.