COG Optimization

Presentation

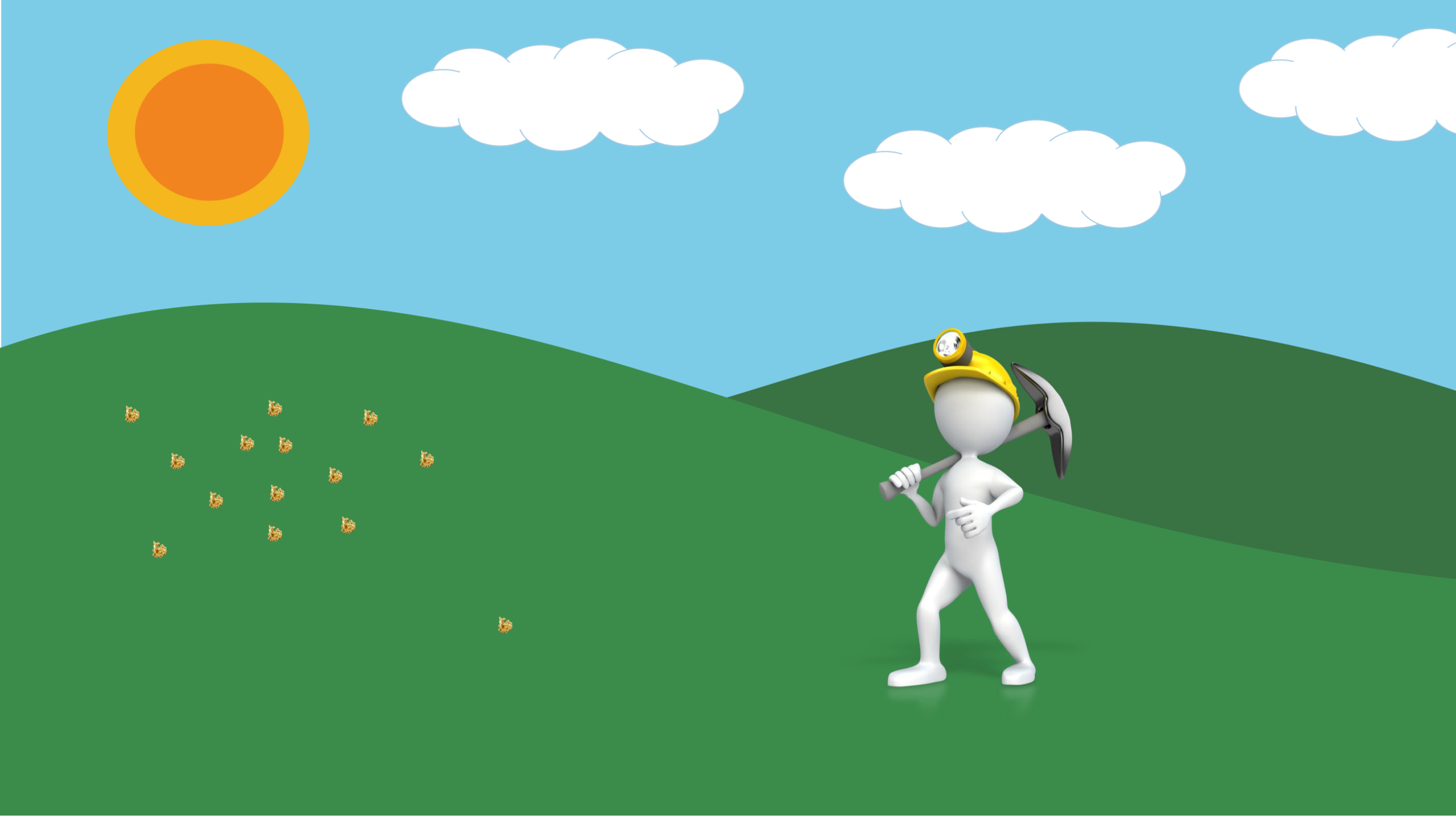
Prepared for:

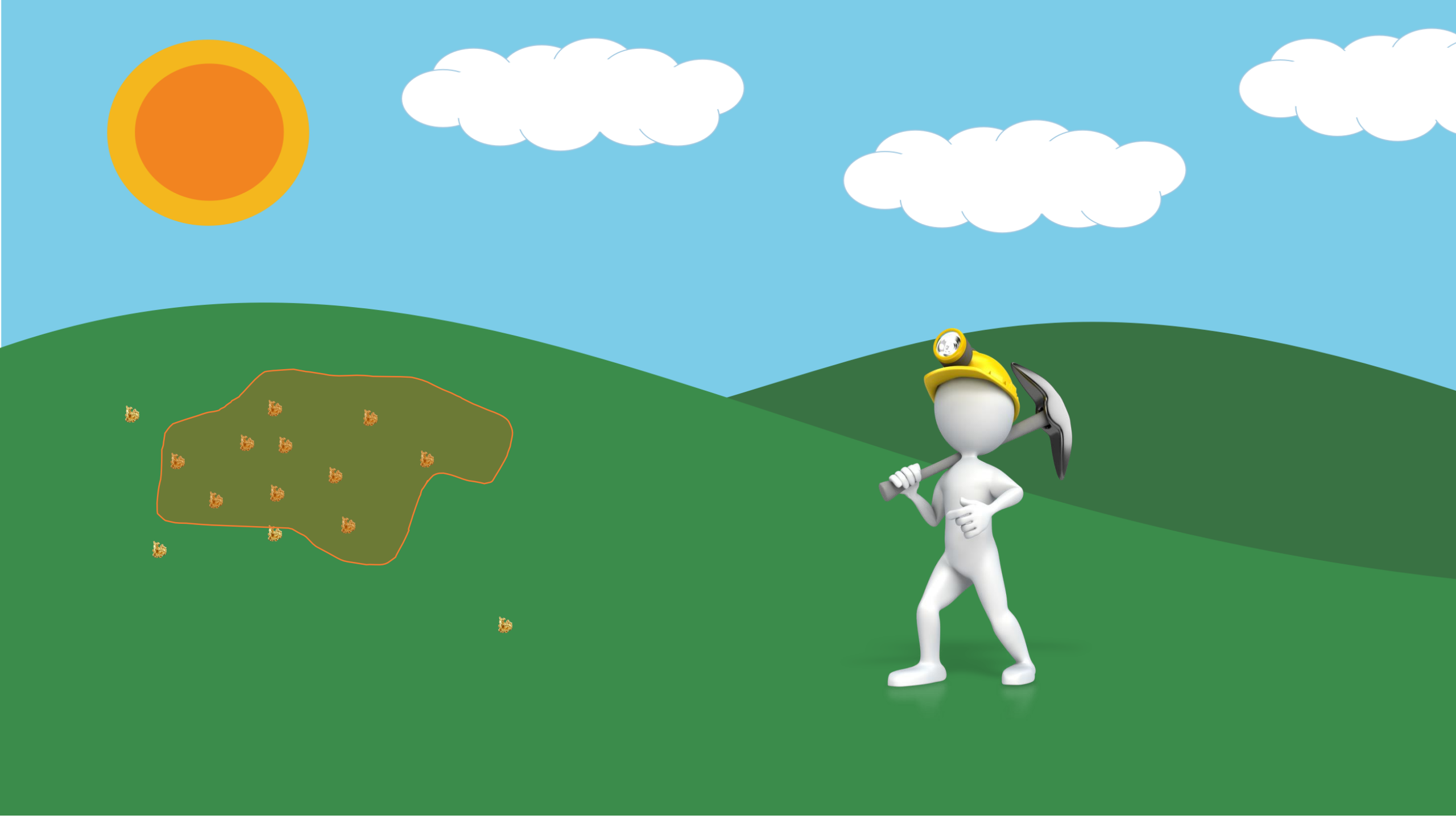
CIM 2018 Convention, Vancouver BC

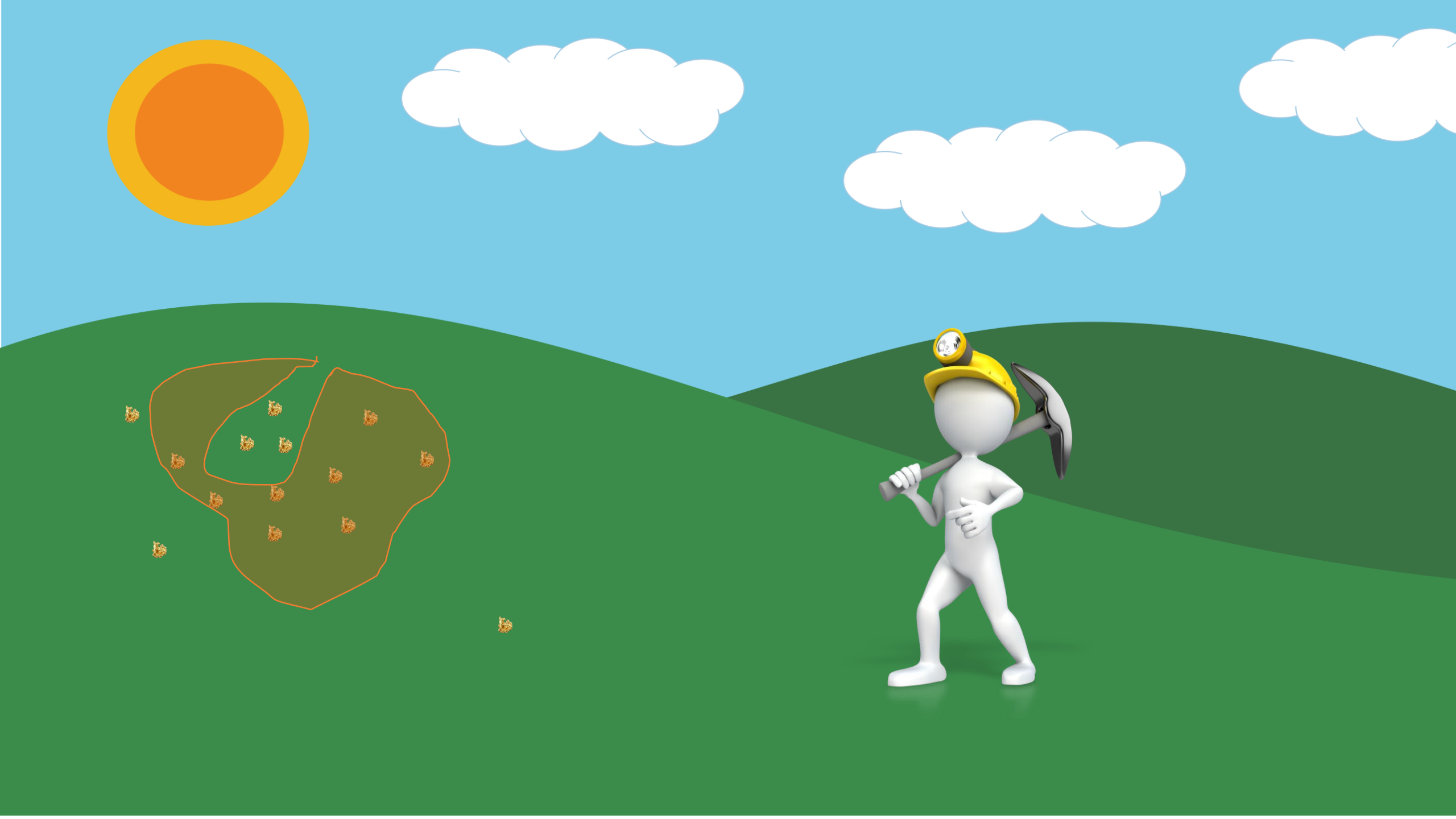
Prepared by:

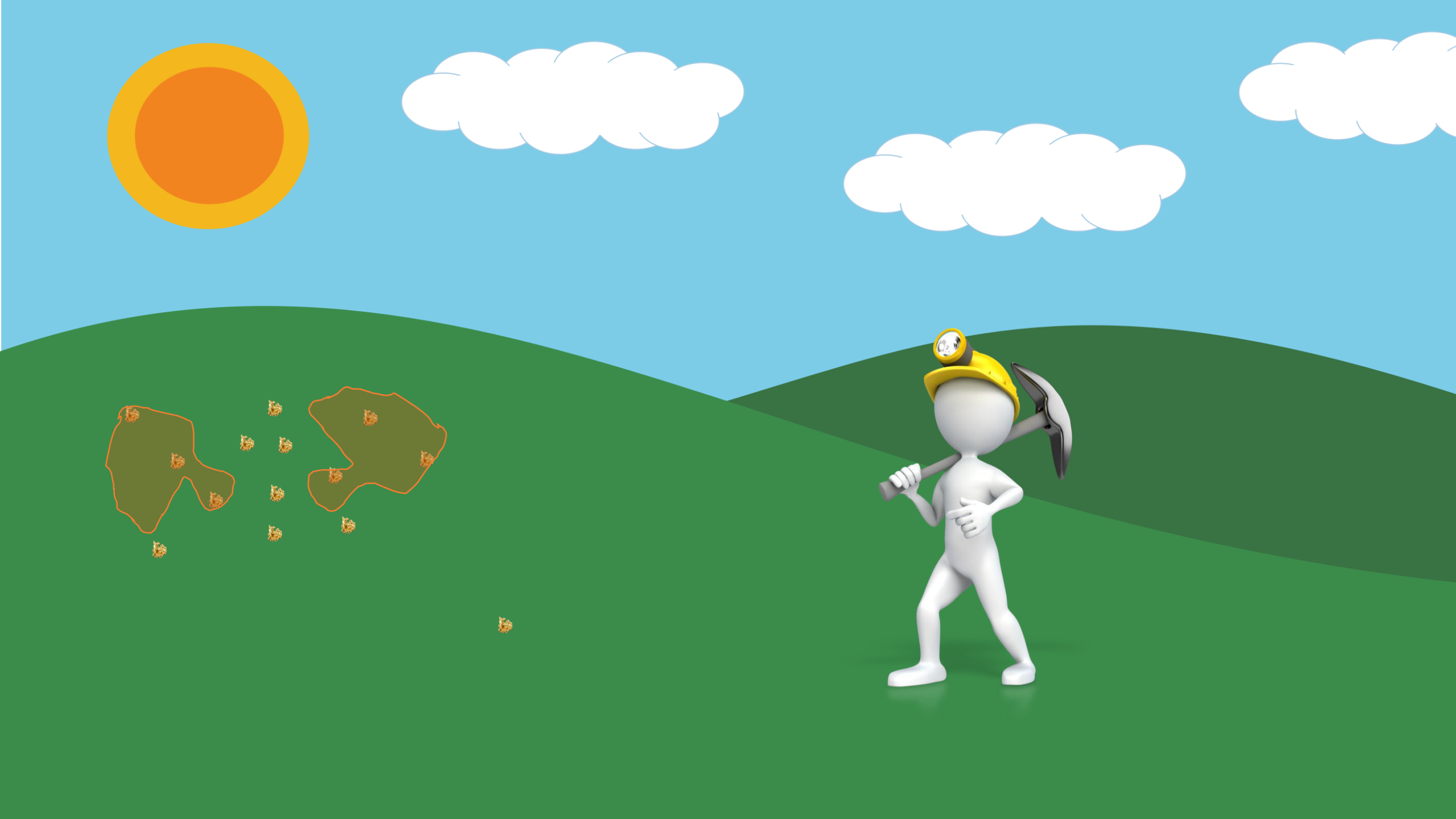
Gary Poxleitner, PEng, PMP, Principal Consultant (Mining)

CIM ICM CIM2018 CONVENTION srk consulting



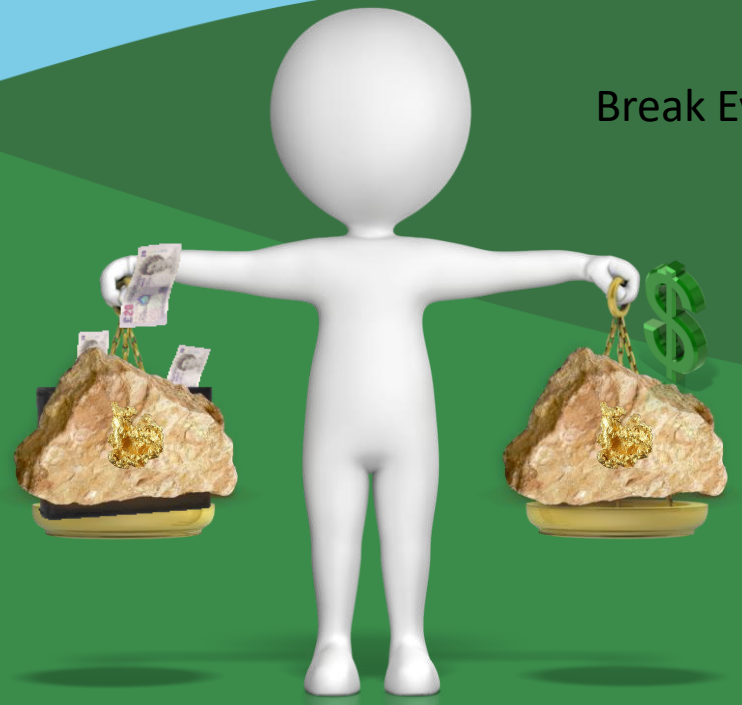






Break Even Cut – off Grade

"Every tonne mined as ore pays for itself."



Break Even Cut – off Grade

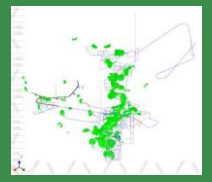
"Every tonne mined as ore pays for itself."

Profitability

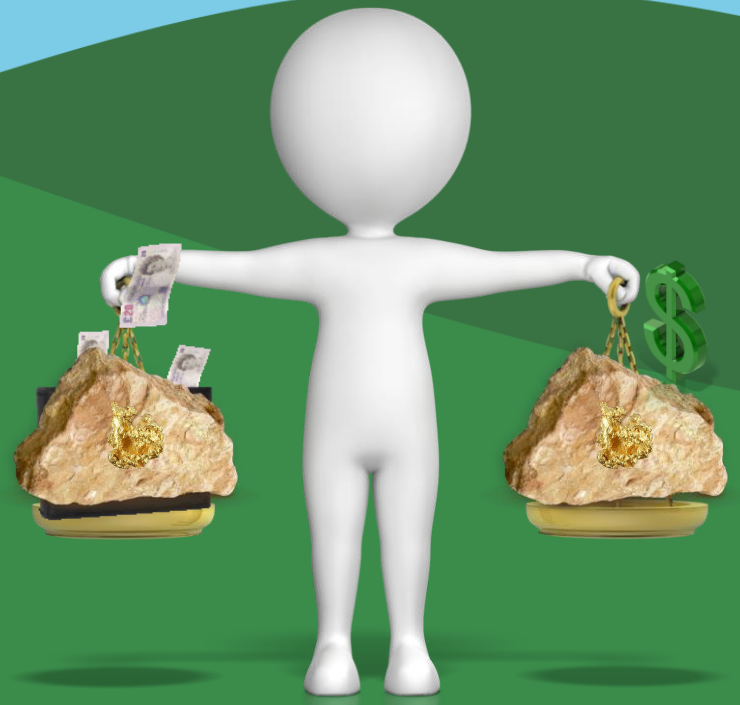
Sustainability

Cash Flow

Mine Plan

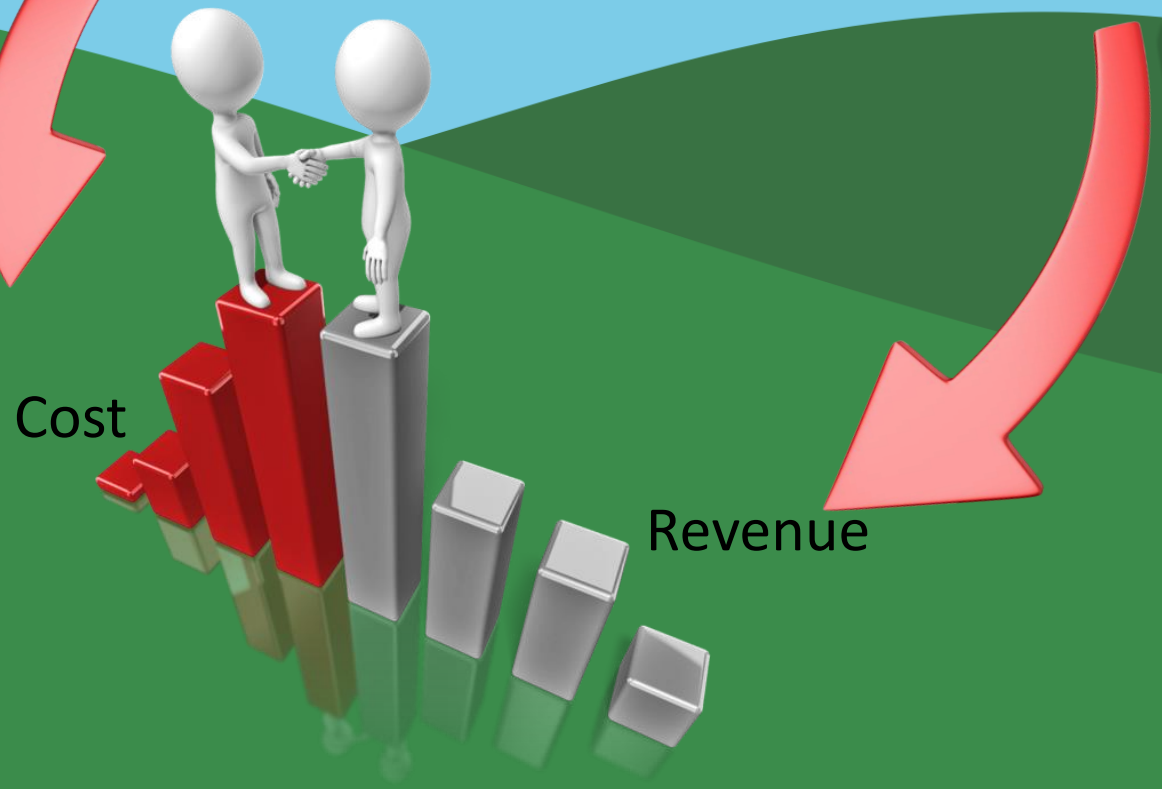


COG



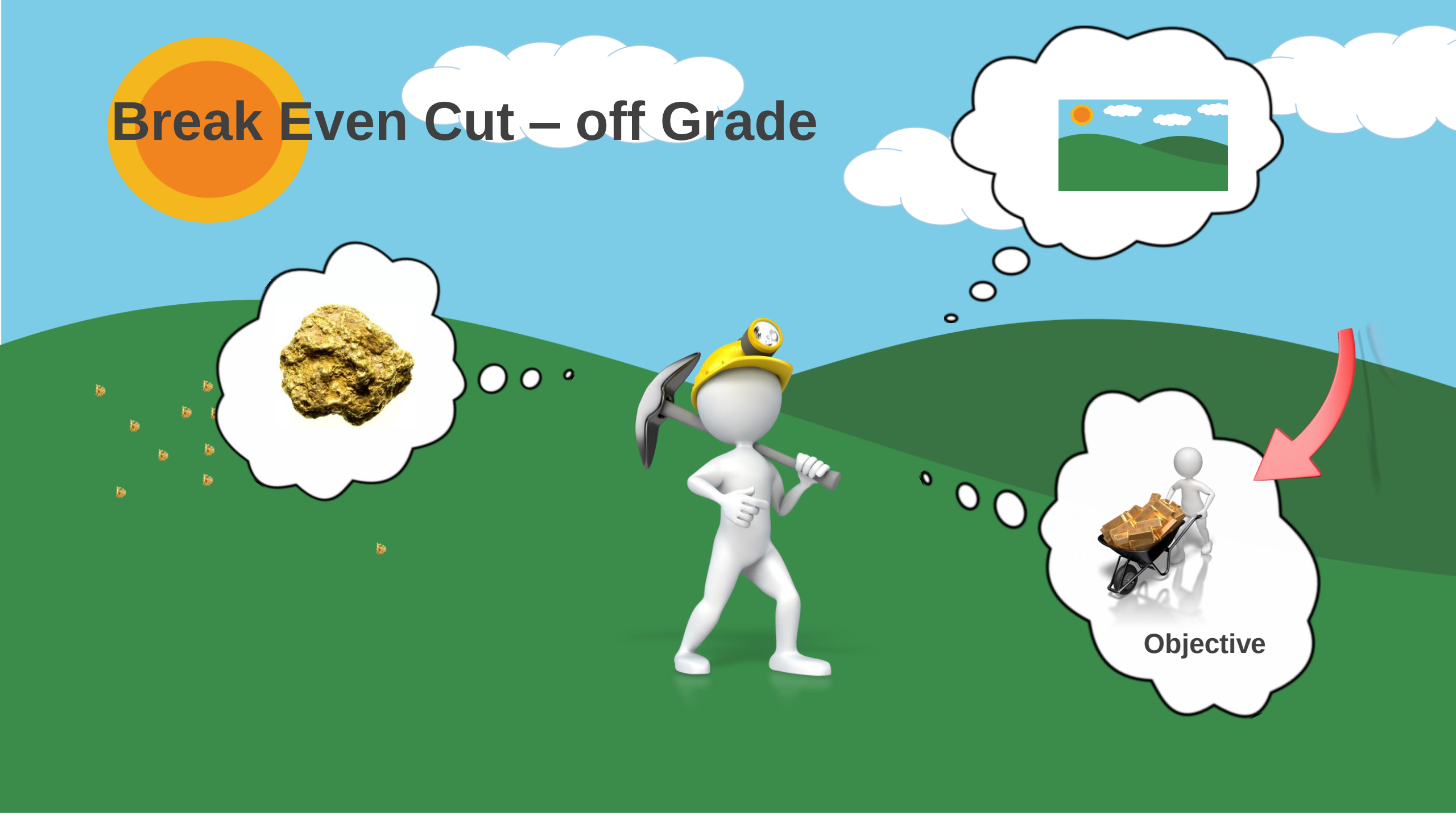
Break Even Cut – off Grade

$$BCOG = \frac{\text{Mining Costs + Process Costs + G\&A Costs}}{\text{Recovery x (Metal Price – Refining Costs – Royalti}}$$



The grade at which revenue obtained is equal to the cost to produce that revenue.

Break Even Cut – off Grade



Break Even Cut – off Grade

Payables

Mining/Milling

Refinery

$40/g Au

Payables

Mining/Milling

I want $40/g

Refinery

We will pay $38/g

Value = $40/g

$40/g

Value	**$40 per g**
Payable Metal	**99%**
Payable Value	**$39.60**
Treatment and Refinery Charges	**($1.60)**
Value (NSR)	**$38**

..and minus any Penalties

$40/g Au

$38/g Au

Royalty

Value	$40/gr
Payable Metal	99%
Payable Value	$39.60
Treatment and Refinery Charges	($1.60)
Value (NSR)	$38 / g

Value = $40/gr

$40/g

Mining/Milling

Royalties **2.6%**

Refinery

Royalty	**(2.6%)**
Royalty Payment	**($1)**
Value (NSR) less Royalty	**$37**

$40/g Au

$37/g Au

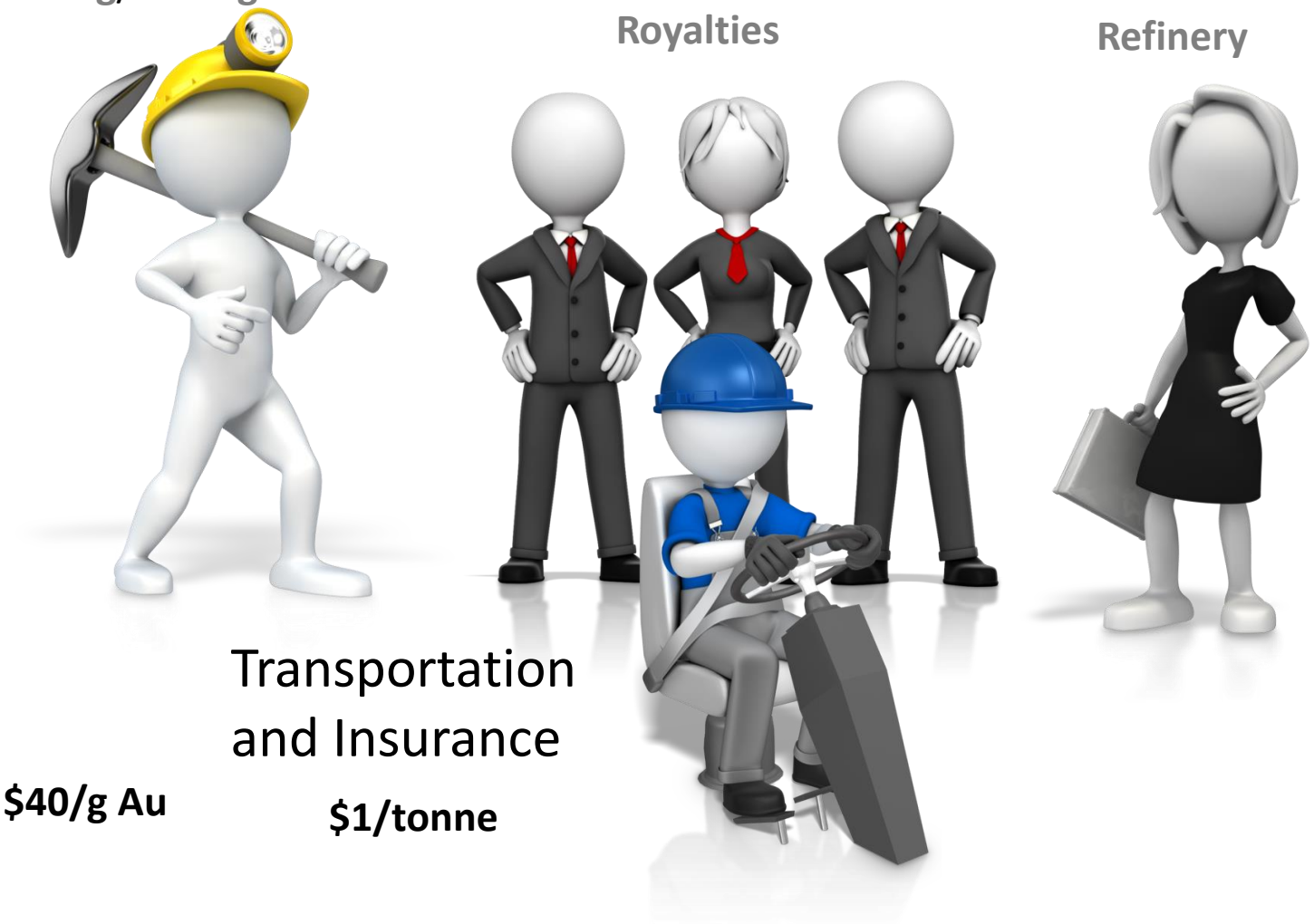
Transport Cost

Value	$40/gr
Payable Metal	99%
Payable Value	$39.60
Treatment and Refinery Charges	($1.60)
Value (NSR)	$38 / g
Royalty	(2.6%)
Royalty Payment	($1)
Value (NSR) less Royalty	$37

Mining/Milling

Royalties

Refinery



Transportation and Insurance

$1/tonne

Total Value = $37 / g	
Transport Cost	($1)
Value (NSR) less Royalty And Transport	**$36**

$40/g Au

$36/g Au

Transport Cost

Value	$40/gr
Payable Metal	99%
Payable Value	$39.60
Treatment and Refinery Charges	($1.60)
Value (NSR)	$38 / g
Royalty	(2.6%)
Royalty Payment	($1)
Value (NSR) less Royalty	$37
Total Value = $37 / g	
Transport Cost	($1)
Value (NSR) less Royalty And Transport	$36
Mill Recovery	**94.5% or $2/t**
Mill Feed Value	**$34/g**

<u>Amount</u>
Value = $40/gr
10 grams x $40

$40/g

Mining/Milling

Royalties

Refinery

$40/g Au

Transportation and Insurance

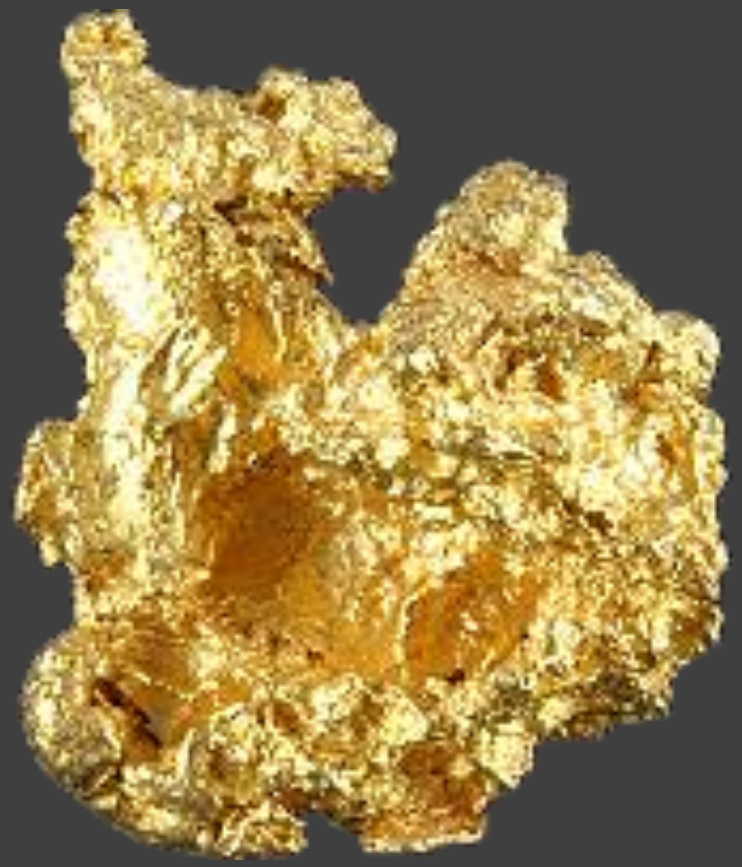
$1/tonne

Mill Recovery

$34/g Au

Mill Feed Value (NPR)

1 g Au in 1 tonne
Value is $34.00/t



In 1 tonne of material with 1 gram of Au			
Description	Unit	Value	Total
Spot Price	$/g	$40/g	$40.00/t
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	94.5%	$2.00/t	34.00/t

Operating Cost

Mine
$40/t

Operating Cost

Mill
$18/t

Mine
$40/t

Operating Cost

G&A
$10/t

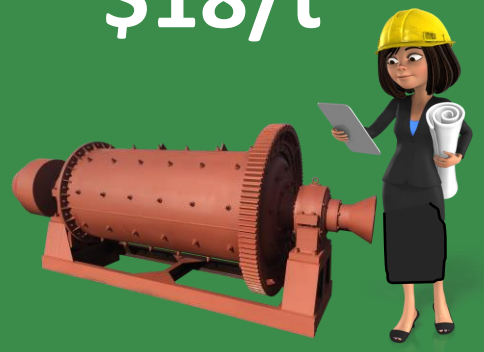
+

Mill
$18/t

+

Mine
$40/t

=



Operating Cost

G&A
$10/t

+

Mill
$18/t

+

Mine
$40/t

=

Break Even COG

Total
$68/t

Break Even COG

G&A
$10/t

+

Mill
$18/t

+

Mine
$40/t

=

Total
$68/t

Break Even COG

1 g is
$34/t

Break Even COG

G&A
$10/t

+

Mill
$18/t

+

Mine
$40/t

=

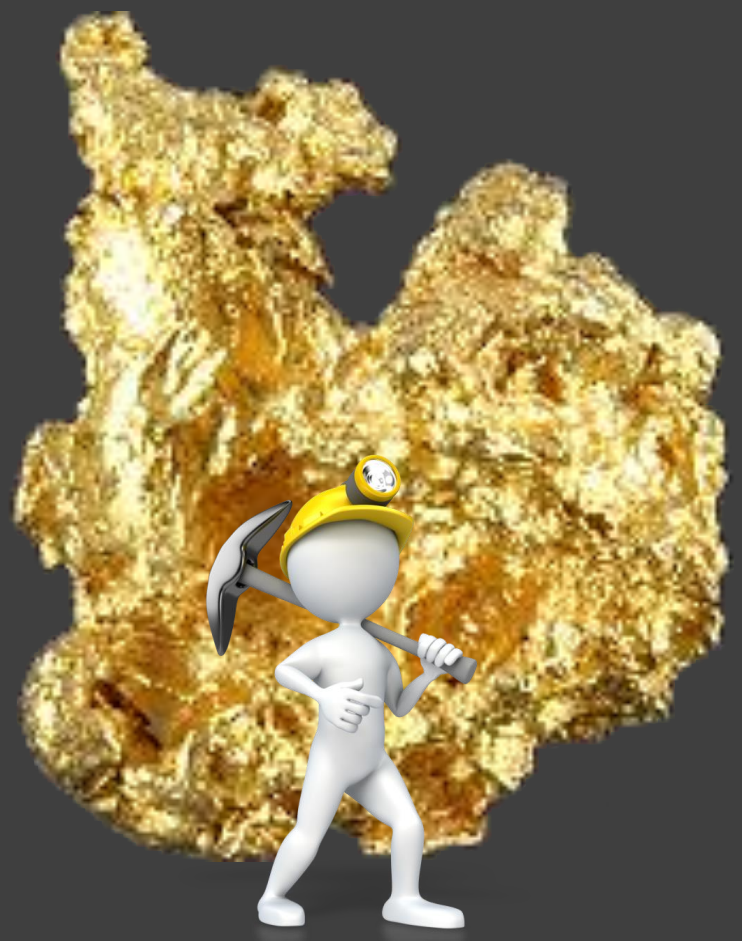
Break Even COG

1 g is
$34/t

Total
$68/t

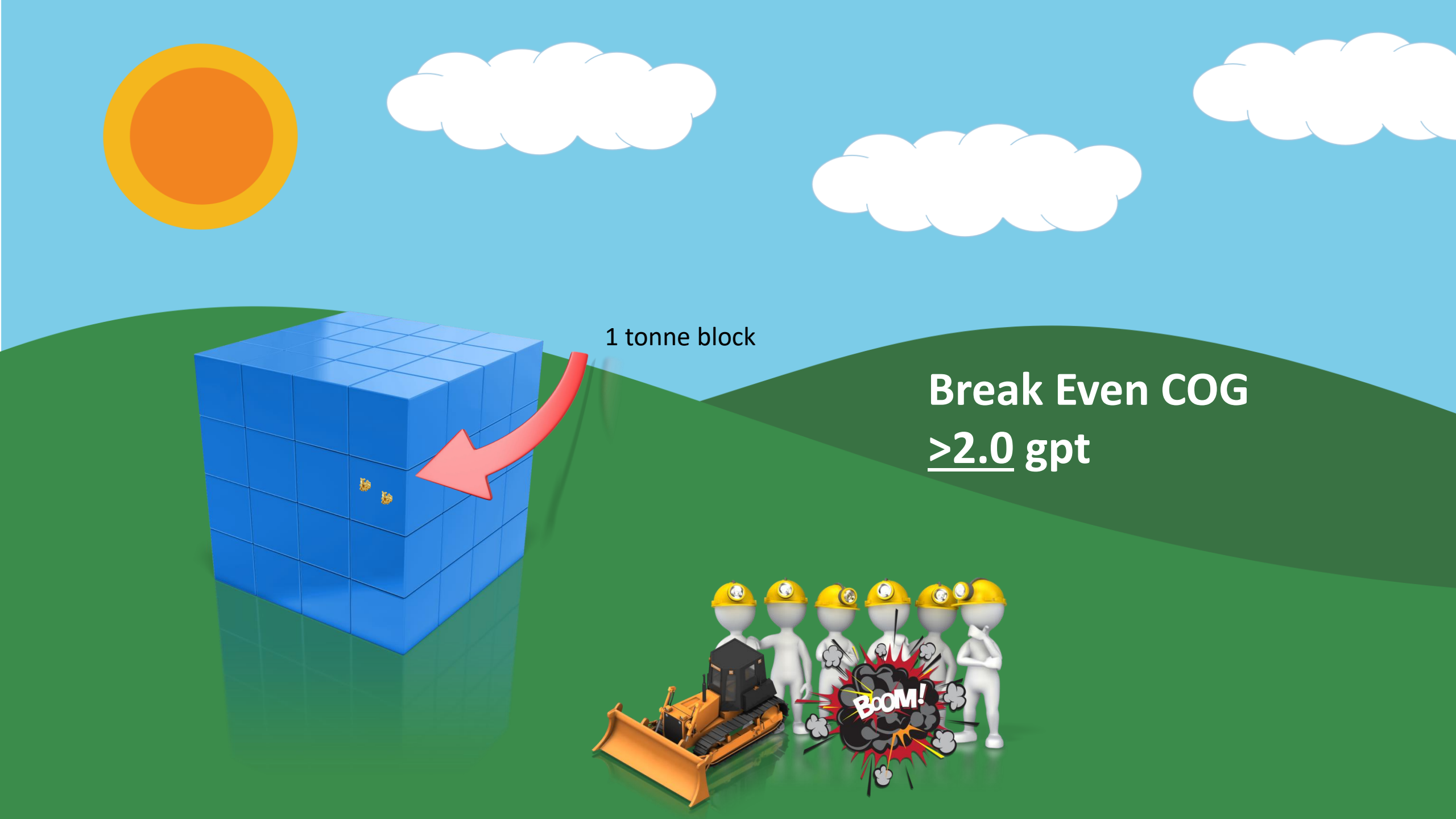
2 g pays for operating cost

Break Even Cut-off Grade

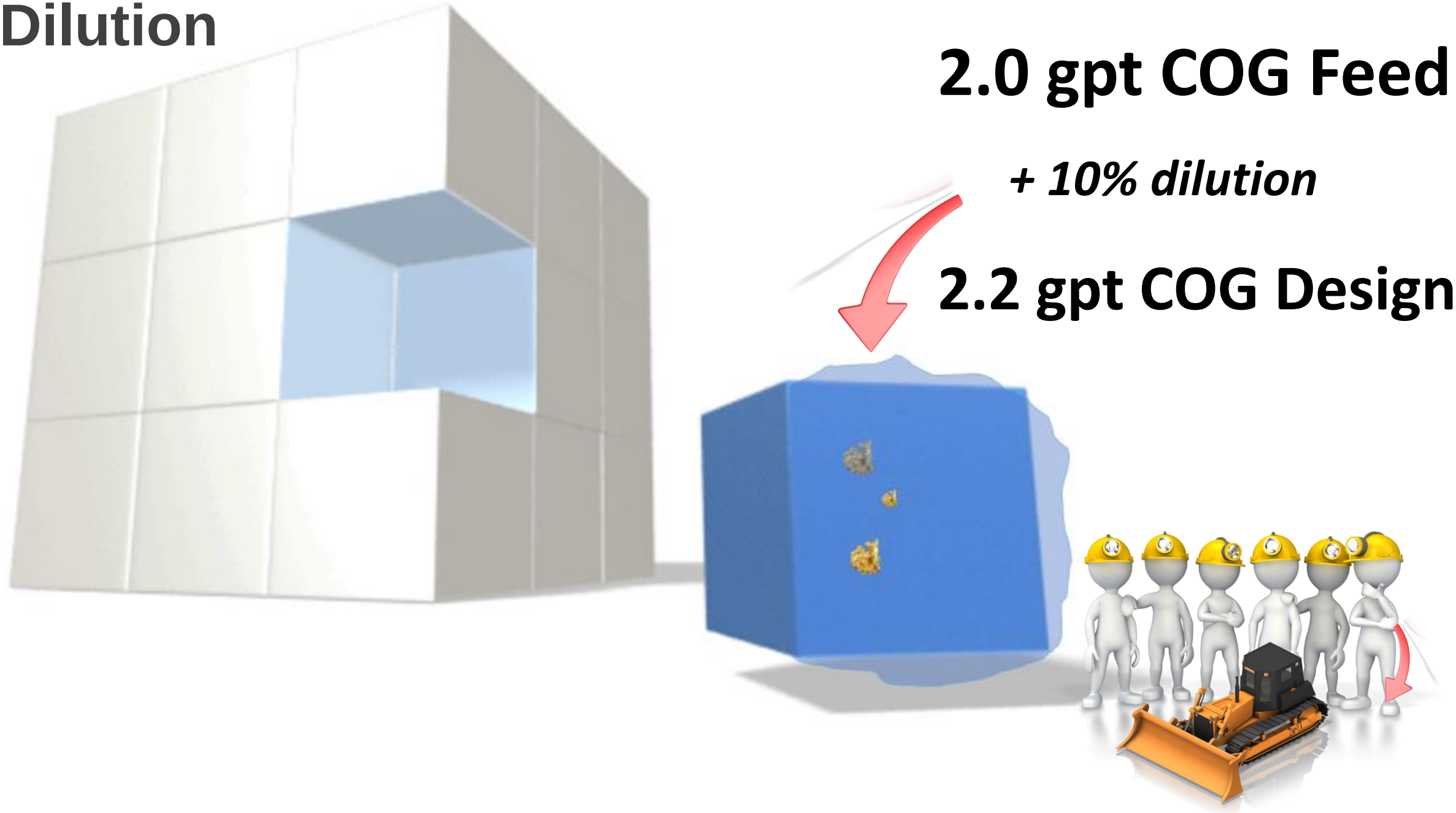


Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

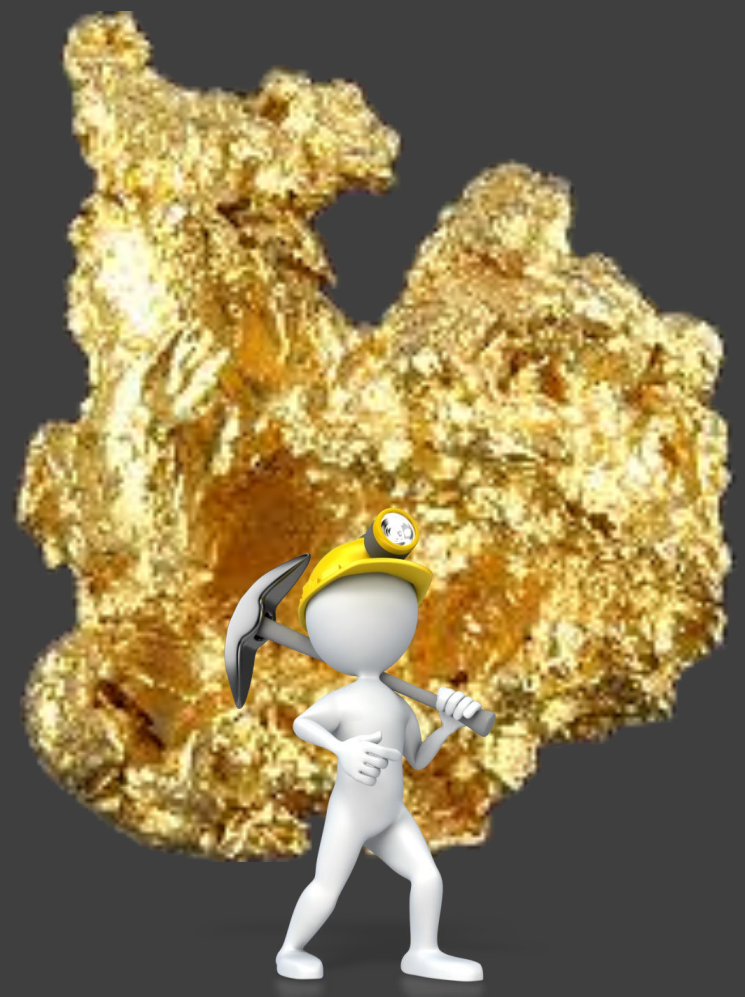
Cost (1 tonne of ore)			
Description	**Unit**		**Total**
Mining	$/t		$40.00/t
Mill	$/t		$18.00/t
Administration(G&A)	$1.60		$10.00/t
Total Opex	$/t		**$68.00/t**
COG – Report - Mill Feed (Head Grade)			**2.0 (Au gpt)**


1 tonne block
Break Even COG
>2.0 gpt
BOOM!

Dilution



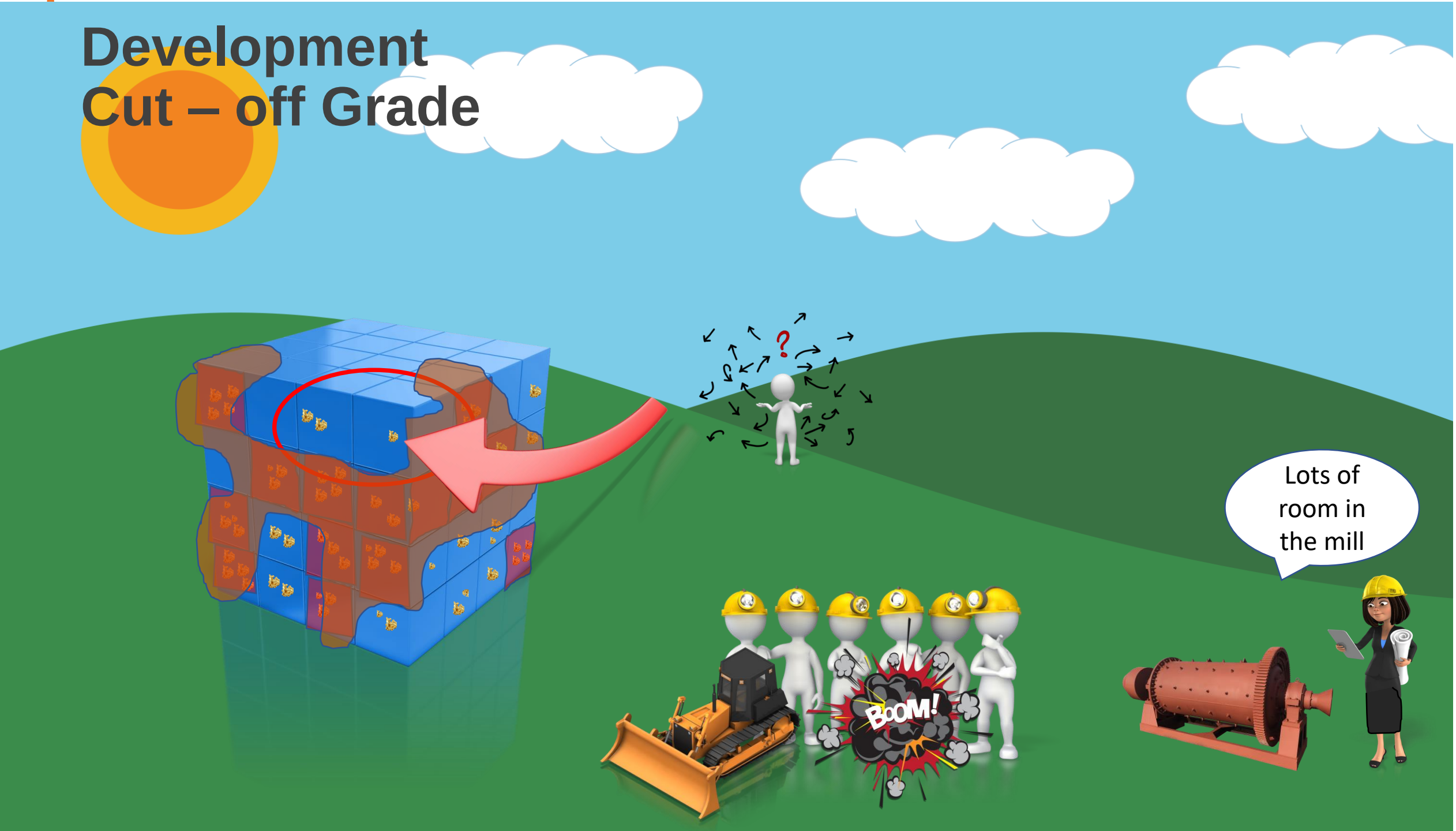
Break Even Cut – off Grade



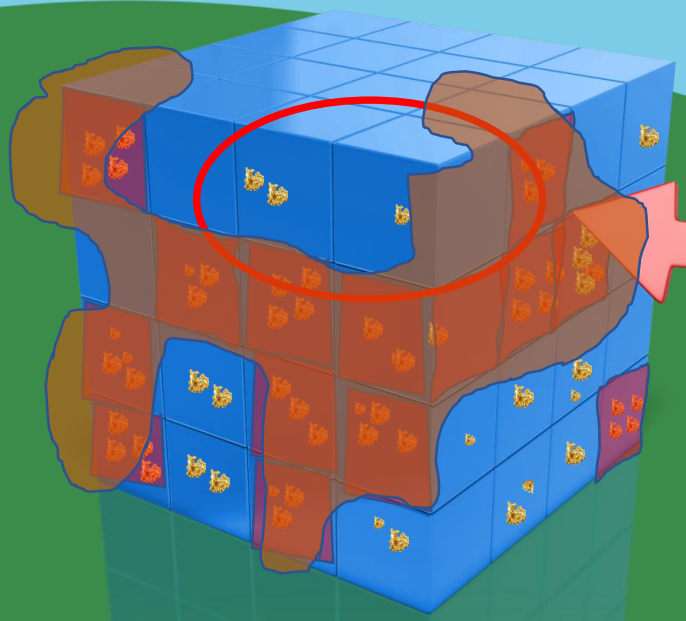
Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

Cost (1 tonne of ore)			
Description	**Unit**		**Total**
Mining	$/t		$40.00/t
Mill	$/t		$18.00/t
Administration(G&A)	$/t		$10.00/t
Total Opex	$/t		**$68.00/t**
COG – Report - Mill Feed (Head Grade)			**2.0 (Au gpt)**
Dilution	**%**		**10%**
COG –Insitu- Mine Design			**2.2 (Au gpt)**

Development Cut – off Grade

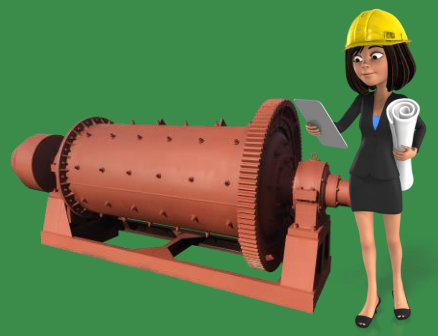


Development Cut – off Grade



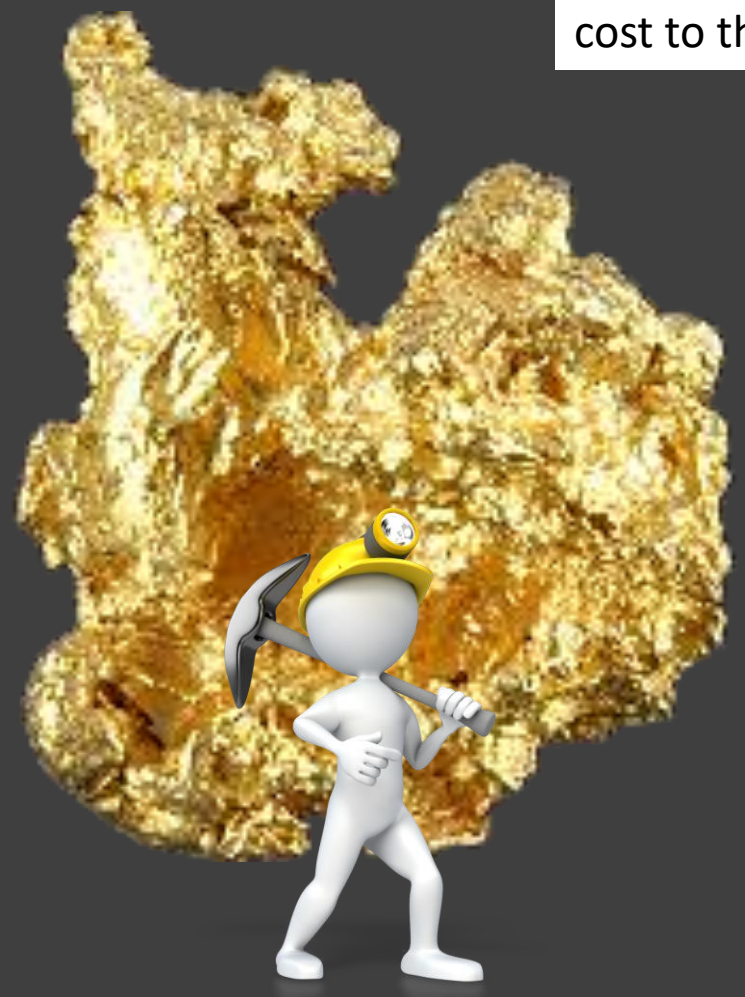
Development COG

? gpt



Development Cut – off Grade

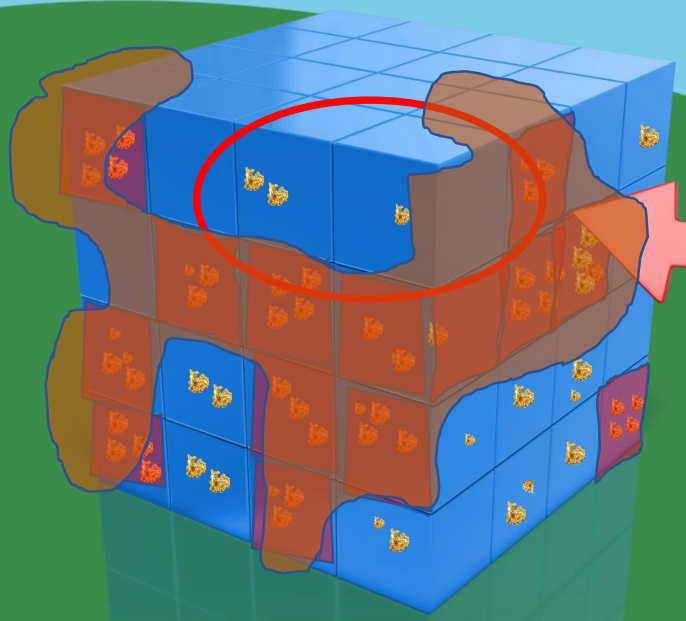
Additional haulage cost to the mill



Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
[illegible]	[illegible]	$0.40/g	$39.60/t
Treatment/Refinery	[illegible]	$1.60/g	38.00/t
Royalty	2.6%		37.00/t
Transport	$1/g		36.00/t
Mill Recovery	**94.5%**		**34.00/t**

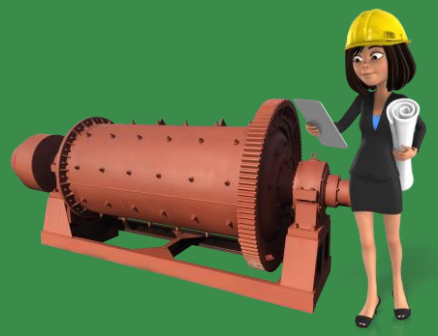
Cost (1 tonne of ore)				
Description	**Unit**	**Fixed**	**Var**	**Development**
Mining	$/t	~~$20/t~~	~~$20/t~~	$2.00/t
Mill	$/t	~~$9/t~~	$9/t	$9.00/t
Administration(G&A)	$/t	~~$8/t~~	$2/t	$2.00/t
Total Opex	$/t			**$13.00/t**
COG – Report - Mill Feed (Head Grade)				**0.38 (Au gpt)**
Dilution	**%**			**0%**
COG –Insitu- Mine Design				**0.38 (Au gpt)**

Development Cut – off Grade

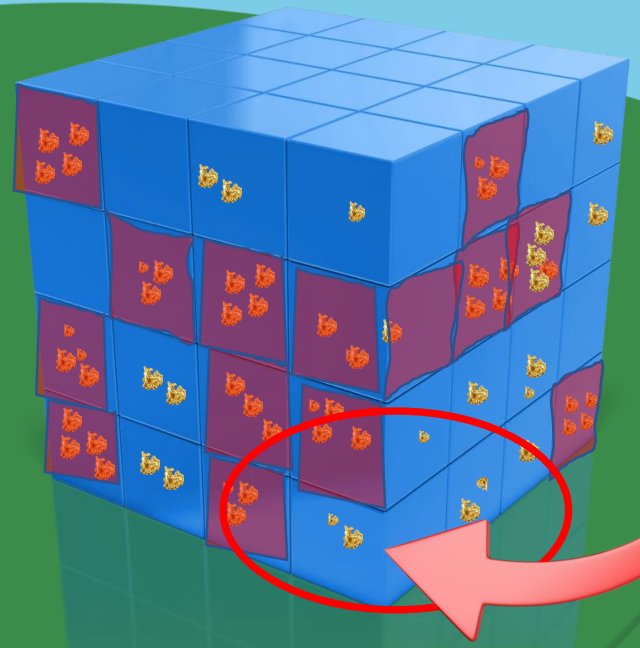


Development COG

<u>>0.38</u> gpt



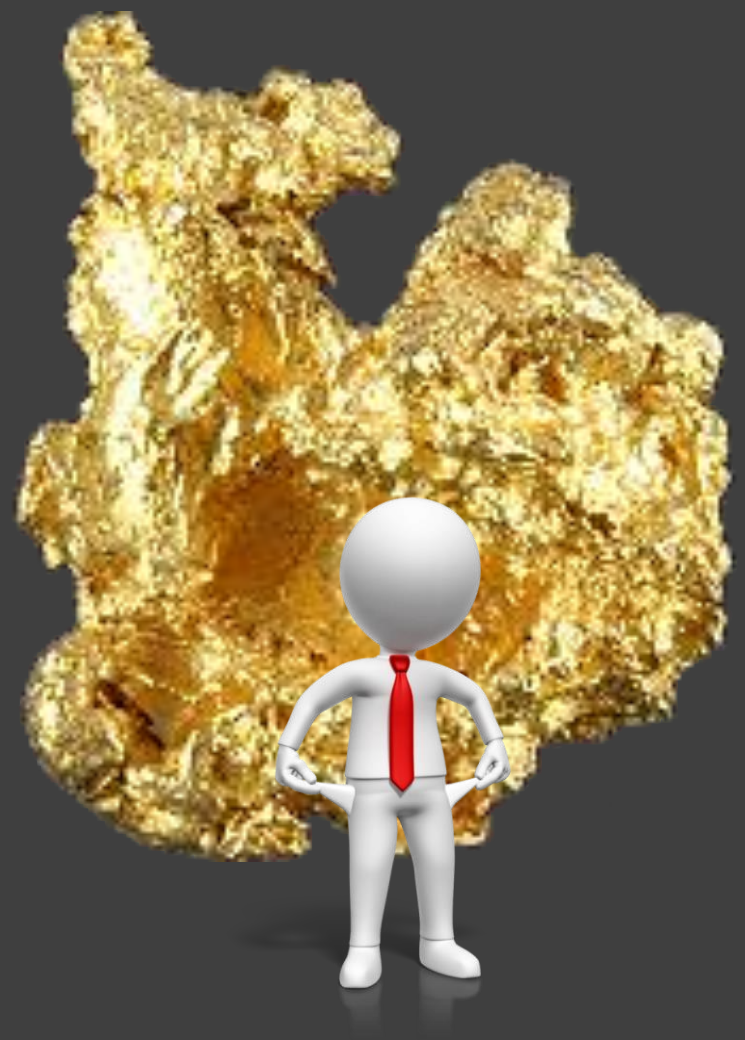
Incremental Cut – off Grade



Incremental COG

? gpt

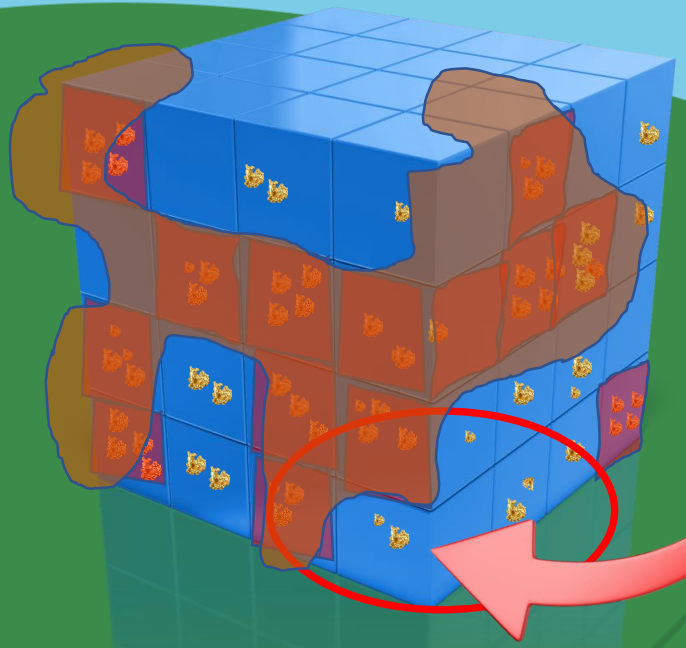
Incremental Cut – off Grade



Au Value (1g per tonne)			
Description	**Unit**	**Value**	**Total**
Spot Price	**$/g**	**$40/g**	**$40.00/t**
Payable	99%	$0.40/g	$39.60/t
Treatment/Refinery	$1.60	$1.60/g	38.00/t
Royalty	2.6%	$1.00/t	37.00/t
Transport	$1/g	$1.00/t	36.00/t
Mill Recovery	**94.5%**	**$2.00/t**	**34.00/t**

Cost (1 tonne of ore)				
Description	**Unit**	**Fixed**	**Var**	**Development**
Mining	$/t	~~$20/t~~	$20/t	$20.00/t
Mill	$/t	~~$9/t~~	$9/t	$9.00/t
Administration(G&A)	$/t	~~$8/t~~	$2/t	$2.00/t
Total Opex				**$31.00/t**
COG – Report - Mill Feed (Head Grade)				**0.91 (Au gpt)**
Dilution	**%**			**10%**
COG –Insitu- Mine Design				**1.00(Au gpt)**

Incremental Cut – off Grade



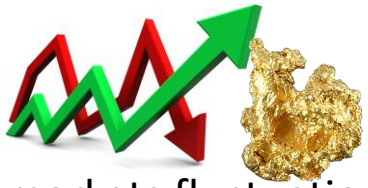
Incremental COG

>1.0 gpt

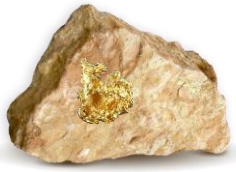
BECOG Limitations

Assumes everything is fixed except the COG
No clear definition of BECOG

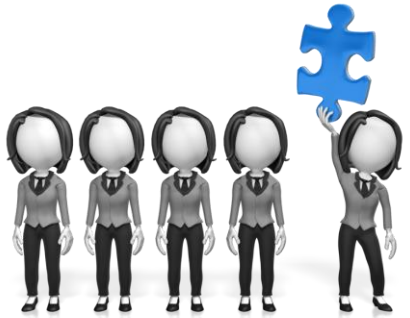
BECOG Limitations
Does not take into account…



…markets fluctuations



…average grade



…objective

Assumes everything is fixed except the COG
No clear definition of BECOG

…fixed cost

…grade distribution

…timeline of extraction

…multiple mining methods

…variability in mill recovery

…capital cost changes by year

…mine sequencing

…robustness of parameters such as opex, price

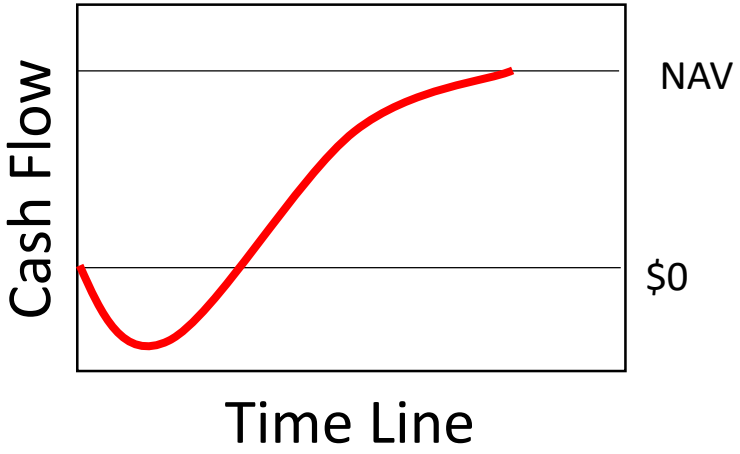
Optimum Cut – off Grade

The goal for an Optimum cut – off grade is that it…

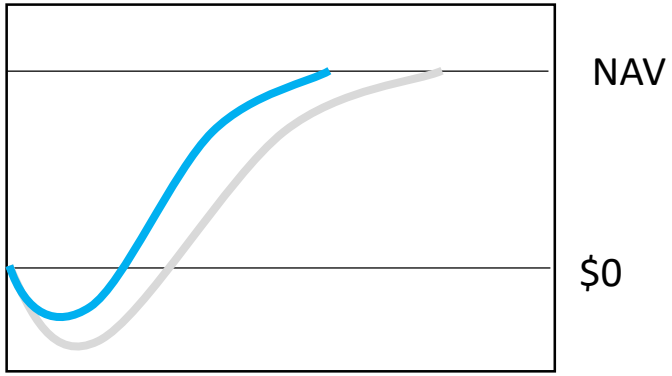
- provides the greatest benefit to the miner
- meets the miners objective!

COG Objective

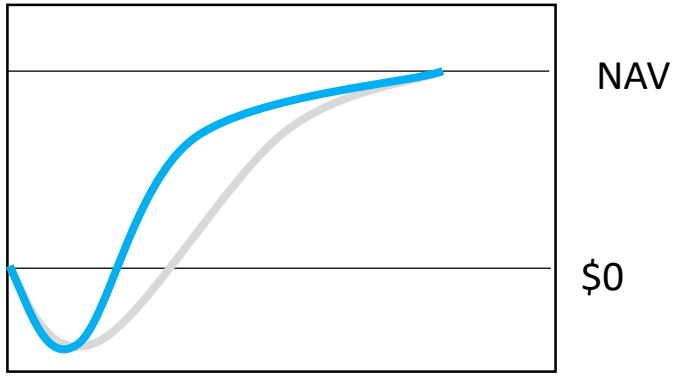
Base Case



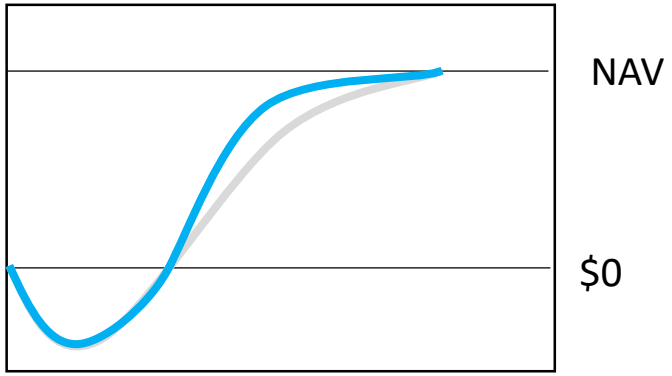
Reduce Investment



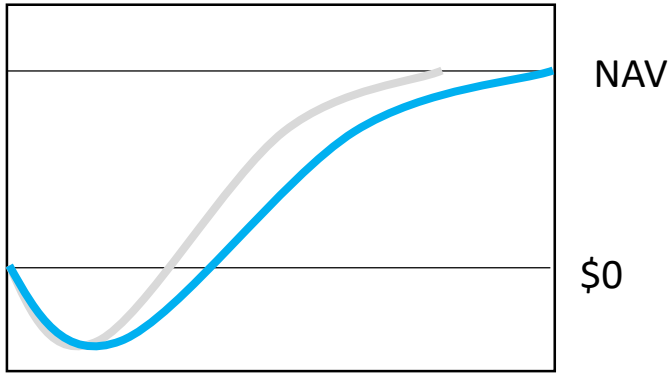
Reduce Payback



Early Revenue



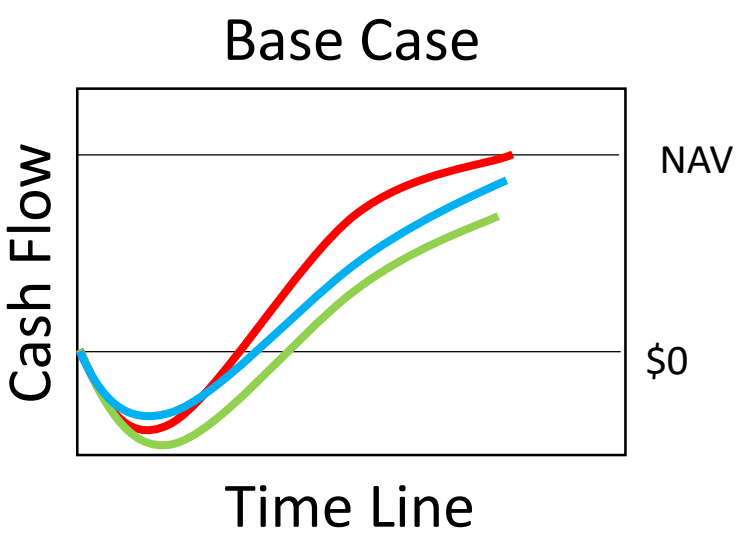
Longer Mine Life

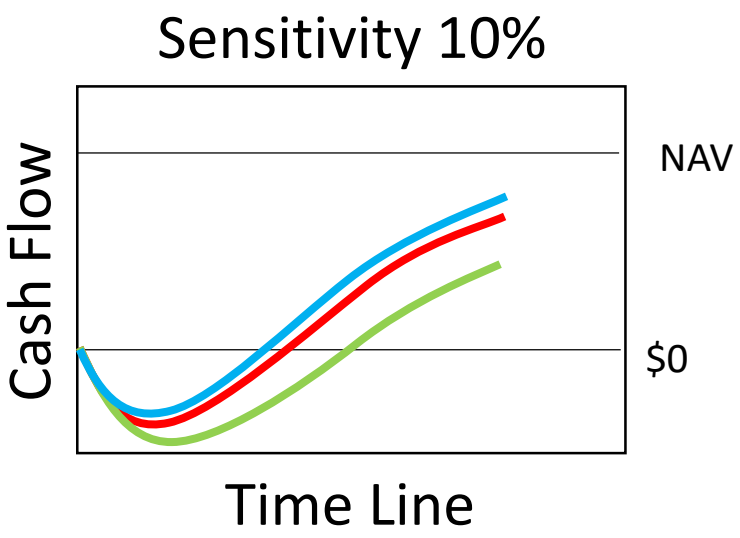


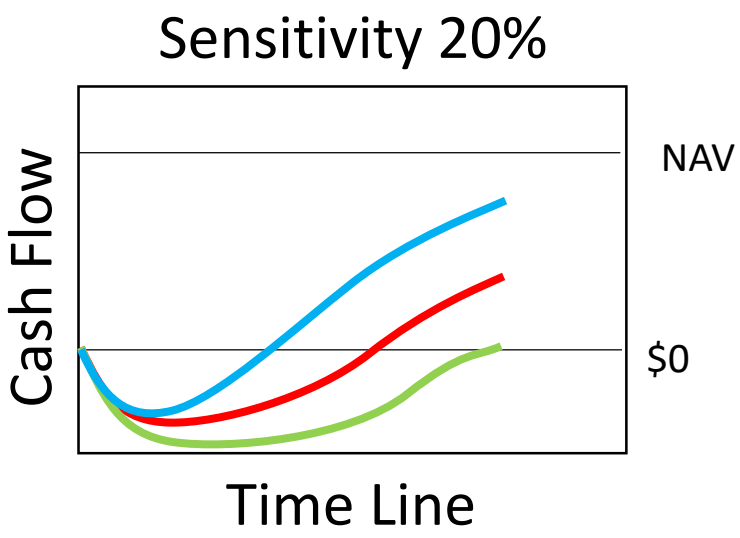
= Strategy Cash Flow

= Base Case Cash Flow (for reference)

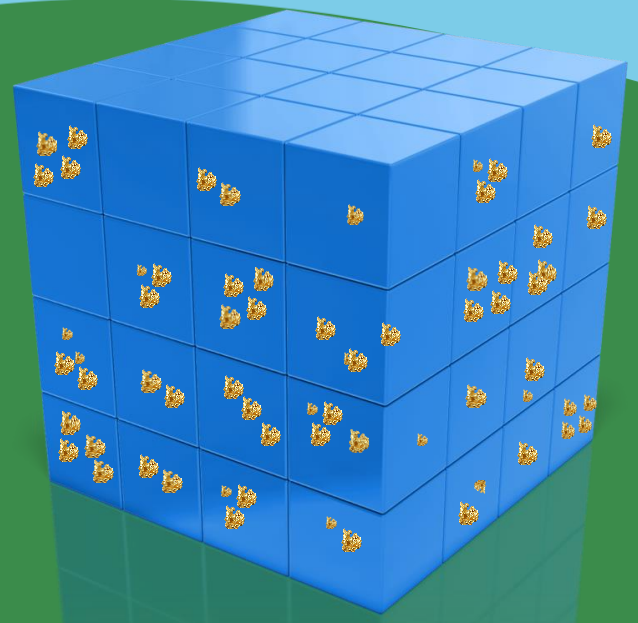
COG Robustness



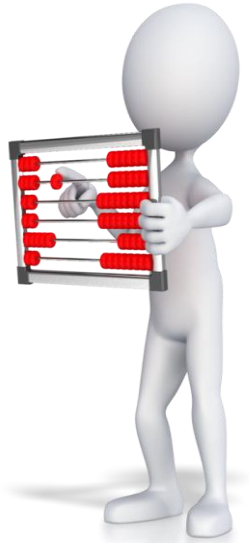




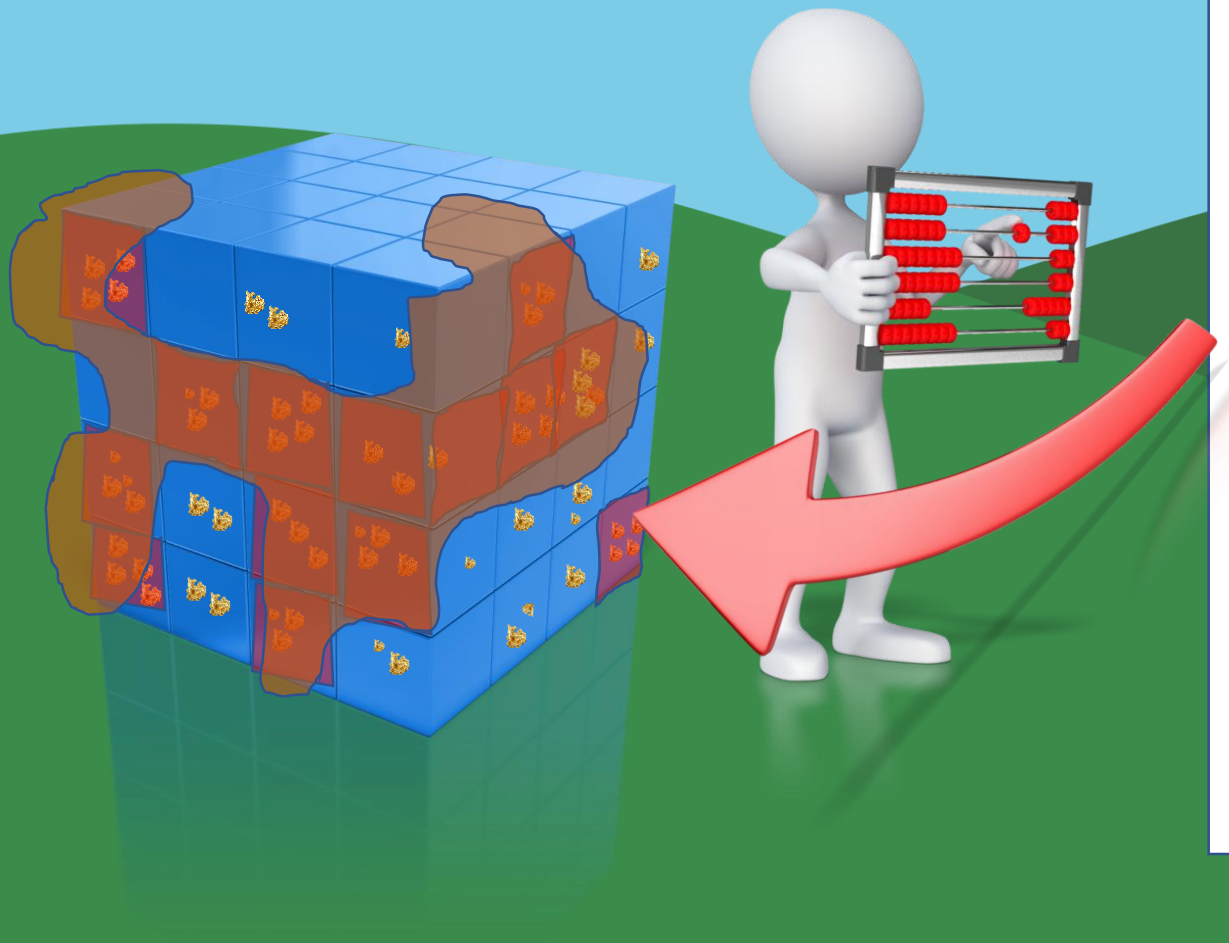
Optimized Cut – off Grade Steps…



1. Create Mine Plan and Sequencing
2. Calculate Revenue
   - Include TC/RC/Mill Recovery
3. Operating Cost with Fixed/Variable
4. Sustaining Capital
5. Cash Flow
6. Generate
   - NPV
   - IRR

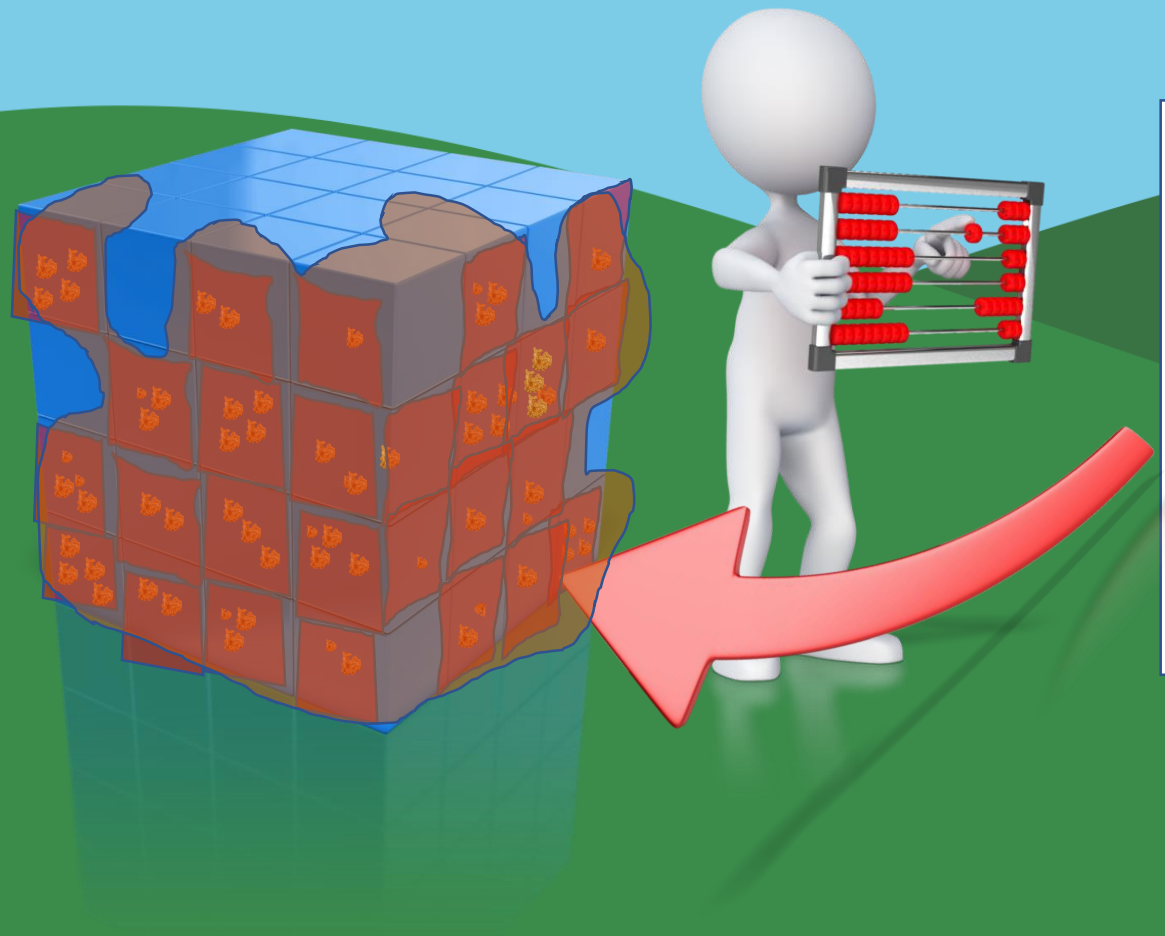


Optimized Cut – off Grade
3 Scenarios



Scenarios	COG(gpt)
Base Case	2.0 gpt
Scenario 1	1.0 gpt
Scenario 2	3.0 gpt

Optimized Cut – off Grade
3 Scenarios



Scenarios	COG(gpt)
Base Case	2.0 gpt
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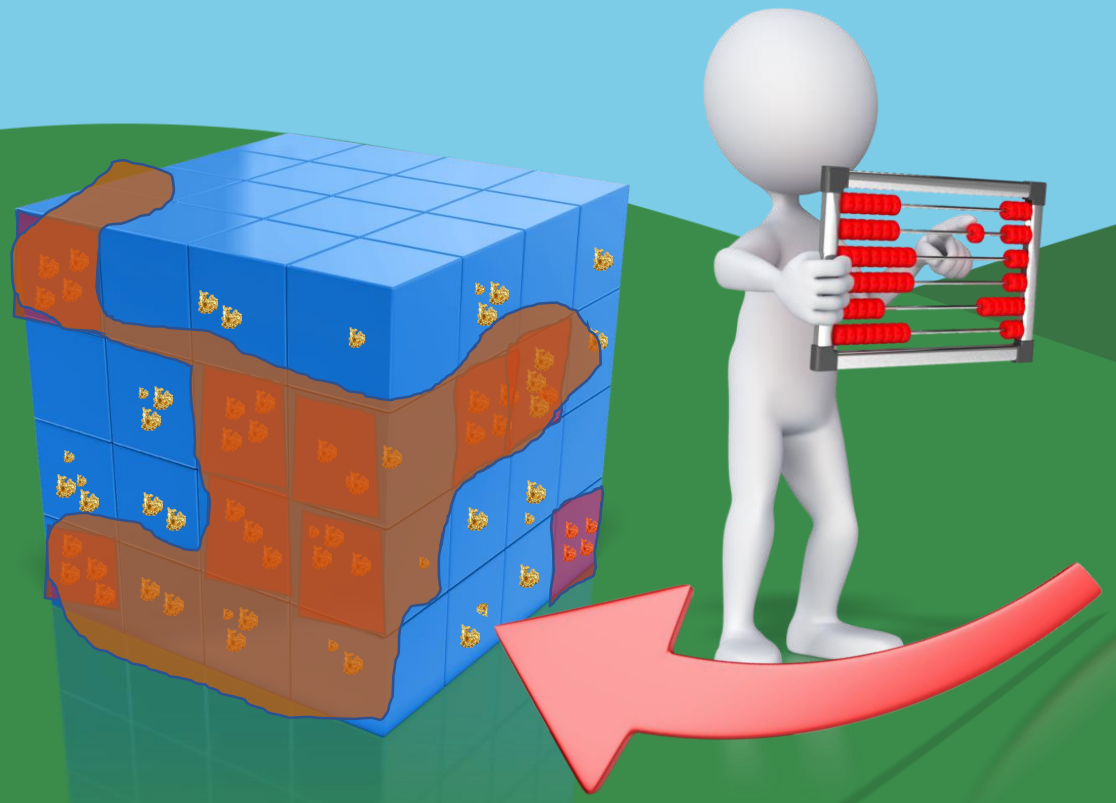
Optimized Cut – off Grade
3 Scenarios



Scenarios	COG(gpt)
Base Case	2.0 gpt
Scenario 1	1.0 gpt
Scenario 2	3.0 gpt

Cash Flow - BECOG 2.0 gpt

Cash Flow Model COG 2.0 gpt											
Timeline	**Units**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tonnes	**t**	**1**	**2**	**4**	**4**	**4**	**4**	**2**	**1**	**1**	**1**
Au	g	2	4	8	16	20	20	10	10	7	3
TRCC	$	6	12	24	24	24	24	12	6	6	6
Total Revenue	$	80	160	320	640	800	800	400	400	280	120
Operating Cost - Variable	$	31	62	124	124	124	124	62	31	31	31
Operating Cost - Fixed	$	74	74	74	74	74	74	74	74	74	74
Sustaining Cost	$	50	27	40	40	40	40	27	21	21	-
Cash Flow	$	(81)	(15)	58	378	538	538	225	268	148	9
Cumulative Cash Flow	$	(81)	(96)	(38)	341	879	1,417	1,642	1,910	2,058	2,067
NPV	**$1,537**										
IRR	**117%**										

Optimized Cut – off Grade
3 Scenarios

Scenario	Base Case	1	2
COG	2.0	1.0	3.0
Production Rate	4 tpd	8 tpd	3 tpd
Mining Method	Blast Hole	Sub Level Cave	Cut and Fill
Mine Life			
Total Tonnes			
Pay back			
IRR			
NPV			

Optimized Cut – off Grade
3 Scenarios

Scenario	Base Case	1	2
COG	2.0	1.0	3.0
Production Rate	4 tpd	8 tpd	3 tpd
Mining Method	Blast Hole	Sub Level Cave	Cut and Fill
Mine Life	10		
Total Tonnes	24 t		
Pay back	2 yrs.		
IRR	117%		
NPV	$1,537		

Optimized Cut – off Grade
3 Scenarios

Scenario	Base Case	1	2
COG	2.0	1.0	3.0
Production Rate	4 tpd	8 tpd	3 tpd
Mining Method	Blast Hole	Sub Level Cave	Cut and Fill
Mine Life	10	12 years	
Total Tonnes	24 t	37 t	
Pay back	2 yrs.	3 yrs	
IRR	117%	$114%	
NPV	$1,537	$1,236	

Optimized Cut – off Grade
3 Scenarios

Scenario	Base Case	1	2
COG	2.0	1.0	3.0
Production Rate	4 tpd	8 tpd	3 tpd
Mining Method	Blast Hole	Sub Level Cave	Cut and Fill
Mine Life	10	12 years	7 yrs.
Total Tonnes	24 t	37 t	16 t
Pay back	2 yrs.	3 yrs.	1 yr.
IRR	117%	$114%	232%
NPV	$1,537	$1,236	$1,942

Optimized Cut – off Grade
3 Scenarios

Scenario	Base Case	1	2
COG	2.0		3.0
Production Rate	4 tpd		3 tpd
Mining Method	Blast Hole	Cave	Cut and Fill
Mine Life	10	s	7 yrs.
Total Tonnes	24 t		16 t
Pay back	2 yrs.	3	1 yr.
IRR	117%	$1	232%
NPV	$1,537	$1	$1,942

Optimized Cut – off Grade
3 Scenarios

Scenario	Base Case	1	2
COG	2.0	1.0	3.0
Production Rate	4 tpd	8 tpd	3 tpd
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IRR	117%	$114%	232%
NPV	$1,537	$1,236	$1,942

Optimized Cut – off Grade

Item #	Weight	Parameter	2.0g/t	1.0g/t	3.0g/t
			4 tpd	**8 tpd**	**3 tpd**
1	**High**	Net Present Value (NPV)			
2	**High**	Reserve basis			
3	**Low**	Mine life			
5	**High**	Environmental Impact			
7	**Medium**	Sensitivity to Au price			
8	**Low**	Sensitivity to Operating Costs			

Optimized Cut – off Grade

Item #	Weight	Parameter	2.0g/t	1.0g/t	3.0g/t
			4 tpd	8 tpd	3 tpd
			25		
1	High	Net Present Value (NPV)	2		
2	High	Reserve basis	2		
3	Low	Mine life	2		
5	High	Environmental Impact	2		
7	Medium	Sensitivity to Au price	0		
8	Low	Sensitivity to Operating Costs	0		

Optimized Cut – off Grade

Item #	Weight	Parameter	2.0g/t	1.0g/t	3.0g/t
			4 tpd	8 tpd	3 tpd
			25	35	51
1	High	Net Present Value (NPV)	2	1	3
2	High	Reserve basis	2	3	2
3	Low	Mine life	2	3	1
5	High	Environmental Impact	2	1	3
7	Medium	Sensitivity to Au price	0	1	3
8	Low	Sensitivity to Operating Costs	0	2	3

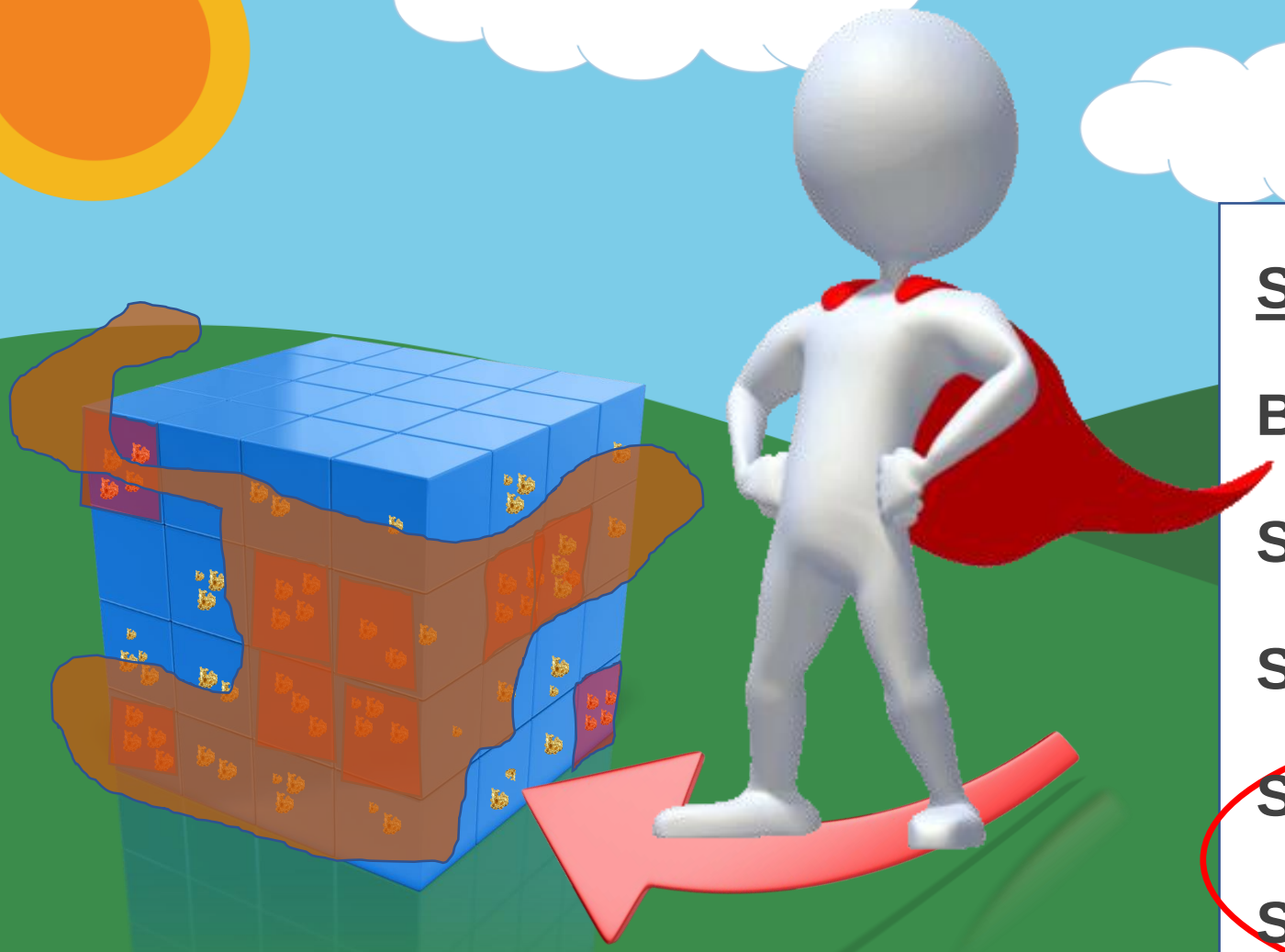
Optimized Cut – off Grade

Item #	Weight	Parameter	2.0g/t	1.0g/t	3.0g/t
			4 tpd	8 tpd	3 tpd
			25	35	51
1	High	Net Present Value (NPV)	2	1	3
2	High	Reserve basis	2	3	2
3	Low	Mine life	2	3	1
5	High	Environmental Impact	2	1	3
7	Medium	Sensitivity to Au price	0	1	3
8	Low	Sensitivity to Operating Costs	0	2	3

Optimized Cut – off Grade

Scenarios	COG(gpt)
Base Case	2.0 gpt
Scenario 1	1.0 gpt
Scenario 2	3.0 gpt

Optimized Cut – off Grade



Scenarios	COG(gpt)
Base Case	2.0 gpt
Scenario 1	1.0 gpt
Scenario 2	3.0 gpt
Scenario 2a	2.5 gpt
Scenario 2b	3.5 gpt

Summary

- Identify corporate objectives
- Run various production schedules
- Vary mining methods
- Apply various COG
- Fluctuation in mill recoveries
- Identify operating cost variable rates
- Include sustaining cost
- Effects of mining high grade first
- Time value of money

Summary

Test robustness on input parameters

Update COG Plan:

- Yearly
- Changes in metal prices
- Changes in corporate objective
- Discovery of new resources
- New innovative ways of doing things

Final Thoughts…

Balance Effort vs Value

Test robustness on input parameters

Select ideal range and increments on COG

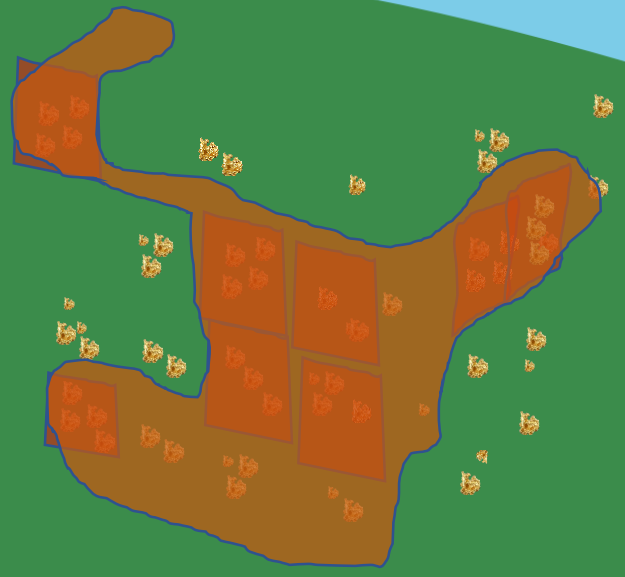
Treat Sustaining like opex

Consider Fixed and Variable cost

Consider mine development separately

Consider Major Capital i.e. Mill expansion

Consider tax and working capital



Careful when sending incremental material to the mill

Consider Multiple COG where warranted

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A
CIM
ICM
CIM2018
CONVENTION
srk consultin