

THE MEASUREMENT OF THE VIABILITY OF PGM-MINING PROJECTS IN A COMPETITIVE MARKET

by **PAUL LOUIS BROGAN**

submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in the Faculty of

ENGINEERING

in the University of the Witwatersrand, Johannesburg

August 1991

PROMOTER : DR I. CLARK

DECLARATION

I declare that this project is my own, unaided work. It is being submitted in partial fulfilment of the degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



(Paul Louis Brogan)

FOURTH day of SEPTEMBER 1992

THE MEASUREMENT OF THE VIABILITY OF PGM-MINING PROJECTS IN A COMPETITIVE MARKET

by **PAUL LOUIS BROGAN**

submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

in the Faculty of

ENGINEERING

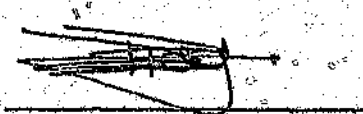
in the University of the Witwatersrand, Johannesburg

August 1991

PROMOTER : DR I. CLARK

DECLARATION

I declare that this project is my own, unaided work. It is being submitted in partial fulfilment of the degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.



(Paul Louis Brogan)

FOURTH day of SEPTEMBER 1992

ACKNOWLEDGEMENTS

I would like to express my gratitude to the following :-

The management of Impala Platinum Holdings Limited for permission to embark on this study, their constant encouragement and their willingness to peruse my work and to provide the facilities necessary to complete this research.

My promoter, Doctor Isobel Clark, for her interest in getting me started on this project and for her subsequent nagging to ensure that it was finished within our agreed time constraint.

My friends, for understanding that there were times when my study called more loudly than the next round.

My lady friends, for understanding

Tout nouveau, tout beau.

INDEX

	PAGE
1. Synopsis	1
2. Introduction	3
3. The Model	8
3.1 General	8
3.2 Conventional Sensitivity Analysis	11
3.3 Risk Analysis	14
3.4 Robustness Criteria	17
4. Hartley Platinum Mine	19
4.1 General	19
4.2 Conventional Results	24
4.3 Risk Analysis Results	41
4.4 Robustness Criteria	55
5. XYZ PGM Mine	71
5.1 General	71
5.2 Conventional Results	76
5.3 Risk Analysis Results	92
5.4 Robustness Criteria	106
6. Comparison of Results	121
7. Conclusions	127
8. Computer Disk with Model	128
9. References	129

THE MEASUREMENT OF THE VIABILITY OF PGM-MINING PROJECTS IN A COMPETITIVE MARKET

1. SYNOPSIS

The careful management and design of PGM (Platinum Group Metal) mining projects has recently assumed importance with projected increases in demand for PGMs and the subsequent establishment of new PGM-mining ventures. The following points merit particular attention with regard to the overall confidence in the robustness of these projects :-

- (i) cost - competitive position,
- (ii) ability to sustain downturns, and
- (iii) operational flexibility.

This research concentrates on what measurement criteria should be used to test the ability of proposed new PGM mines to maintain profitability during times of demand reductions and increased vulnerability to competition.

For ease of reference, the following abbreviations and terms apply throughout this document :-

PGM	:	Platinum Group Metal
Pt	:	Platinum
Pd	:	Palladium
Au	:	Gold
Rh	:	Rhodium
Ru	:	Ruthenium
Ir	:	Iridium
Ni	:	Nickel

Cu	:	Copper
Oz	:	Troy ounce
Capex	:	Capital Expenditure
IRR	:	Internal Rate of Return
NPV	:	Net Present Value
R	:	Rand
t	:	metric ton
g	:	gram
UG2	:	Upper Group 2, Bushveld Igneous Complex, South Africa
Merensky	:	Merensky Reef, Bushveld Igneous Complex, South Africa
NCR	:	Nickel / Copper Refinery
PMR	:	Precious Metals Refinery
SACPI	:	South African Consumer Price Index
USCPI	:	United States Consumer Price Index
US\$	:	United States Dollar
£	:	British Pound Sterling
pa	:	Per Annum
Upside	:	Increase in parameter value (not necessarily favourable)
Downside	:	Decrease in parameter value (not necessarily unfavourable)

2. INTRODUCTION

~~The importance~~ of evaluating and measuring the robustness of proposed new PGM-mining projects has recently been highlighted by :-

- (i) the increase in demand for PGMs, especially platinum, palladium and rhodium, in the last decade and the forecast continuance of this upward trend to the end of this century¹.
- (ii) the subsequent announcement of new PGM-mining ventures such as the Kennedy's Vale, Crocodile River, Northam, Potgietersrus Platinum, Karee, Messina, Maandagshoek, Hartley and Stillwater mines.
- (iii) announced expansions at established operations such as Impala, Rustenburg, Atok, Western Platinum and Eastern Platinum mines.
- (iv) the volatility of PGM prices and their sensitivity to general business confidence, as witnessed by recent wide fluctuations in the prices of rhodium and platinum.
- (v) the recent mothballing of Messina, Kennedy's Vale and Crocodile River Mines.
- (vi) the deferment of expansion plans at Atok, Stillwater and Impala Mines.

As a result of these recent developments in the PGM market (both on the supply and on the demand sides), it has become imperative that PGM producers analyse the risks and uncertainties involved with establishing new mining projects and expansions with an increased perspicacity. This includes quantifying the potential ranges of a project's input parameters used in its evaluation via sensitivity and risk analysis. However, perhaps of greater importance is the question of a project's robustness.

In general, and under a normal free-market system with little or no opportunities for government assistance to unprofitable mining operations (which is a basic assumption of this research), a mine will continue to produce as long as it is breaking even on its working costs, interest payments and other such obligations, although its capex plans can be curtailed during periods of lower-than-normal profits, albeit thus limiting the mine's long-term potential to survive. If this kind of situation were to continue, the mine would have to close down because of the lack of capital investment in future replacement production sources and because of the refusal of shareholders to continue their investment without a return.

This process would be accelerated if the operation were to make a working loss for an extended period. In some cases, a third party may be able to salvage the operation. This, however, represents a loss of control by the initiator of the project.

The following points apply to the question of premature project failure :-

- (i) Different project managers use different forecasts of economic input parameters in their project evaluations. The only certainty here is that all of these forecasts will be wrong. The best that one can hope for is to be as close to the parameters actually achieved as possible.
- (ii) Basic assumptions, both technical and conceptual, may be wrong, either because of unforeseen eventualities or simply by mistake.
- (iii) Substantial longer-term drops in metal prices, occurring because of an oversupply of or a reduction in demand for these metals, reduce profit levels.
- (iv) Higher-than-planned escalations in capex and working costs also reduce profit levels.
- (v) Changes in lease, royalty and tax rates may also reduce a project's return.

Apart from the possibilities of technical or conceptual errors (which have been ignored in this study), the above factors are common to all new projects. Sensitivity and risk analyses help to quantify the potential negative effects of these factors and thus one should assume that investors are aware of the size of any risk to which their funds are exposed.

This research concentrates on the ability of PGM-mining projects to weather out reductions in working profit, or even short-term working losses, which result from the above unexpected eventualities. It is assumed that, as profits are reduced, operations would be forced into closure one-by-one until supply has been cut back sufficiently to encourage a price balance at a level that will sustain the other operations at a normal working profit. Thus, the least favourably-placed operation would close first and the most favourably-placed operation would close last. The more profitable that a mine is, the more robust it would be.

The focal question of this research is thus :-

How does one measure this robustness meaningfully and thus position any particular primary PGM operation on a scale of competitiveness?

In determining whether to proceed with a new PGM-mining venture, the following factors are normally taken into account, amongst others :-

- (i) Real IRR of the project (%)
- (ii) Real IRR to the investors (%)
- (iii) NPV, at a hurdle discount rate, of the project (R million, base date)
- (iv) Payback period (years from first project expenditure)
- (v) Maximum cash exposure (R million)
- (vi) Corporate financial and marketing strategy

In determining the profitability of a project (current or projected), criteria such as the following are used :-

- (i) Working cost per ton milled net of by-product revenue (R/t)
- (ii) Working cost per ounce of platinum produced net of by-product revenue (R/oz Pt)
- (iii) Profit per ton milled (R/t)
- (iv) Profit per ounce of platinum produced (R/oz Pt)
- (v) Cut-off head grade (g PGM/t)
- (vi) Cash margin or Profit/Revenue ratio (%)

The relationship between the above profitability or robustness criteria and project decision-making factors is important, because the more consistent this relationship is over the project-evaluation period, the better that criterion will be in predicting the likelihood that the project survives in the long term.

The approach is thus as follows :-

- (i) Divide Real IRR and NPV @ 0% discount by the 6 profitability criteria listed above to create a number for each of the project years. This number has meaningless units and so is considered to be unitless in this study. It is used merely to examine the relationship between project factors and robustness criteria.
- (ii) Determine the variability of each of these numbers.
- (iii) Conclude which criterion is most suited to measuring robustness by choosing the one which is least variable.

Two projects will be used for the analysis : Hartley Platinum Mine and a fictitious South African Mine, XYZ.

-7-

Hartley Platinum Mine in Zimbabwe has not yet started full-scale operations, but has nevertheless announced some evaluation results. It is located on the Great Dyke in Zimbabwe and is planned to mine one of the PGM-bearing sulphide zones in this geological complex.

XYZ will add focus to the conclusions from the Hartley evaluation. It will mine a different reef type, have different grades and will be subject to different tax, lease and royalty rates. It will also be located in a country with political and economic and uncertainties different from those in Zimbabwe. A different reef type is evaluated in an attempt to examine the effect of the composition of a reef on the results of this study. For example, the UG7 Reef contains lower proportions of platinum and higher proportions of rhodium than either the Merensky Reef or this Great Dyke sulphide zone.

It should be noted that no allowance has been made for management response to low or negative profitability. Not only is it difficult to predict the form and the extent of such a response, but it can also vary widely between mines and mining houses. In effect, therefore, it is assumed that management responses for each competitor would be equivalent to the extent that their positions in a profitability or competitiveness ranking would not change.

This is not to say, however, that management response cannot be modelled. If one were to apply the techniques of this study to a particular mine or mining group, and assuming that management response could be reasonably predicted, then a project could be analysed that much more thoroughly.

3. THE MODEL

3.1 GENERAL

Refer to appendix 1 for a copy of the model and to page 10 for a diagrammatic representation of the model's layout.

The model is written in Lotus 1-2-3, release 2.2 software² and is approximately 430 kbytes in size.

It is important to note that as much realism as possible has been applied to the numbers used in the evaluations of this study. However, the conclusions centre on general project behaviour rather than on the specific projects chosen for this research.

Referring to appendix 1 and to page 10, the following descriptions apply :-

Instantaneous Project Profitability Sheet :-

This sheet, also entitled "Intramarginal Analysis of Platinum Producers", works from in situ grades and splits, to head grades, then to recoveries at the Concentrator, Smelter, NCR and PMR and thus to yield, in g PGM/t, for Merensky and UG2 reefs separately, for each metal (Pt, Pd, Au, Rh, Ru, Ir plus the base metals Ni and Cu).

These yields are averaged for the percentage of UG2 milled and multiplied by the sales prices (free-market prices adjusted for sales discounts) for each metal, to produce a figure for revenue per ton milled. It is an instantaneous picture at a base date (July 1991 for all calculations in this document) using prices at that date.

In addition, working costs (including ongoing capex and average royalty and lease paid) are calculated in base date terms. The results produced are profitability figures for July 1991, namely, total costs net of by-product credits per ton milled (R/t) and per ounce of platinum produced (R/oz Pt), profit per ton milled (R/t) and per ounce

of platinum produced (R/oz Pt), cash margin (profit divided by revenue expressed as a percentage) and cut-off head grades for Merensky Reef, UG2 Reef and the combined production of both for the operation being examined, in g PGM/t.

Screen :-

This area is used to assist the operator, via menu systems and associated macros, by showing messages and instructions.

Input Parameters :-

Included in this area are basic parameters used elsewhere in the worksheet, such as metal pipelines (for yearly metal production calculations), lease formula, royalty percentages, tax rates, whether there is a tax shield for the project or not, base date calculations, sales contract percentages, sensitivity and risk analysis parameters and starting-point data for the previous financial year, July 1990 to June 1991.

Sensitivities Output Area :-

Sensitivities are calculated and placed in this area for printing.

Macro Area :-

Macros are included here for inputting data, calculating, saving, sensitivity/risk analysis, printing, viewing results graphically, editing the worksheet, returning to the main directory menu and quitting from Lotus 1-2-3.

25 - Year Project Profiles :-

The input in this area, for 25 financial years (July to June) starting in 1991/92, include the SA and USCPI's, head grades, tons milled, free market prices, exchange rates, tax surcharge rates and capex. Figures from elsewhere in the worksheet are used to calculate metal production, costs and other financial data and, finally, 25 - year profiles of cashflows, NPV's, Real IRR's and the robustness parameters mentioned previously are produced.

GENERAL LAYOUT OF MODEL

**Instantaneous
Project
Profitability
Sheet**

Screen

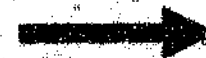
Input Parameters

**Sensitivities
Output Area**

Macro Area



25 - YEAR PROJECT PROFILES



3.2 CONVENTIONAL SENSITIVITY ANALYSIS

The forecast economic parameters used in this study until the financial year 1999/2000 are detailed on page 13. These figures represent one of many views of the possible economic scenario for the next ten years but have a basis in the predictions of PGM experts¹. They are considered sufficient for this exercise's purposes. It has been said that economic forecasts tend to be even less reliable than weather forecasts but that, in fact, the average annualised error of long-term forecasts is often smaller than that of short-term ones³. After FY1999/2000, purchasing-power-parity is assumed⁴. That is, metal prices are escalated at the USCPI and the R/US\$ exchange rate is escalated by SACPI/USCPI in order to maintain constant real metal prices in Rand terms. A straight-line price forecast is thus assumed.

The conventional results are straightforward calculations of cashflows based on the input parameters assumed and thus only one set of results in year 25 is produced. The accounting of inflation is important from a taxation point of view. Constant money terms are arrived at after discounting both negative and positive cash flows by the cumulative SACPI for each applicable year.

For sensitivity analysis, the following parameters are allowed to vary :-

- (i) Individual Metal Prices (US\$/oz for PGMs, US\$/t for Ni and £/t for Cu)
- (ii) Working Costs (R)
- (iii) Capex (R)
- (iv) Recovered Grades (g PGM/t)
- (v) Milled Tons (t)
- (vi) SACPI (% pa)
- (vii) USCPI (% pa)
- (viii) R/US\$ Exchange Rate
- (ix) R/£ Exchange Rate
- (x) Lease Payments (R)

- (xi) Royalty Payments (R)
- (xii) Tax Rate (% applicable to taxable profit)
- (xiii) Timing of Initial Production (important in build-up and expansion phases)

The worksheet menu allows for input of required sensitivity ranges for instantaneous results of net working costs per ton-milled, net working costs per ounce of platinum produced and cash margin. In all cases in this study, these instantaneous figures were calculated for $\pm 5\%$ on the above sensitivity parameters.

In addition, the long-term results for 25-year NPV @ 0% discount (R million, base date), 5-year Real IRR (%) and escalated maximum cash exposure (R million escalated) were calculated for $\pm 20\%$ on the above sensitivity parameters.

Finally, best and worst cases for all the above were calculated using the $\pm 5\%$ or $\pm 20\%$ sensitivity, as the case may be. 5% and 20% were chosen to illustrate the sensitivity analysis technique, although different percentages could be chosen, depending on the preference of the operator.

FORECAST ECONOMIC PARAMETERS

Financial Parameters

Financial Year	'92	'93	'94	'95	'96	'97	'98	'99	'00
USCPI %	5,00	4,75	4,50	4,50	4,50	4,50	4,50	4,50	4,50
SACPI %	12,75	12,00	11,25	10,75	10,25	10,00	10,00	10,00	10,00
Exch. Rate R/US\$	2,88	3,03	3,08	3,13	3,24	3,42	3,60	3,80	4,00
Exch. Rate US\$/£	1,89	1,88	1,86	1,92	1,95	1,90	1,88	1,88	1,88

Projected Metal Prices (Free Market)

Financial Year	'92	'93	'94	'95	'96	'97	'98	'99	'00
Pt US\$/oz	387	455	513	575	613	638	665	698	729
Pd US\$/oz	98	113	133	148	175	175	185	194	210
Rh US\$/oz	3 375	3 620	4 065	4 372	4 875	4 875	5 250	4 850	5 250
Ru US\$/oz	58	58	61	64	69	69	73	77	81
Ir US\$/oz	298	305	320	320	352	352	369	388	407
Au US\$/oz	374	420	470	490	530	530	555	652	685
Ni US\$/t	8 133	8 401	8 800	9 300	10 100	10 100	10 650	11 200	11 750
Cu \$/t	1 294	1 392	1 525	1 625	1 675	1 725	1 725	1 775	1 825

3.3 RISK ANALYSIS

@Risk, produced by Palisade Corporation, is a true "add-in" to Lotus 1-2-3, using Lotus-style menus and @functions. It allows for uncertain cell values in 1-2-3 to be defined as probability distributions using @functions. A cell containing the distribution @function @NORMAL (10;10), for example, would return samples during a simulation drawn from a normal distribution (mean = 10; standard deviation 10). Distribution @functions are only invoked during a simulation (in normal 1-2-3 operations, they show a single cell value - just the same as 1-2-3 without @Risk). Available distribution types include :-

Beta	Erlang	Lognormal
Binomial	Exponential	Negative Binomial
Chi-Square	Gamma	Normal
Correlations	General	Pareto
Cumulative	Geometric	Poisson
Discrete	Histogram	Triangular
Discrete Uniform	Hypergeometric	Uniform
Error Functions	Logistic	Weibull

@Risk has sophisticated capabilities for specifying and executing simulations of 1-2-3 models. Both Monte Carlo and Latin Hypercube sampling techniques are supported and distributions of possible results may be generated for any cell or range of cells in the spreadsheet model.

For this research, the model was designed to allow for the following distributions of input parameters :-

INPUT PARAMETER	DOWNWARD POTENTIAL %	EXPECTED %	UPWARD POTENTIAL %
Pt Price (US\$/oz)	x_1	100	y_1
Pd Price (US\$/oz)	x_2	100	y_2
Au Price (US\$/oz)	x_3	100	y_3
Rh Price (US\$/oz)	x_4	100	y_4
Ru Price (US\$/oz)	x_5	100	y_5
Ir Price (US\$/oz)	x_6	100	y_6
Ni Price (US\$/t)	x_7	100	y_7
Cu Price (£/t)	x_8	100	y_8
Working Costs (R)	x_9	100	y_9
Capex (R)	x_{10}	100	y_{10}
Recovery Grades (g PGM/t)	x_{11}	100	y_{11}
Milled Tons (t)	x_{12}	100	y_{12}
SACPI (% pa)	x_{13}	100	y_{13}
USCPI (% pa)	x_{14}	100	y_{14}
R/US\$	x_{15}	100	y_{15}
R/£	x_{16}	100	y_{16}
Lease (R)	x_{17}	100	y_{17}
Royalty (R)	x_{18}	100	y_{18}
Tag (%)	x_{19}	100	y_{19}
Timing	x_{20}	100	y_{20}

The distribution @function used in all cases follows the form of @TNORMAL(1;@MAX(y_n -100;100- x_n)/3; x_n ; y_n) for $n = 1$ to 20.

@TNORMAL(μ ; σ ;minimum;maximum) is a truncated Normal distribution, constrained by truncated minimum and maximum values as shown above. The density function is:-

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-1/2\sigma^2(x-\mu)^2} [F_n(\text{maximum}) - F_n(\text{minimum})]^{-1}$$

where $F_n(x)$ is the distribution function for the Normal.

The Normal distribution was used to represent the fact that quantities which are the sums of other quantities tend to a Normal distribution because of the central limit theorem. The input parameters above are each the sum of many other variables and subject to a host of influences that in themselves may vary according to their own distribution functions. Hence, a Normal distribution was felt to be justified. The truncation values are used in order to reflect the operator's assessment of minima and maxima. In all cases, the Latin Hypercube sampling technique was used.

It must be kept in mind that @Risk is merely a tool used during this study and that the study itself is more than just an examination of this tool.

3.4 ROBUSTNESS CRITERIA

As mentioned previously, the Real IRR (%) and NPV @ 0% discount (R million, base date) are divided by the following criteria in each of financial years 1 to 25 :-

- (i) Working cost per ton milled net of by-product revenue (R/t)
- (ii) Working cost per ounce of platinum produced net of by-product revenue (R/oz Pt)
- (iii) Profit per ton milled (R/t)
- (iv) Profit per ounce of platinum produced (R/oz Pt)
- (v) Cut-off head grade (g FGM/t)
- (vi) Cash margin (or Profit/Revenue ratio) (%)

In all cases, costs include ongoing capex, royalty payments and lease payments in order to properly compare projects with different requirements for these items. Therefore, figures produced for net costs, profit and margin take account of these expenditures.

If :-

x = Project Factor (Real IRR or NPV @ 0% discount)

and y = Robustness Criterion (one of the 6 above),

then the following number is produced :-

$$z = x/y$$

During simulation, each iteration produces a number :-

$$z + \Delta z = \frac{x + \Delta x}{y + \Delta y}$$

The objective is thus to determine which of the above "y" factors follows the rise and fall of the above "x" factors most closely. That is, which produces the smaller average number for Δz . For ease, the output variable examined in the simulations is:-

$$(x/y)/((x + \Delta x)/(y + \Delta y)) - 1 = z/(z + \Delta z) - 1 = V$$

which should average as closely as possible to zero.

In this work, 1 000 iterations were run per simulation, producing both the risk analysis results and the variability of V around zero, as well as the expected result for V.

4. HARTLEY PLATINUM MINE

4.1 GENERAL

Delta Gold NL have made several announcements in recent years on the results from exploration and feasibility studies at their Hartley PGM deposit on the Great Dyke in Zimbabwe⁶.

They have declared that the project is viable at a production level of 2 million t pa, 106 000 oz Pt pa and 2 450 t Ni pa. Pages 20 to 23 shows the input parameters used, taken from Delta's evaluation. The main differences in these input parameters from those used by Delta are the assumption of South African Rand terms and the forecast economic parameters shown on page 13. For strict evaluation purposes (rather than this more comparative exercise), Hartley should be rather evaluated using Zimbabwean currency and economic factors.

The reef to be mined at Hartley is a Great Dyke sulphide zone and is more similar to the Bushveld Igneous Complex's Merensky Reef than to its UG2 Reef. This evaluation has been confined to published data on this project and any missing data was estimated. No confidential information is used or, indeed, was available.

HARTLEY EVALUATION, JUNE 1991

[illegible]

29-JUL-91 JUL 1991 TERMS										HARTLEY EVALUATION, JUNE 1991									
HARTLEY-MKT										INTRACRIMINAL ANALYSIS OF PLATINUM PRODUCERS									
GEOLOGICAL RESERVES (TONS) MININGABLE										EXCHANGE RATES: JUL 1991 TERMS									
FACTS										WORKING COSTS: JUL 1991 TERMS									
VERENSKY UG2										VERENSKY UG2									
1.15 * 1.27 *										2.035 1.580									
CORRECTED										CORRECTED									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										METAL PRICES: JUL 1991 TERMS									
VERENSKY UG2										FREE MARKET SALES									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										US\$/oz R/oz									
TOTALS										TOTALS									
		44,732	2,529	2,120	82.28%	97.58%	98.08%	99.08%	1,840	47.08%	55.49	Pt	378.28	1,046.97					
Pd		36,295	2,529	2,120	82.28%	97.58%	98.08%	99.08%	1,739	57.89%	11.81	Pd	354.50	203.00					
Au		7,608	2,529	2,120	82.28%	97.58%	98.08%	99.08%	1,739	6.89%	7.78	Au	354.50	100.11					
Rh		5,352	2,529	2,120	82.28%	97.58%	98.08%	99.08%	1,739	3.78%	3.78	Rh	2,275.00	947.30					
Ru		2,112	2,529	2,120	82.28%	97.58%	98.08%	99.08%	1,739	0.95%	0.95	Ru	55.50	101.52					
Ir		2,112	2,529	2,120	82.28%	97.58%	98.08%	99.08%	1,739	0.95%	0.95	Ir	205.00	814.50					
TOTALS		188,00%	5,580	4,740	78.52%	97.58%	97.49%	97.71%	3,981	189.08%	111.84								
Ni		g/t	2,127	1,089	74.52%	95.90%	95.90%		1,225	733	27.51	Ni	0.535,01	22,460.78					
Cu		g/t	1,290	1,100	78.28%	95.88%	95.88%		705	476	2.78	Cu	6/t	3,549.99					
MINING UNCORRECTED										TOTAL REVENUE 142.24									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 73.85%									
64.84% 4,970 4,120										RATES kg/t 2.631									
CORRECTED										COMBINED VERENSKY & UG2									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										YIELD % SPLIT REVENUE									
UG2										YIELD % SPLIT REVENUE									
		7,626	5,185		83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Pt		45,06%	3,573	3,550	83.00%	97.58%	98.08%	99.08%	1,452	45.91%	82.33	Pt	1,540	47.08%	55.49				
Pd		31.51%	2,466	1,627	83.00%	97.58%	98.08%	99.08%	1,278	32.37%	19.03	Pd	1,289	87.09%	11.81				
Au		5.33%	0,873	0,840	83.00%	97.58%	98.08%	99.08%	0,837	0.63%	1.10	Au	0,739	6.08%	7.78				
Rh		6.01%	0,533	0,352	83.00%	97.58%	98.08%	99.08%	0,257	0.51%	74.68	Rh	0,124	3.55%	36.17				
Ru		12.85%	0,592	0,355	83.00%	97.58%	98.08%	99.08%	0,458	1.18%	2.30	Ru	0,143	2.66%	0.85				
Ir		2.41%	0,189	0,124	92.00%	97.58%	98.08%	99.08%	0,066	1.65%	1.74	Ir	0,120	0.92%	0.73				
TOTALS		158,00%	7,820	5,185	83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Ni		g/t	383	198	40.80%	95.88%	95.88%		87	47	1.95	Ni	1,225	743	27.51				
Cu		g/t	150	99	73.00%	95.88%	95.88%		87	47	0.24	Cu	785	476	2.78				
MINING UNCORRECTED										TOTAL REVENUE 155.33									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 76.43%									
66.00% 6,107 4,803										MAYTE kg/t 0.282									
CORRECTED										TOTAL REVENUE 142.24									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										OVERALL RECOVERY 75.05%									
UG2										MAYTE kg/t 2.631									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										COMBINED VERENSKY & UG2									
TOTALS										YIELD % SPLIT REVENUE									
		7,626	5,185		83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Pt		45.06%	3,573	3,550	83.00%	97.58%	98.08%	99.08%	1,452	45.91%	82.33	Pt	1,540	47.08%	55.49				
Pd		31.51%	2,466	1,627	83.00%	97.58%	98.08%	99.08%	1,278	32.37%	19.03	Pd	1,289	87.09%	11.81				
Au		5.33%	0,873	0,840	83.00%	97.58%	98.08%	99.08%	0,837	0.63%	1.10	Au	0,739	6.08%	7.78				
Rh		6.01%	0,533	0,352	83.00%	97.58%	98.08%	99.08%	0,257	0.51%	74.68	Rh	0,124	3.55%	36.17				
Ru		12.85%	0,592	0,355	83.00%	97.58%	98.08%	99.08%	0,458	1.18%	2.30	Ru	0,143	2.66%	0.85				
Ir		2.41%	0,189	0,124	92.00%	97.58%	98.08%	99.08%	0,066	1.65%	1.74	Ir	0,120	0.92%	0.73				
TOTALS		158,00%	7,820	5,185	83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Ni		g/t	383	198	40.80%	95.88%	95.88%		87	47	1.95	Ni	1,225	743	27.51				
Cu		g/t	150	99	73.00%	95.88%	95.88%		87	47	0.24	Cu	785	476	2.78				
MINING UNCORRECTED										TOTAL REVENUE 155.33									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 76.43%									
66.00% 6,107 4,803										MAYTE kg/t 0.282									
CORRECTED										TOTAL REVENUE 142.24									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										OVERALL RECOVERY 75.05%									
UG2										MAYTE kg/t 2.631									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										COMBINED VERENSKY & UG2									
TOTALS										YIELD % SPLIT REVENUE									
		7,626	5,185		83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Pt		45.06%	3,573	3,550	83.00%	97.58%	98.08%	99.08%	1,452	45.91%	82.33	Pt	1,540	47.08%	55.49				
Pd		31.51%	2,466	1,627	83.00%	97.58%	98.08%	99.08%	1,278	32.37%	19.03	Pd	1,289	87.09%	11.81				
Au		5.33%	0,873	0,840	83.00%	97.58%	98.08%	99.08%	0,837	0.63%	1.10	Au	0,739	6.08%	7.78				
Rh		6.01%	0,533	0,352	83.00%	97.58%	98.08%	99.08%	0,257	0.51%	74.68	Rh	0,124	3.55%	36.17				
Ru		12.85%	0,592	0,355	83.00%	97.58%	98.08%	99.08%	0,458	1.18%	2.30	Ru	0,143	2.66%	0.85				
Ir		2.41%	0,189	0,124	92.00%	97.58%	98.08%	99.08%	0,066	1.65%	1.74	Ir	0,120	0.92%	0.73				
TOTALS		158,00%	7,820	5,185	83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Ni		g/t	383	198	40.80%	95.88%	95.88%		87	47	1.95	Ni	1,225	743	27.51				
Cu		g/t	150	99	73.00%	95.88%	95.88%		87	47	0.24	Cu	785	476	2.78				
MINING UNCORRECTED										TOTAL REVENUE 155.33									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 76.43%									
66.00% 6,107 4,803										MAYTE kg/t 0.282									
CORRECTED										TOTAL REVENUE 142.24									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										OVERALL RECOVERY 75.05%									
UG2										MAYTE kg/t 2.631									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										COMBINED VERENSKY & UG2									
TOTALS										YIELD % SPLIT REVENUE									
		7,626	5,185		83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Pt		45.06%	3,573	3,550	83.00%	97.58%	98.08%	99.08%	1,452	45.91%	82.33	Pt	1,540	47.08%	55.49				
Pd		31.51%	2,466	1,627	83.00%	97.58%	98.08%	99.08%	1,278	32.37%	19.03	Pd	1,289	87.09%	11.81				
Au		5.33%	0,873	0,840	83.00%	97.58%	98.08%	99.08%	0,837	0.63%	1.10	Au	0,739	6.08%	7.78				
Rh		6.01%	0,533	0,352	83.00%	97.58%	98.08%	99.08%	0,257	0.51%	74.68	Rh	0,124	3.55%	36.17				
Ru		12.85%	0,592	0,355	83.00%	97.58%	98.08%	99.08%	0,458	1.18%	2.30	Ru	0,143	2.66%	0.85				
Ir		2.41%	0,189	0,124	92.00%	97.58%	98.08%	99.08%	0,066	1.65%	1.74	Ir	0,120	0.92%	0.73				
TOTALS		158,00%	7,820	5,185	83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Ni		g/t	383	198	40.80%	95.88%	95.88%		87	47	1.95	Ni	1,225	743	27.51				
Cu		g/t	150	99	73.00%	95.88%	95.88%		87	47	0.24	Cu	785	476	2.78				
MINING UNCORRECTED										TOTAL REVENUE 155.33									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 76.43%									
66.00% 6,107 4,803										MAYTE kg/t 0.282									
CORRECTED										TOTAL REVENUE 142.24									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										OVERALL RECOVERY 75.05%									
UG2										MAYTE kg/t 2.631									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										COMBINED VERENSKY & UG2									
TOTALS										YIELD % SPLIT REVENUE									
		7,626	5,185		83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Pt		45.06%	3,573	3,550	83.00%	97.58%	98.08%	99.08%	1,452	45.91%	82.33	Pt	1,540	47.08%	55.49				
Pd		31.51%	2,466	1,627	83.00%	97.58%	98.08%	99.08%	1,278	32.37%	19.03	Pd	1,289	87.09%	11.81				
Au		5.33%	0,873	0,840	83.00%	97.58%	98.08%	99.08%	0,837	0.63%	1.10	Au	0,739	6.08%	7.78				
Rh		6.01%	0,533	0,352	83.00%	97.58%	98.08%	99.08%	0,257	0.51%	74.68	Rh	0,124	3.55%	36.17				
Ru		12.85%	0,592	0,355	83.00%	97.58%	98.08%	99.08%	0,458	1.18%	2.30	Ru	0,143	2.66%	0.85				
Ir		2.41%	0,189	0,124	92.00%	97.58%	98.08%	99.08%	0,066	1.65%	1.74	Ir	0,120	0.92%	0.73				
TOTALS		158,00%	7,820	5,185	83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Ni		g/t	383	198	40.80%	95.88%	95.88%		87	47	1.95	Ni	1,225	743	27.51				
Cu		g/t	150	99	73.00%	95.88%	95.88%		87	47	0.24	Cu	785	476	2.78				
MINING UNCORRECTED										TOTAL REVENUE 155.33									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 76.43%									
66.00% 6,107 4,803										MAYTE kg/t 0.282									
CORRECTED										TOTAL REVENUE 142.24									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										OVERALL RECOVERY 75.05%									
UG2										MAYTE kg/t 2.631									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										COMBINED VERENSKY & UG2									
TOTALS										YIELD % SPLIT REVENUE									
		7,626	5,185		83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Pt		45.06%	3,573	3,550	83.00%	97.58%	98.08%	99.08%	1,452	45.91%	82.33	Pt	1,540	47.08%	55.49				
Pd		31.51%	2,466	1,627	83.00%	97.58%	98.08%	99.08%	1,278	32.37%	19.03	Pd	1,289	87.09%	11.81				
Au		5.33%	0,873	0,840	83.00%	97.58%	98.08%	99.08%	0,837	0.63%	1.10	Au	0,739	6.08%	7.78				
Rh		6.01%	0,533	0,352	83.00%	97.58%	98.08%	99.08%	0,257	0.51%	74.68	Rh	0,124	3.55%	36.17				
Ru		12.85%	0,592	0,355	83.00%	97.58%	98.08%	99.08%	0,458	1.18%	2.30	Ru	0,143	2.66%	0.85				
Ir		2.41%	0,189	0,124	92.00%	97.58%	98.08%	99.08%	0,066	1.65%	1.74	Ir	0,120	0.92%	0.73				
TOTALS		158,00%	7,820	5,185	83.00%	97.58%	97.15%	87.18%	3,947	100.08%	152.14	TOTAL	3,581	158,00%	121.91				
Ni		g/t	383	198	40.80%	95.88%	95.88%		87	47	1.95	Ni	1,225	743	27.51				
Cu		g/t	150	99	73.00%	95.88%	95.88%		87	47	0.24	Cu	785	476	2.78				
MINING UNCORRECTED										TOTAL REVENUE 155.33									
EXTRACTION IN-SITU HEAD										OVERALL RECOVERY 76.43%									
66.00% 6,107 4,803										MAYTE kg/t 0.282									
CORRECTED										TOTAL REVENUE 142.24									
IN-SITU IN-SITU HEAD CONCENTRATOR ESTIMATED RECOVERIES										OVERALL RECOVERY 75.05%									
UG2										MAYTE kg/t 2.631									

91-07-23

INPUT PARAMETERS

* Company : HARTLEY EVALUATION, JUNE 1991

METAL, 1ST OR PIPELINE, INPUT FACTORS :

PL	70.00%	LEASE FORMULA : Y	0.00 / X
PA	57.00%	ROYALTY PERCENTAGE	0.00%
SA	48.00%	TAX RATE	50.00%
SN	48.00%	TAX CASE? (Y/N)	N
IR	48.00%		
RI	90.00%		
CU	90.00%		

BASE DATE CALCULATION : JUL 1991 TERMS
MONTHS FROM JUL Y 1991 : 0ESTIMATED LIMITS
BOTTOM MIDDLE

PL PRICE :	70.00%	100.00%	120.00%
PA PRICE :	57.00%	100.00%	120.00%
SA PRICE :	64.00%	100.00%	130.00%
SN PRICE :	60.00%	100.00%	130.00%
IR PRICE :	64.00%	100.00%	130.00%
RI PRICE :	60.00%	100.00%	130.00%
CU PRICE :	64.00%	100.00%	130.00%
WORKING COSTS :	45.00%	100.00%	120.00%
CAPEX :	95.00%	100.00%	130.00%
RECOVERED GRADE :	85.00%	100.00%	140.00%
MILLED TONNAGES :	90.00%	100.00%	110.00%
SACPI :	90.00%	100.00%	125.00%
USCPI :	90.00%	100.00%	110.00%
R/US\$ EXCHANGE RATE :	90.00%	100.00%	125.00%
R/E EXCHANGE RATE :	90.00%	100.00%	125.00%
LEASE PAYMENT :	0.00%	100.00%	150.00%
ROYALTY PAYMENT :	80.00%	100.00%	120.00%
TAX RATE :	50.00%	100.00%	150.00%
TINING :	90.00%	100.00%	130.00%

SALES CONTRACTS :

PL PRICE :	100.00%
PA PRICE :	100.00%
SA PRICE :	100.00%
SN PRICE :	100.00%
IR PRICE :	100.00%
RI PRICE :	100.00%
CU PRICE :	100.00%

RECOVERED GRADE :	100.00%
CAPEX :	100.00%
MILLED TONNAGES :	100.00%
SACPI :	100.00%
USCPI :	100.00%
R/US\$ EXCHANGE RATE :	100.00%
R/E EXCHANGE RATE :	100.00%
LEASE PAYMENT :	100.00%
ROYALTY PAYMENT :	100.00%
TAX RATE :	100.00%
TINING :	100.00%

RISK ANALYSIS (Y/N) N

STARTING POINTS :

HERBESKY HEAD GRADE, g/t	0.00%
US2 HEAD GRADE, g/t	0.00%
HERBESKY TONS MILLED	0.00%
US2 TONS MILLED	0.00%
LAURENCE CAPEX, \$ million	0.00%

91-87-23

INPUT DATA

HARTLEY, HK1		FINANCIAL YEARS													
		91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	
SALES		12.75%	12.00%	11.25%	10.75%	10.25%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	
SA DISCOUNT FACTOR		1.052	1.109	1.223	1.465	1.615	1.777	1.959	2.150	2.368	2.602	2.862	3.140	3.463	
MERENSKY HEAD GRADE		4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	
US2 HEAD GRADE		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
MERENSKY MILLER		0	0	1 740 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	
US2 MILLER		0	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL MILLER		0	0	1 740 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	
PERCENTAGE US2		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
P1 PRODUCED		0	0	64 554	101 130	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	
P2 PRODUCED		0	0	40 872	79 017	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	
A1 PRODUCED		0	0	0 305	14 564	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	
B1 PRODUCED		0	0	3 341	7 459	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	
A2 PRODUCED		0	0	4 395	0 700	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	
I1 PRODUCED		0	0	675	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	
K1 PRODUCED		0	0	910	2 410	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	
Q1 PRODUCED		0	0	1 220	1 549	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	
P1 PRICE, FREE MARKET		US\$/oz	305.93	455.23	519.00	579.00	613.00	620.00	665.00	690.00	729.00	761.01	799.00	831.01	
P2 PRICE, FREE MARKET		US\$/oz	97.01	113.00	133.00	145.00	153.00	157.00	165.00	165.00	175.00	180.45	189.00	199.00	
A1 PRICE, FREE MARKET		US\$/oz	373.53	420.00	479.00	490.00	510.00	520.00	550.00	550.00	565.00	585.00	600.00	615.00	
B1 PRICE, FREE MARKET		US\$/oz	3 375.00	4 820.00	4 854.50	4 372.00	4 625.00	4 625.00	5 250.00	4 650.00	5 250.00	5 400.25	5 733.12	6 268.72	
A2 PRICE, FREE MARKET		US\$/oz	57.50	50.00	61.00	64.00	66.00	67.00	70.00	70.00	71.00	74.00	76.00	78.00	
I1 PRICE, FREE MARKET		US\$/oz	205.13	305.00	310.00	320.00	325.00	352.00	360.00	360.00	407.00	425.32	444.45	464.45	
K1 PRICE, FREE MARKET		US\$/oz	843.11	1 081.32	0 800.00	9 300.00	9 600.00	9 600.00	10 500.00	11 200.00	11 750.00	12 270.75	12 631.20	13 400.70	
Q1 PRICE, FREE MARKET		US\$/oz	1 204.20	1 391.61	1 525.00	1 575.00	1 625.00	1 675.00	1 725.00	1 750.00	1 825.00	1 900.00	1 954.90	2 022.41	
EXCHANGE RATE		R/US\$	2.80	3.03	3.09	3.13	3.24	3.42	3.60	3.80	4.00	4.21	4.43	4.67	
EXCHANGE RATE		R/£	5.45	5.69	5.73	6.00	6.39	6.91	7.70	7.16	7.53	8.00	8.51	9.04	

91-07-23

INPUT DATA

FINANCIAL YEARS		01/95	02/96	03/97	04/98	05/99	06/00	07/01	08/02	09/03	10/04	11/05	12/06	13/07	14/08	15/09
WASTLEY AK1																
SACPI		10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
SA DISCOUNT FACTOR		3.500	4.100	4.500	5.070	5.577	6.125	6.746	7.423	8.155	8.952	9.820	10.768	11.800	12.920	14.130
MERENSKY HEAD GRADE		g/t	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740	4.740
UG2 HEAD GRADE		g/t	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MERENSKY MILLED		t	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
UG2 MILLED		t	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL MILLED		t	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
PERCENTAGE UG2		%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PE PRODUCED		oz	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000	100 000
PG PRODUCED		oz	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500	03 500
AG PRODUCED		oz	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300	15 300
RH PRODUCED		oz	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000	0 000
RG PRODUCED		oz	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500	10 500
IF PRODUCED		oz	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000
HI PRODUCED		oz	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450	2 450
CG PRODUCED		oz	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570	1 570
PE PRICE, FREE MARKET		US\$/oz	603.47	645.35	692.07	743.71	799.30	864.84	930.32	1 005.76	1 081.16	1 156.52	1 231.85	1 307.16	1 382.45	1 457.71
PG PRICE, FREE MARKET		US\$/oz	251.76	273.47	295.70	317.44	339.69	361.44	383.69	405.44	427.69	449.44	471.69	493.44	515.69	537.44
AG PRICE, FREE MARKET		US\$/oz	652.03	692.05	732.07	772.09	812.11	852.13	892.15	932.17	972.19	1 012.21	1 052.23	1 092.25	1 132.27	1 172.29
RH PRICE, FREE MARKET		US\$/oz	6 642.40	6 896.87	7 151.34	7 405.81	7 660.28	7 914.75	8 169.22	8 423.69	8 678.16	8 932.63	9 187.10	9 441.57	9 696.04	9 950.51
RG PRICE, FREE MARKET		US\$/oz	130.94	139.49	148.04	156.59	165.14	173.69	182.24	190.79	199.34	207.89	216.44	224.99	233.54	242.09
IF PRICE, FREE MARKET		US\$/oz	587.20	630.02	672.84	715.66	758.48	801.30	844.12	886.94	929.76	972.58	1 015.40	1 058.22	1 101.04	1 143.86
HI PRICE, FREE MARKET		US\$/oz	14 642.64	15 381.36	16 120.08	16 858.80	17 597.52	18 336.24	19 074.96	19 813.68	20 552.40	21 291.12	22 029.84	22 768.56	23 507.28	24 246.00
CG PRICE, FREE MARKET		US\$/oz	2 167.53	2 243.39	2 319.25	2 395.11	2 470.97	2 546.83	2 622.69	2 698.55	2 774.41	2 850.27	2 926.13	3 001.99	3 077.85	3 153.71
EXCHANGE RATE		R/US\$	5.17	5.44	5.73	6.03	6.35	6.68	7.03	7.40	7.78	8.18	8.59	9.01	9.44	9.89
EXCHANGE RATE		R/£	10.71	10.05	11.53	12.28	13.03	13.95	14.72	15.64	16.62	17.67	18.79	19.98	21.25	22.60

01-07-23

ANALYSIS RESULTS

WARTLEY, W1	FINANCIAL YEARS	01/92	02/93	03/94	04/95	05/96	06/97	07/98	08/99	09/00	10/01	11/02	12/03	01/04
ESCALATED	R million													
REVENUE		0	0	233	221	483	534	593	641	713	704	663	949	1 844
TOTAL WORKING COST		0	0	184	246	272	299	328	362	399	437	461	529	592
WORKING PROFIT		0	0	49	75	212	235	265	279	315	347	302	420	462
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		219	324	07	0	11	4	11	12	9	7	8	12	36
ORDING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL CAPEX		219	324	07	0	11	4	11	12	9	7	8	12	36
LEASE PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
ROYALTY PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
TAX PAYABLE		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL GOVERNMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(219)	(324)	(51)	178	195	112	123	130	149	165	185	204	287
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(206)	(275)	(38)	116	121	65	63	68	83	83	65	65	60
ESCALATED CUMULATIVE CASH FLOW	R million	(219)	(543)	(425)	(235)	(119)	(118)	(156)	(194)	(283)	(449)	(633)	(837)	(1 844)
BASE DATE CUMULATIVE CASH FLOW	R million	(206)	(479)	(402)	(202)	(119)	(119)	(156)	(194)	(283)	(449)	(633)	(837)	(1 844)
BASE DATE REVENUE PER t MILLED	R/t	0.00	0.00	148.01	148.01	150.18	151.61	149.88	150.75	150.75	150.75	150.75	150.75	150.75
BASE DATE REVENUE PER oz Pt	R/oz Pt	0	0	2 733	2 824	2 073	2 853	2 856	2 813	2 844	2 844	2 844	2 844	2 844
BASE DATE TOTAL COSTS PER t MILLED	R/t	0.00	0.00	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	0	0	1 607	1 607	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	0.00	0.00	50.32	50.30	56.15	56.89	58.39	58.4	57.11	57.11	57.11	57.11	57.11
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	0	0	1 572	1 520	1 625	1 639	1 668	1 612	1 644	1 644	1 644	1 644	1 644
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	0.00	0.00	27.63	2.96	(6.91)	(6.93)	(2.45)	0.53	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	0	0	745	58	(4)	(18)	(46)	19	(22)	(22)	(22)	(22)	(22)
BASE DATE WORKING PROFIT PER t MILLED	R/t	0.00	0.00	15.45	67.07	63.67	64.22	65.66	63.14	64.60	64.80	64.80	64.80	64.80
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	0	0	416	1 195	1 281	1 112	1 239	1 191	1 223	1 223	1 223	1 223	1 223
CASH MARGIN, PROFIT/REVENUE	%	0.00	0.00	15.24	48.24	42.55	42.77	43.31	42.35	42.89	42.89	42.89	42.89	42.89
MEDESKY CUT-OFF HEAD GRADE	g per/t	0.808	0.808	4.010	2.832	2.723	2.713	2.807	2.732	2.702	2.782	2.782	2.782	2.782
US2 CUT-OFF HEAD GRADE	g per/t	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808	0.808
TOTAL CUT-OFF HEAD GRADE	g per/t	0.808	0.808	4.010	2.832	2.723	2.713	2.807	2.732	2.702	2.782	2.782	2.782	2.782
NPV CASH FLOW, 0%	R million	(286)	(473)	(518)	(482)	(282)	(219)	(150)	(95)	(32)	31	86	181	228
NPV CASH FLOW, 1%	R million	(284)	(472)	(509)	(480)	(282)	(224)	(185)	(118)	(52)	5	63	121	173
NPV CASH FLOW, 2%	R million	(282)	(464)	(501)	(469)	(285)	(228)	(174)	(123)	(28)	(18)	34	85	131
NPV CASH FLOW, 3%	R million	(280)	(457)	(493)	(458)	(286)	(233)	(162)	(138)	(95)	(30)	3	53	94
NPV CASH FLOW, 4%	R million	(198)	(451)	(405)	(386)	(287)	(237)	(109)	(145)	(81)	(58)	(16)	24	68
NPV CASH FLOW, 5%	R million	(197)	(444)	(477)	(392)	(288)	(241)	(156)	(125)	(115)	(75)	(39)	(2)	38
NPV CASH FLOW, 6%	R million	(195)	(437)	(478)	(370)	(288)	(244)	(162)	(164)	(127)	(81)	(57)	(25)	3
NPV CASH FLOW, 7%	R million	(193)	(431)	(483)	(374)	(288)	(246)	(167)	(172)	(138)	(105)	(75)	(46)	(21)
NPV CASH FLOW, 8%	R million	(191)	(425)	(486)	(371)	(289)	(249)	(172)	(188)	(146)	(119)	(81)	(65)	(42)
NPV CASH FLOW, 9%	R million	(189)	(419)	(489)	(367)	(290)	(251)	(176)	(188)	(157)	(138)	(105)	(87)	(58)
NPV CASH FLOW, 10%	R million	(187)	(413)	(492)	(363)	(290)	(253)	(178)	(192)	(165)	(141)	(118)	(98)	(66)
NPV CAPEX, 0%	R million	(286)	(473)	(518)	(482)	(282)	(219)	(150)	(95)	(32)	31	86	181	228
IRR CASH FLOW, %	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	(2.92)	1.22	3.31	4.93	6.11

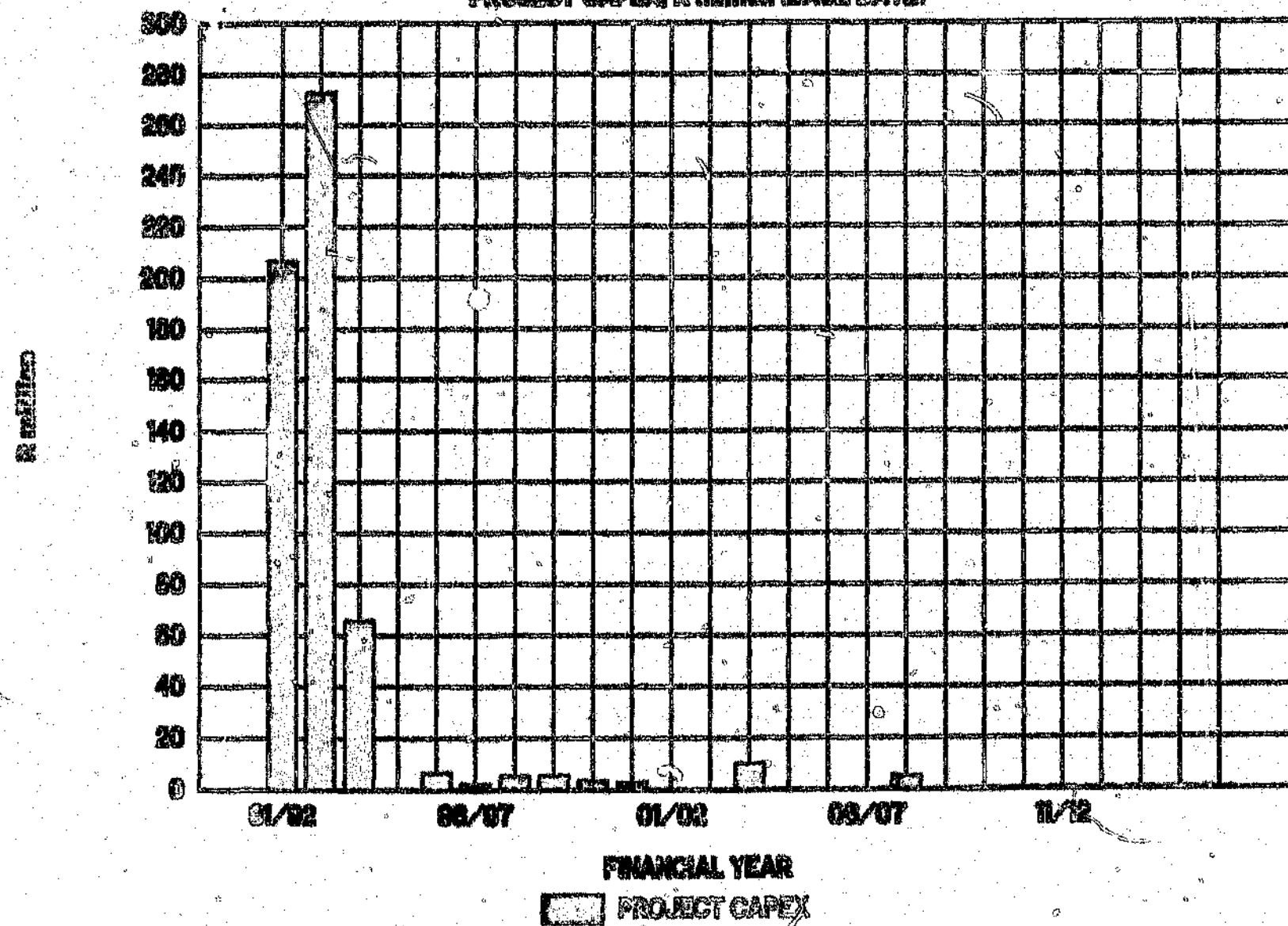
91-87-23

ANALYSIS RESULTS

HARTLEY, W1	FINANCIAL YEARS	04/00	05/00	06/00	07/00	08/00	09/00	10/00	11/00	12/00	13/00	14/00	15/00
ESCALATED	R. million												
REVENUE		1 148	1 263	1 398	1 529	1 681	1 859	2 035	2 238	2 462	2 708	2 979	3 277
TOTAL WORKING COST		641	785	875	953	1 038	1 132	1 135	1 240	1 373	1 519	1 681	1 827
WORKING PROFIT		508	509	523	576	643	727	900	998	1 089	1 189	1 298	1 450
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		2	2	2	2	2	2	2	2	2	2	2	2
ONGOING CAPEX		14	16	17	19	21	23	25	28	31	34	37	41
TOTAL CAPEX		16	18	19	21	23	25	27	30	33	36	39	43
LEASE PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0
ROYALTY PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0
TAX PAYABLE		116	272	299	315	361	395	436	479	522	568	630	702
TOTAL GOVERNMENT		240	272	299	315	361	395	436	479	522	568	630	702
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		268	237	224	261	282	332	464	519	567	621	668	748
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		65	65	65	62	68	65	65	65	65	65	65	65
ESCALATED CUMULATIVE CASH FLOW	R. million	1 208	1 561	1 850	2 175	2 536	2 922	3 380	3 847	4 374	4 954	5 592	6 294
BASE DATE CUMULATIVE CASH FLOW	R. million	285	350	414	477	541	606	671	735	800	864	929	993
BASE DATE REVENUE PER t MILLED	R/t	150.75	150.75	150.75	150.75	150.75	150.75	150.75	150.75	150.75	150.75	150.75	150.75
BASE DATE REVENUE PER oz Pt	R/oz Pt	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844	2 844
BASE DATE TOTAL COSTS PER t MILLED	R/t	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94	85.94
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622	1 622
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	87.11	87.11	87.11	87.11	87.11	87.11	87.11	87.11	87.11	87.11	87.11	87.11
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644	1 644
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)	(1.16)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)	(22)
BASE DATE WORKING PROFIT PER t MILLED	R/t	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80	64.80
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223	1 223
CASH MARGIN, PROFIT/REVENUE		42.99	42.99	42.99	42.99	42.99	42.99	42.99	42.99	42.99	42.99	42.99	42.99
HERENSKY CUT-OFF HEAD GRADE	g PM/t	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782
102 CUT-OFF HEAD GRADE	g PM/t	8 888	8 888	8 888	8 888	8 888	8 888	8 888	8 888	8 888	8 888	8 888	8 888
TOTAL CUT-OFF HEAD GRADE	g PM/t	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782	2 782
NPV CASH FLOW, 0%	R. million	285	350	414	477	541	606	671	735	800	864	929	993
NPV CASH FLOW, 1%	R. million	279	341	403	465	527	590	653	715	778	840	902	964
NPV CASH FLOW, 2%	R. million	273	333	395	456	517	579	641	702	764	825	887	948
NPV CASH FLOW, 3%	R. million	268	326	387	447	507	567	627	687	747	807	867	927
NPV CASH FLOW, 4%	R. million	263	320	380	439	498	557	616	675	734	793	852	911
NPV CASH FLOW, 5%	R. million	258	314	373	432	491	550	608	667	725	784	842	901
NPV CASH FLOW, 6%	R. million	253	308	367	425	483	541	599	657	715	773	831	889
NPV CASH FLOW, 7%	R. million	248	302	360	418	476	533	591	648	705	762	819	876
NPV CASH FLOW, 8%	R. million	243	296	353	410	467	524	581	637	694	750	807	863
NPV CASH FLOW, 9%	R. million	238	290	346	403	459	515	571	627	683	738	794	849
NPV CASH FLOW, 10%	R. million	233	284	339	395	450	505	560	615	670	725	780	835
NPV CAPEX, 0%	R. million	503	503	503	503	503	503	503	503	503	503	503	503
IRR CASH FLOW, %		7.14	7.14	8.64	9.19	9.64	10.02	10.34	10.62	10.85	11.04	11.21	11.36

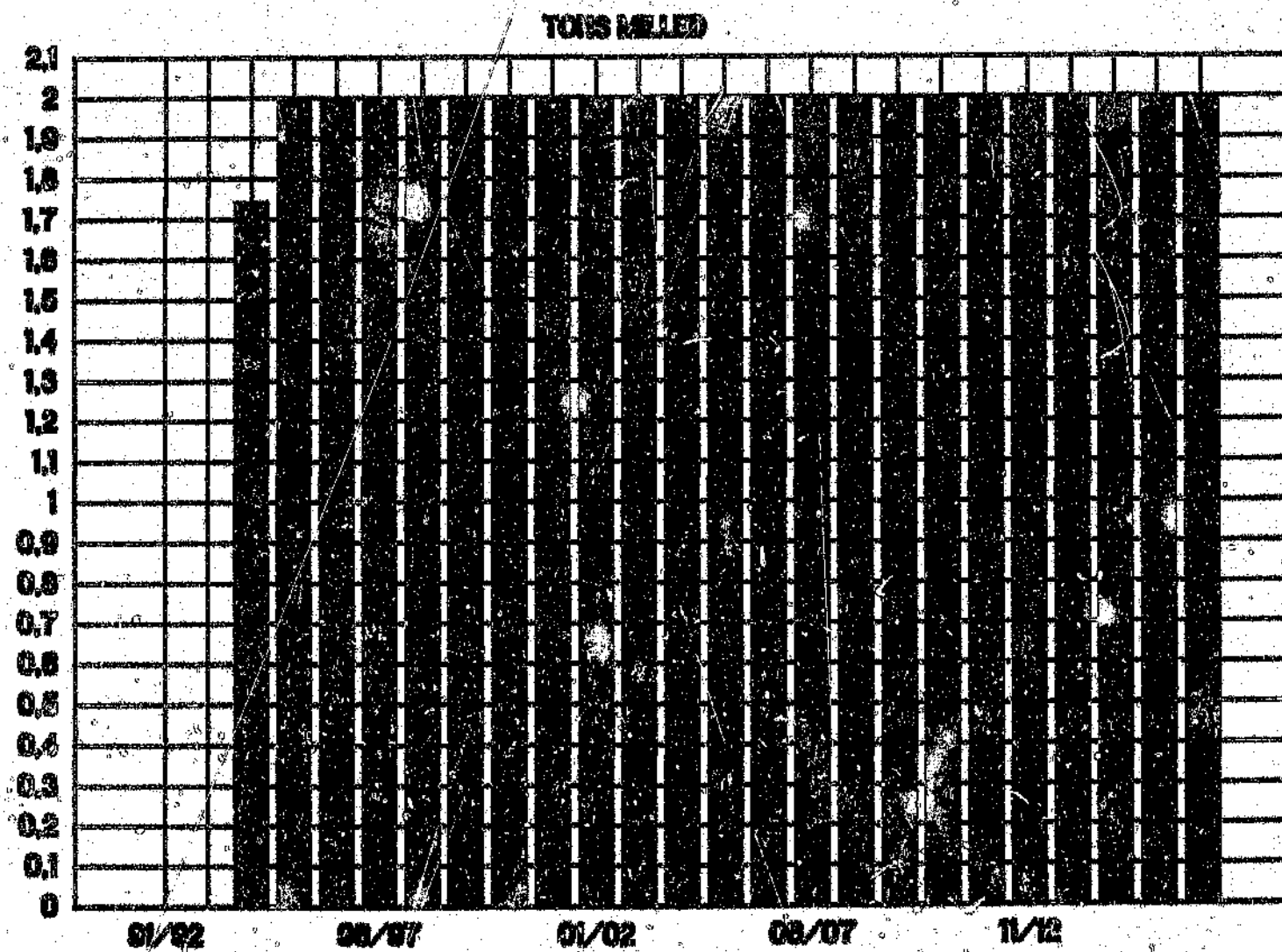
HARTLEY EVALUATION, JULY 1991

PROJECT CAPEX, R million (BASE DATE)



HARTLEY EVALUATION, JULY 1991

TONS MILLED
(MILLIONS)



FINANCIAL YEAR



MERENSKY

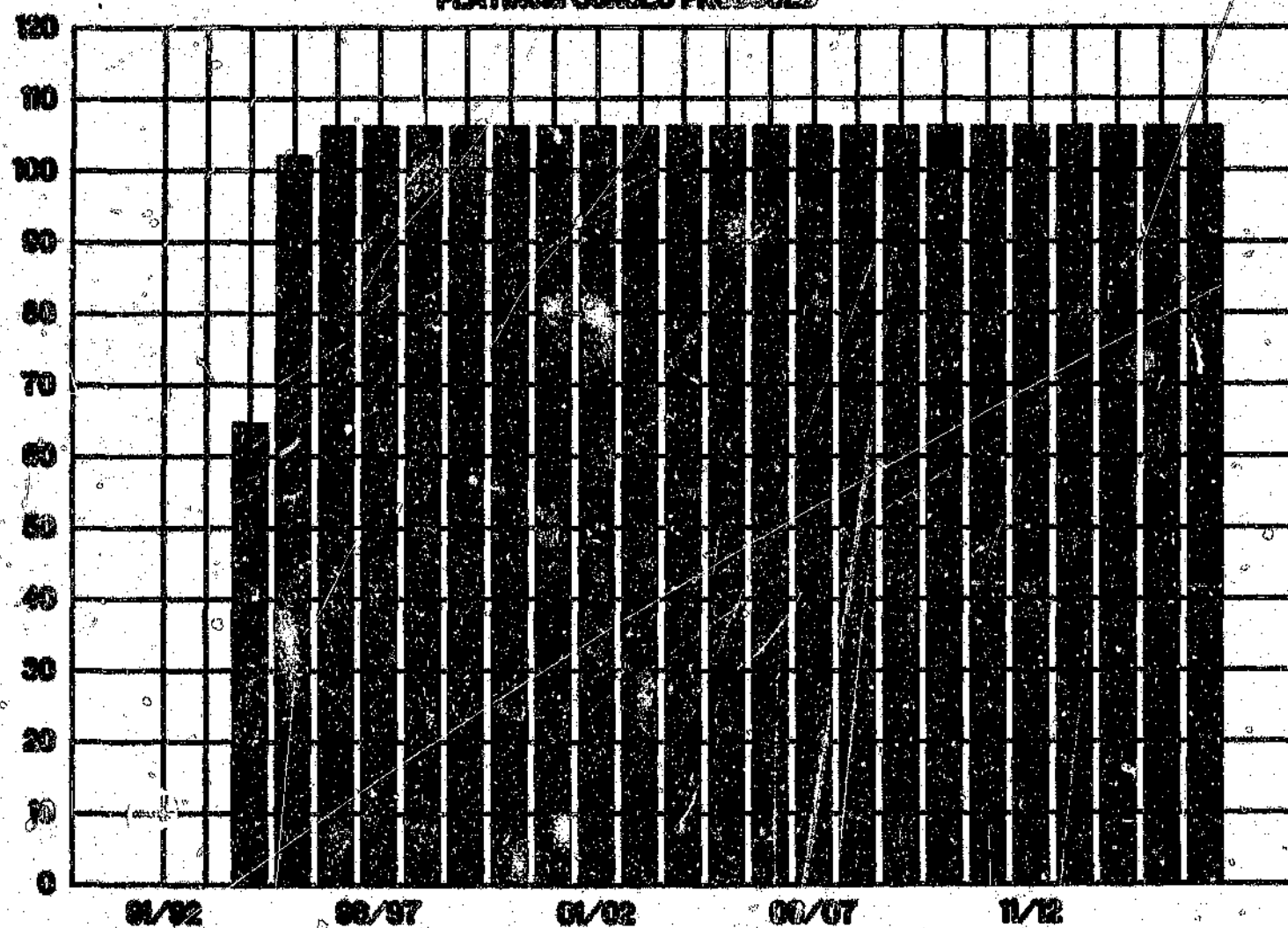


UG2

HARTLEY EVALUATION, JULY 1991

PLATINUM OUNCES PRODUCED

oz Pt
(Thousands)

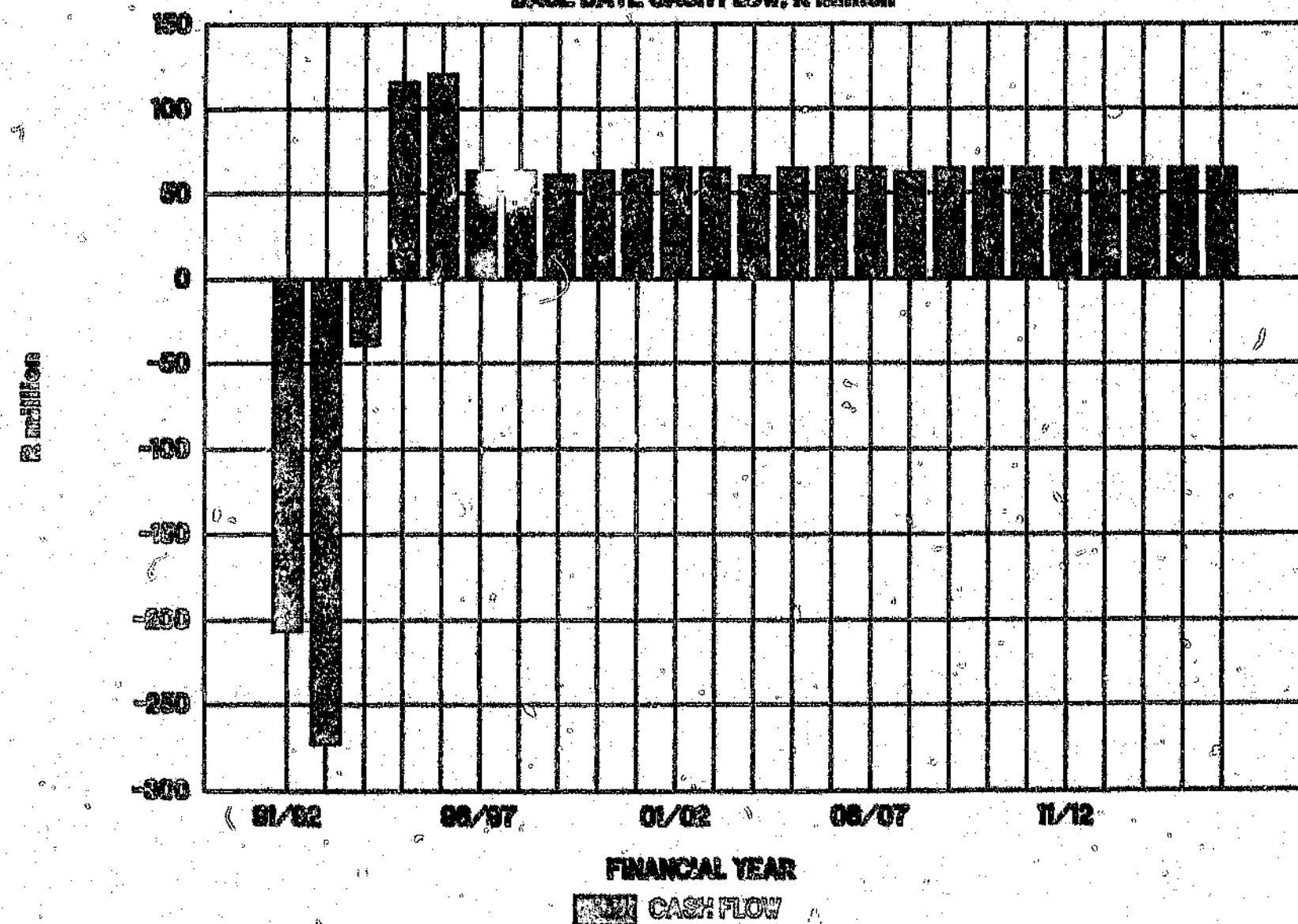


FINANCIAL YEAR

PLATINUM PRODUCED

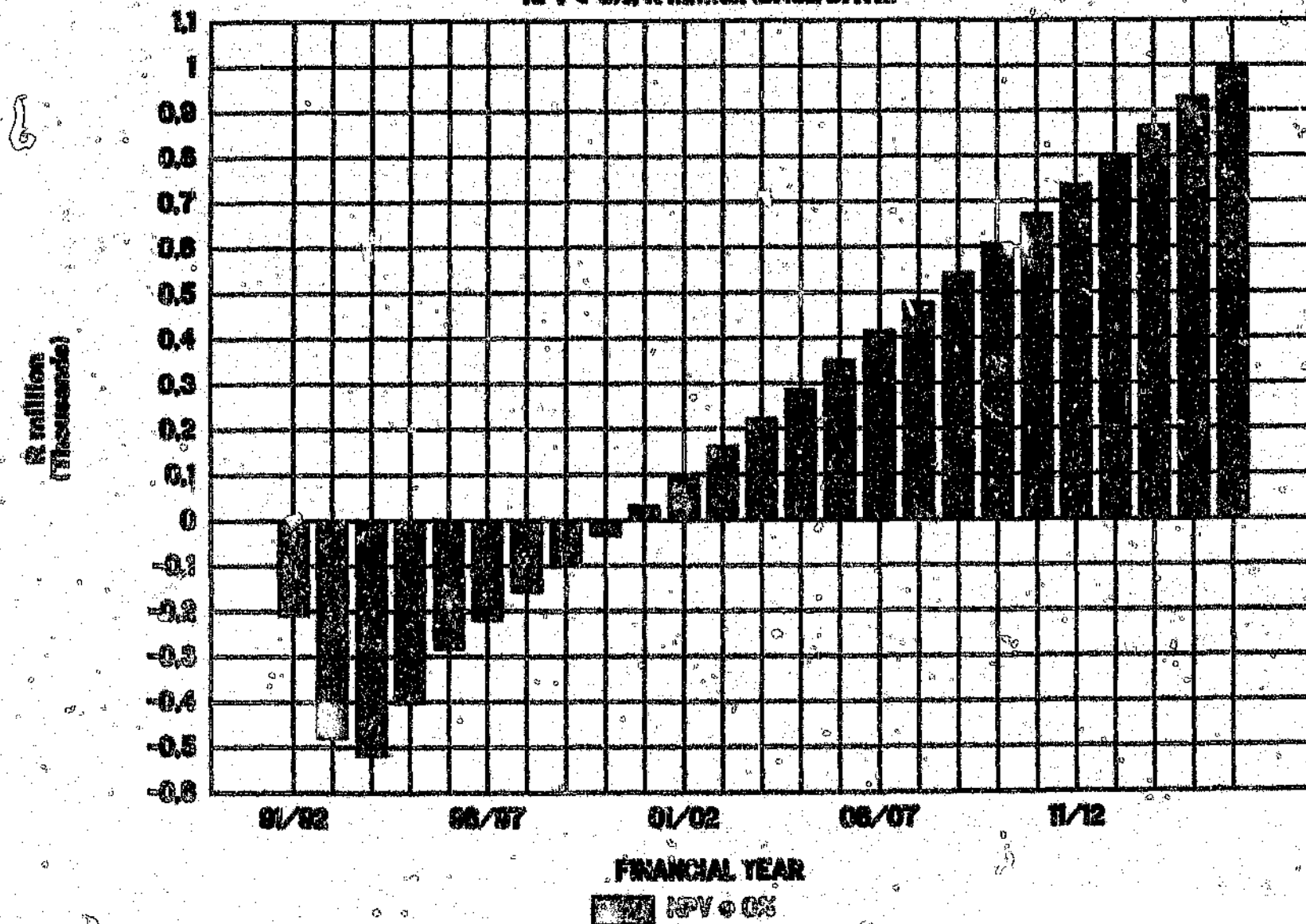
HARTLEY EVALUATION, JULY 1991

BASE DATE CASH FLOW, R million



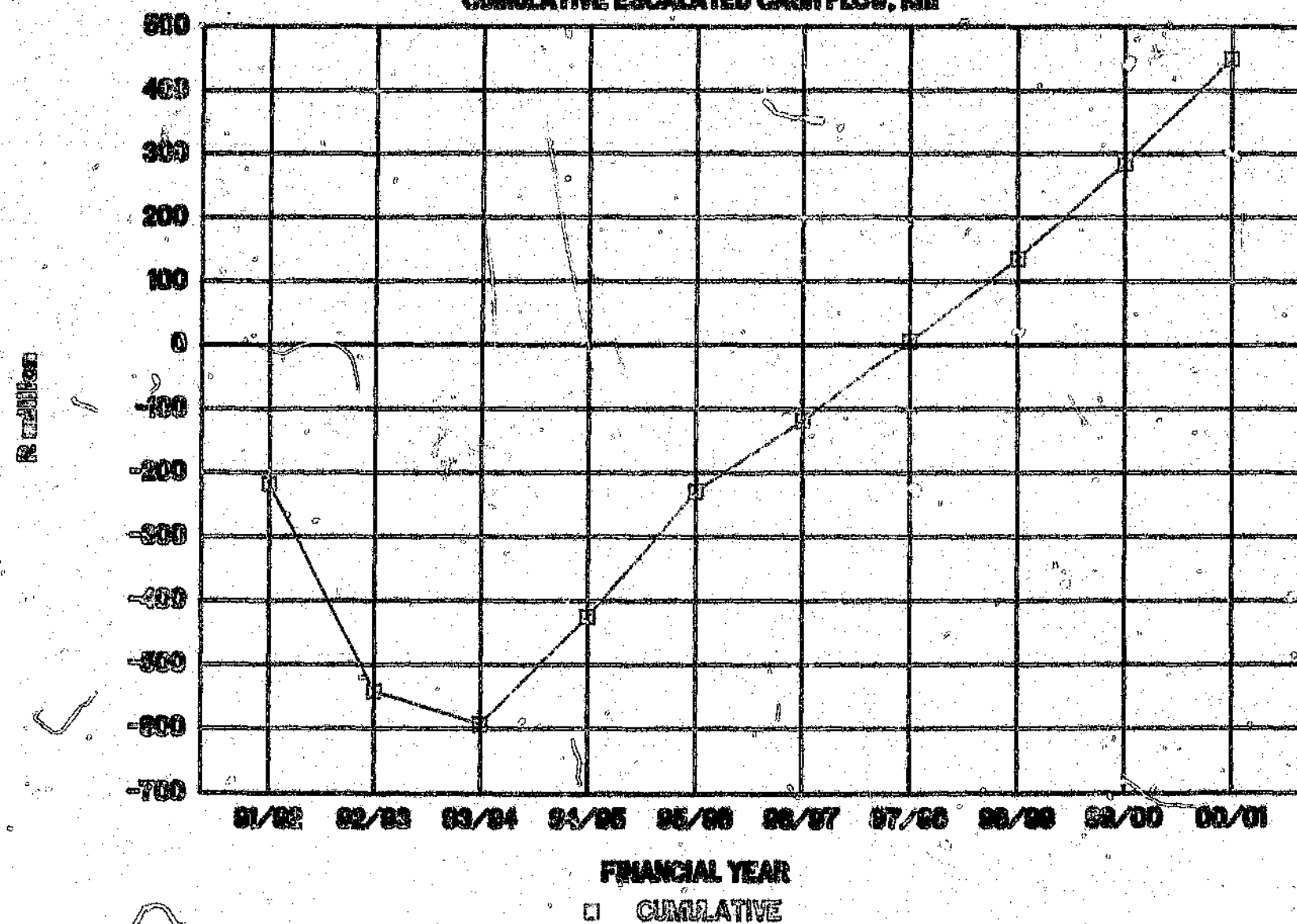
HARTLEY EVALUATION, JULY 1991

NPV @ 0%, R million (BASE DATE)



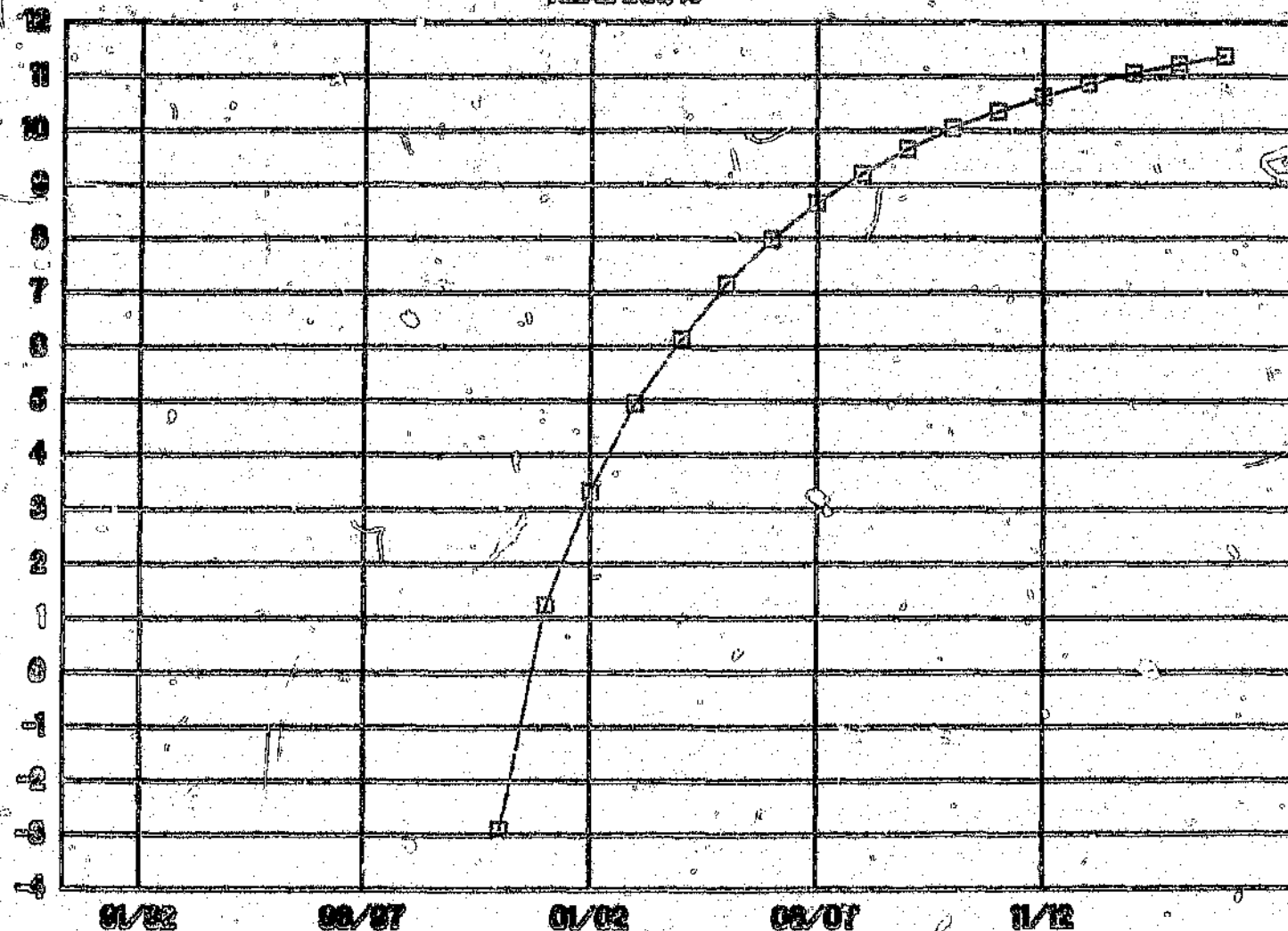
HARTLEY EVALUATION, JULY 1991

CUMULATIVE ESCALATED CASH FLOW, Rm



HARTLEY EVALUATION, JULY 1991

REAL IRR %



FINANCIAL YEAR

□ REAL IRR

91-07-27

SENSITIVITIES

Company: HARTLEY EVALUATION, JUNE 1981

SENSITIVITIES ON NETT TOTAL COSTS PER t, R/t

	-5%	BASE	5%
*METAL PRICES	3.47	(8.00)	(5.00)
*WORK COSTS	(5.01)	(0.00)	2.40
*CAPEX	(0.90)	(0.00)	(0.71)
*REC GRADES	3.47	(0.00)	(0.00)
*MILLED TONS	(0.00)	(0.00)	(0.00)
*SACPI	(0.00)	(0.00)	(0.00)
*USCPI	(0.00)	(0.00)	(0.00)
*R/US\$	3.47	(0.00)	(0.00)
*R/E	(0.00)	(0.00)	(0.00)
*LEASE	(0.00)	(0.00)	(0.00)
*ROYALTY	(0.00)	(0.00)	(0.00)
*TAX RATE	(0.00)	(0.00)	(0.00)

*WORST CASE 15.00
 *BEST CASE (10.50)

SENSITIVITIES ON NPV @ 8%, \$ million

	-20%	BASE	20%
*METAL PRICES	207	809	1 717
*WORK COSTS	1 426	993	607
*CAPEX	1 107	993	500
*REC GRADES	207	993	1 717
*MILLED TONS	711	993	1 006
*SACPI	1 176	993	700
*USCPI	1 119	993	609
*R/US\$	755	993	1 251
*R/E	670	993	1 017
*LEASE	993	993	993
*ROYALTY	993	993	993
*TAX RATE	1 240	993	730
*TIMING	1 010	993	993

*WORST CASE (1 403)
 *BEST CASE 9 531

SENSITIVITIES ON IT TOTAL COSTS PER oz Pt, R/oz Pt

	-5%	BASE	5%
*METAL PRICES	65	(15)	(95)
*WORK COSTS	(94)	(15)	64
*CAPEX	(17)	(15)	(13)
*REC GRADES	65	(15)	(91)
*MILLED TONS	(15)	(15)	(19)
*SACPI	(15)	(15)	(15)
*USCPI	(15)	(15)	(15)
*R/US\$	65	(15)	(90)
*R/E	(15)	(15)	(15)
*LEASE	(15)	(15)	(15)
*ROYALTY	(15)	(15)	(15)
*TAX RATE	(15)	(15)	(15)

*WORST CASE 311
 *BEST CASE (394)

SENSITIVITIES ON IRR, % REAL

	-20%	BASE	20%
*METAL PRICES	3.00	11.30	19.05
*WORK COSTS	15.70	11.30	7.81
*CAPEX	14.95	11.30	9.20
*REC GRADES	3.00	11.30	10.66
*MILLED TONS	0.77	11.30	14.25
*SACPI	10.54	11.30	12.44
*USCPI	11.19	11.30	11.09
*R/US\$	7.54	11.30	15.54
*R/E	11.11	11.30	11.60
*LEASE	11.30	11.30	11.30
*ROYALTY	11.30	11.30	11.30
*TAX RATE	19.09	11.30	0.30
*TIMING	11.06	11.30	11.00

*WORST CASE 0.00
 *BEST CASE 0.00

SENSITIVITIES ON CASH MARGIN, %

	-5%	BASE	5%
*METAL PRICES	35.44	39.50	42.41
*WORK COSTS	42.53	39.50	36.67
*CAPEX	35.44	39.50	30.51
*REC GRADES	35.44	39.50	42.41
*MILLED TONS	35.44	39.50	39.50
*SACPI	35.44	39.50	39.50
*USCPI	35.44	39.50	39.50
*R/US\$	35.44	39.50	42.41
*R/E	35.44	39.50	39.50
*LEASE	35.44	39.50	39.50
*ROYALTY	35.44	39.50	39.50
*TAX RATE	35.44	39.50	39.50

*WORST CASE 26.10
 *BEST CASE 50.70

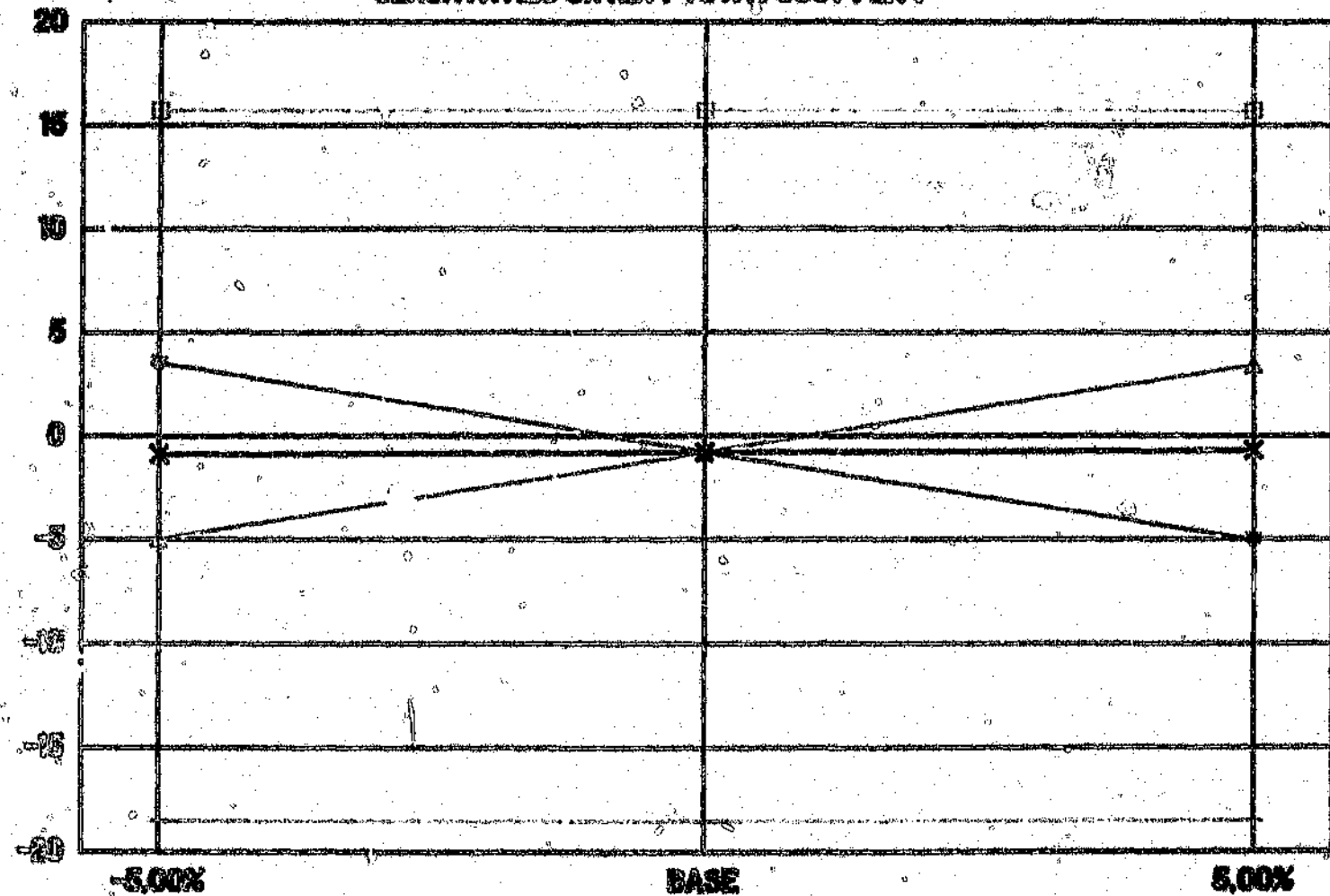
SENSITIVITIES ON MAX EXPOSURE, \$ million

	-20%	BASE	20%
*METAL PRICES	(541)	(595)	(540)
*WORK COSTS	(550)	(595)	(633)
*CAPEX	(489)	(595)	(721)
*REC GRADES	(541)	(595)	(540)
*MILLED TONS	(502)	(595)	(500)
*SACPI	(511)	(595)	(579)
*USCPI	(504)	(595)	(567)
*R/US\$	(543)	(595)	(584)
*R/E	(507)	(595)	(503)
*LEASE	(595)	(595)	(595)
*ROYALTY	(595)	(595)	(595)
*TAX RATE	(595)	(595)	(595)
*TIMING	(466)	(595)	(602)

*WORST CASE 0.00
 *BEST CASE (300)

HARTLEY EVALUATION, JULY 1991

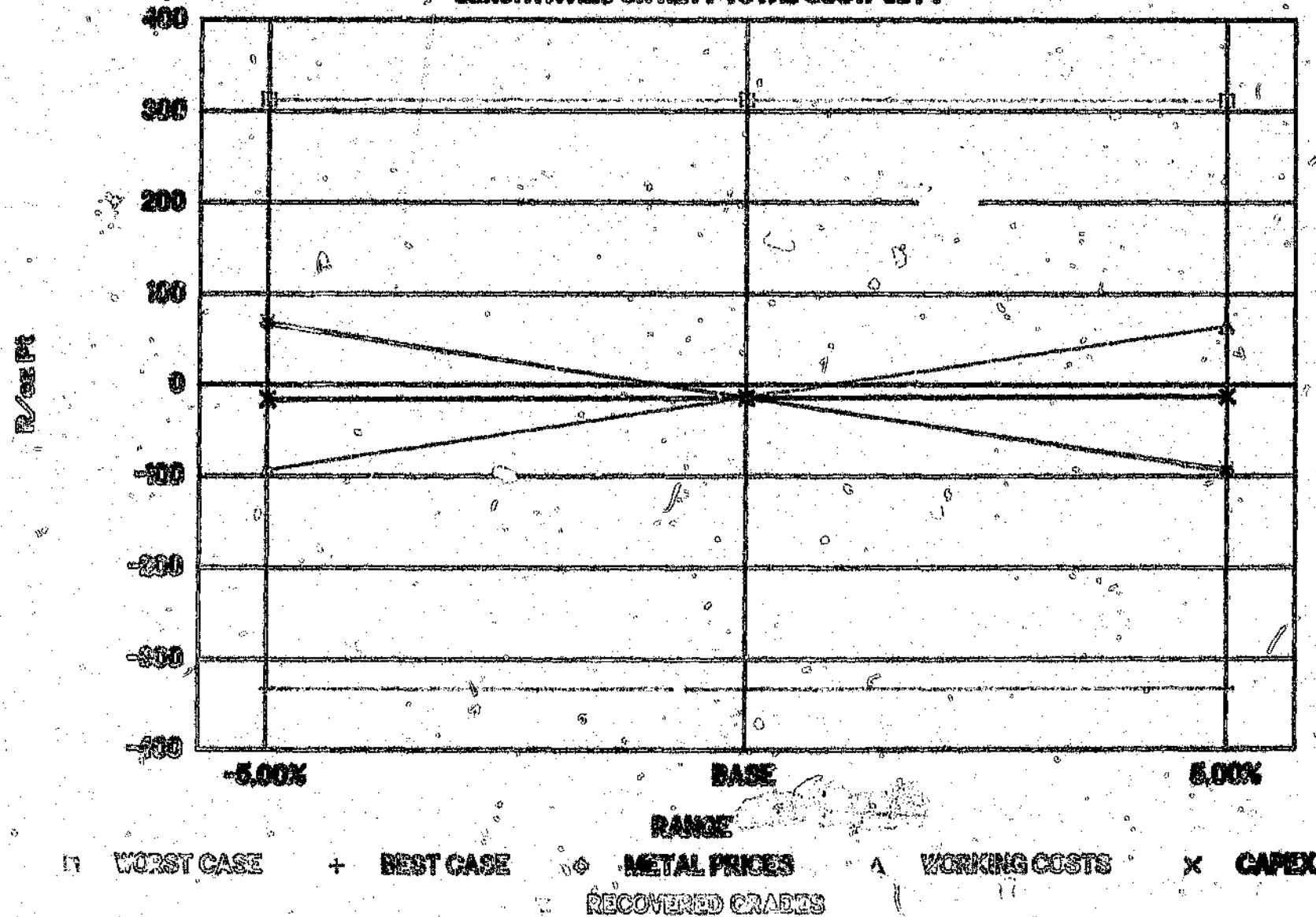
SENSITIVITIES ON NETT TOTAL COST PER t



□ WORST CASE + BEST CASE ◇ METAL PRICES △ WORKING COSTS x CAPEX
 RECOVERED GRADES

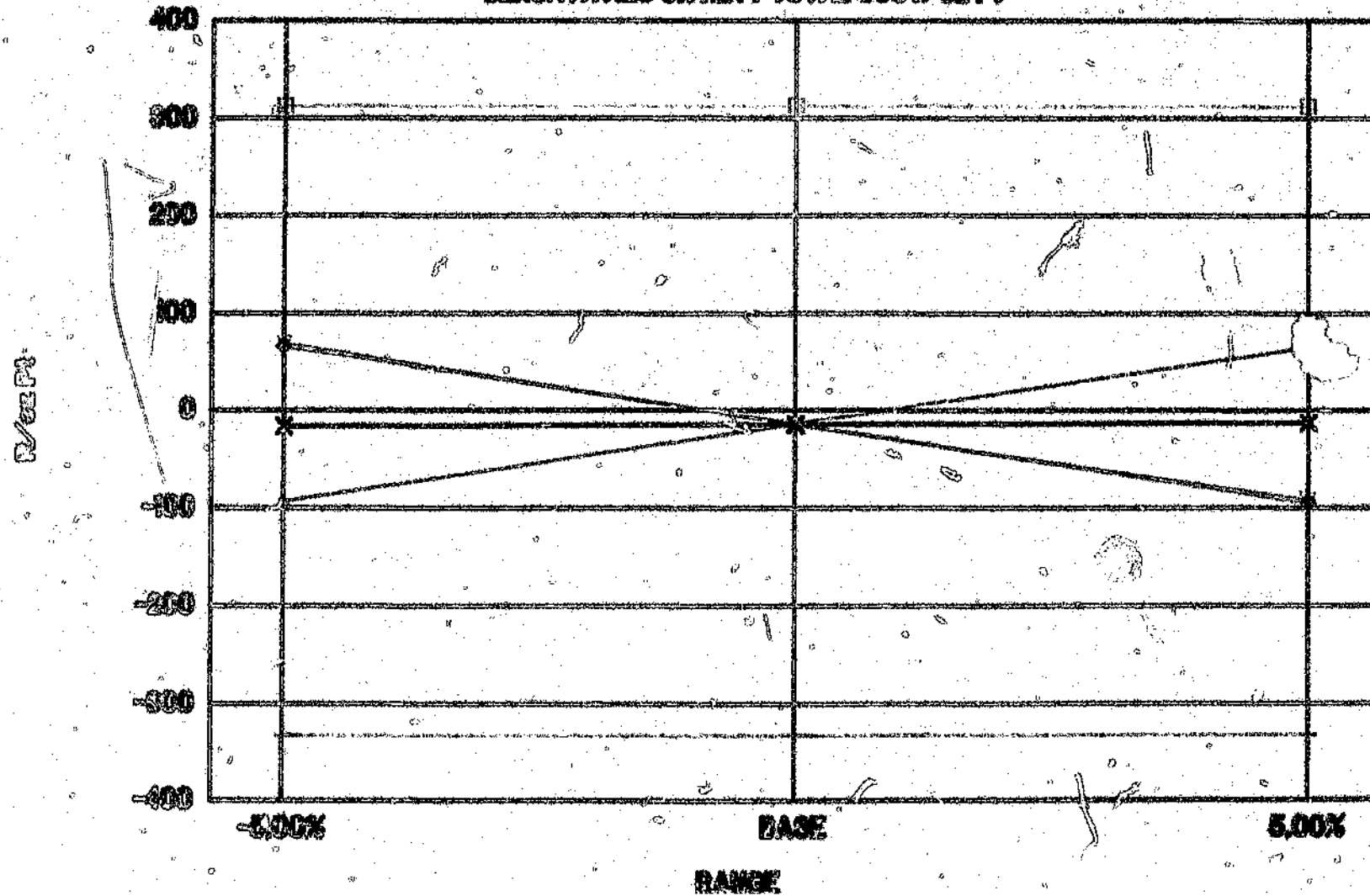
HARTLEY EVALUATION, JUL 1991

SENSITIVITIES ON NETT TOTAL COST/oz Pt



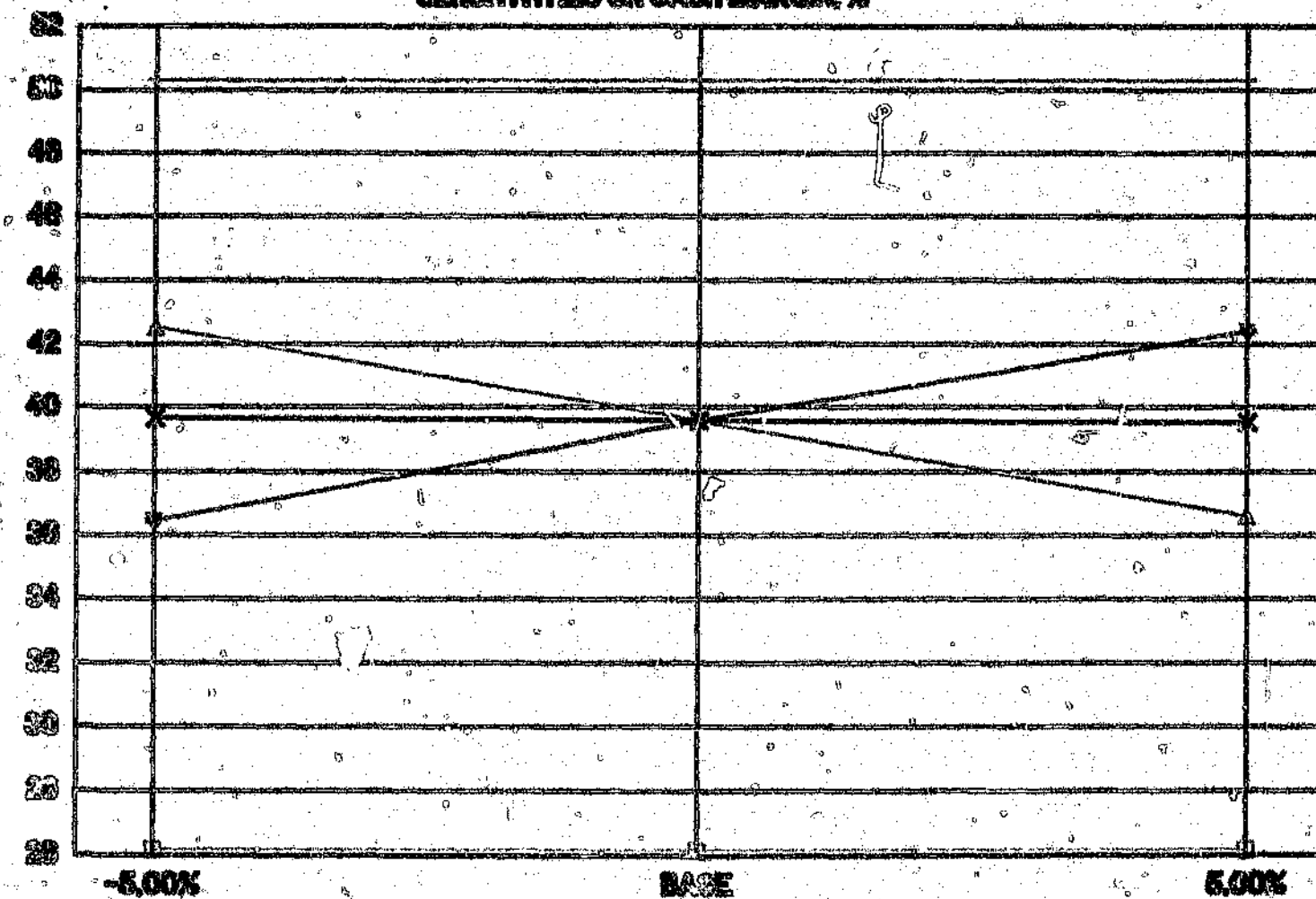
HARTLEY EVALUATION, JULY 1991

SENSITIVITIES ON NETT TOTAL COST/oz Pt



HARTLEY EVALUATION, JULY 1991

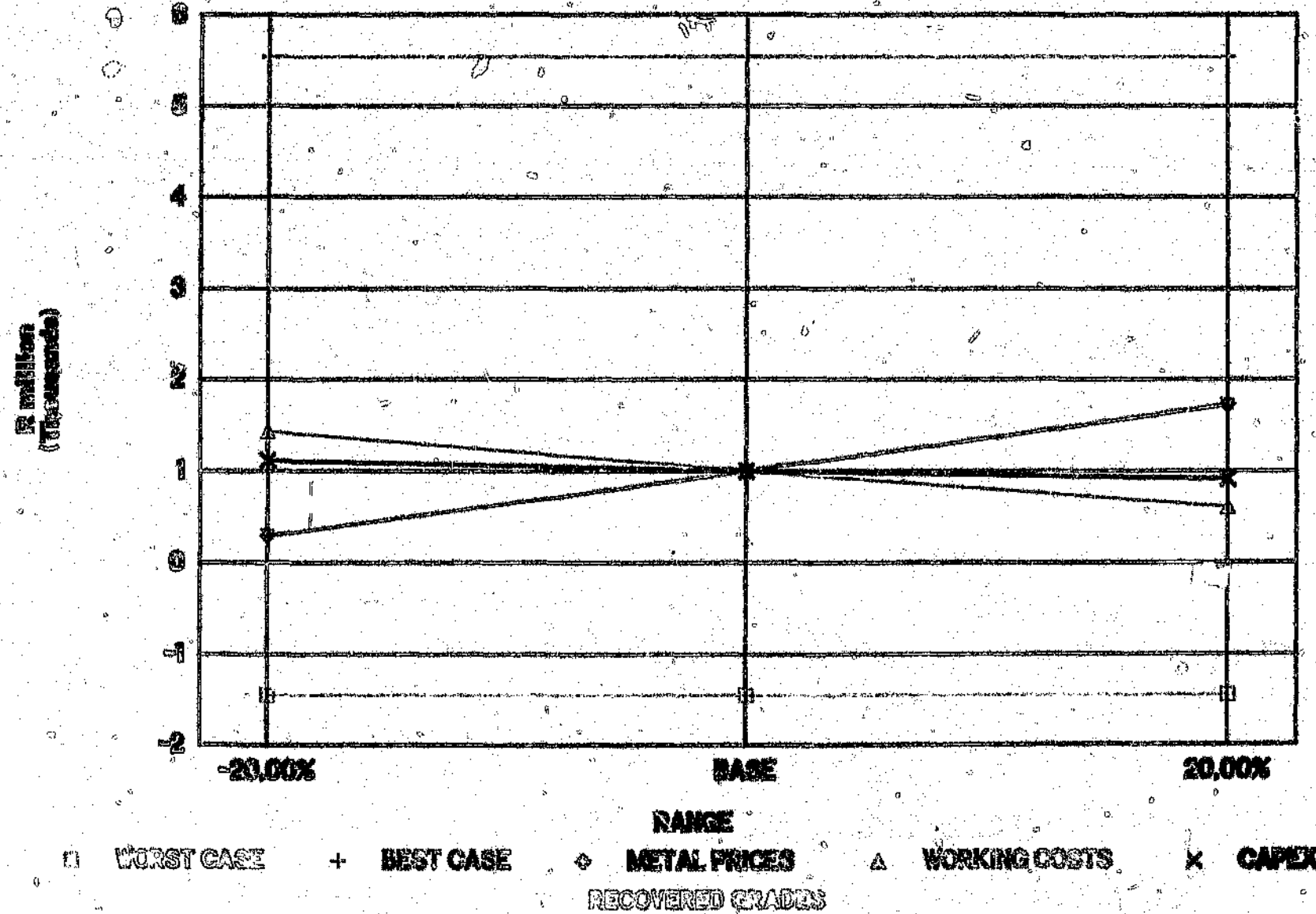
SENSITIVITIES ON CASH MARGIN, %



□ WORST CASE + BEST CASE ♦ METAL PRICES △ WORKING COSTS × CAPEX
 RECOVERED GRADES

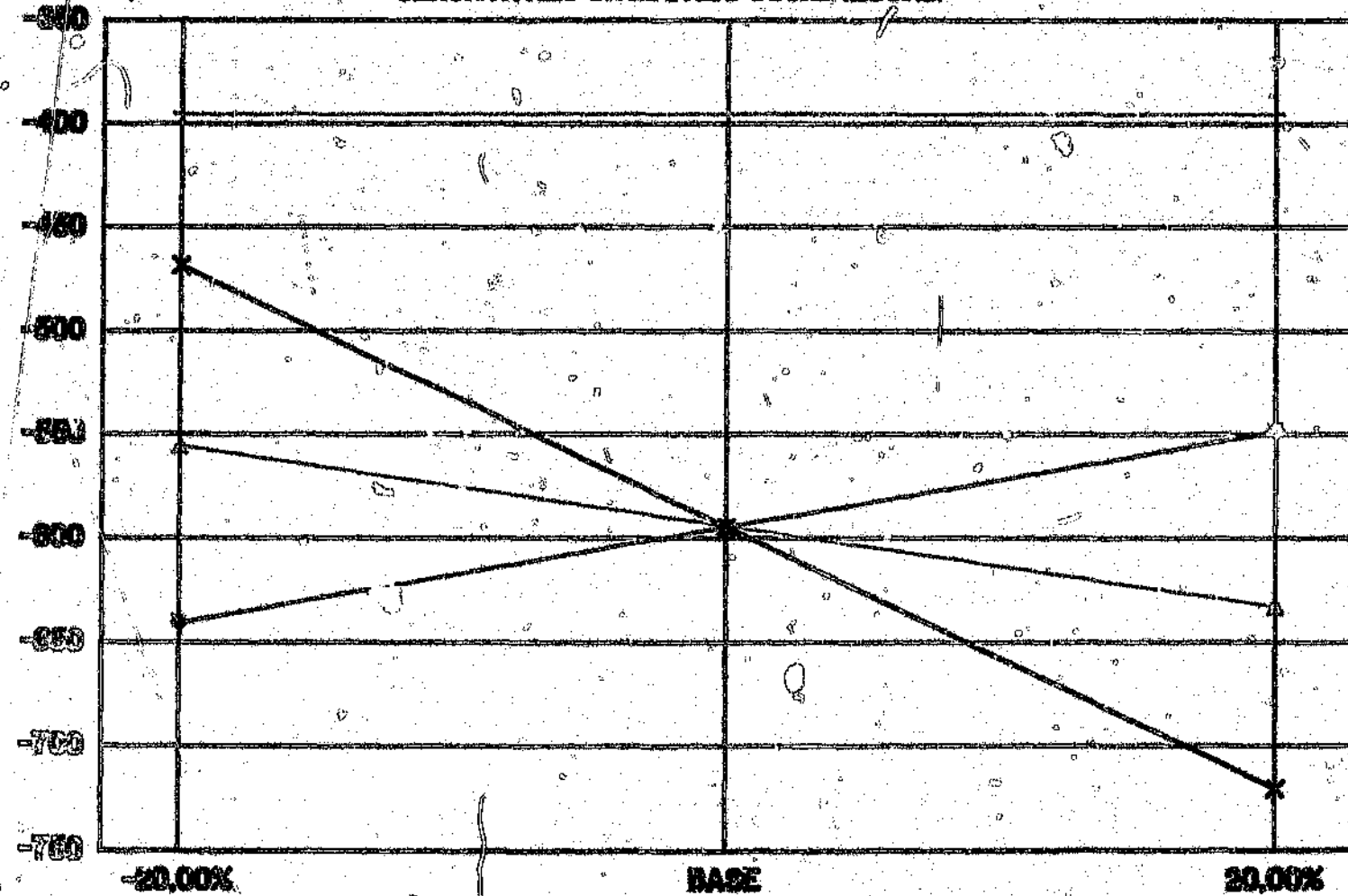
HARTLEY EVALUATION, JULY 1991

SENSITIVITIES ON NPV @ 0% R million



HARTLEY EVALUATION, JULY 1991

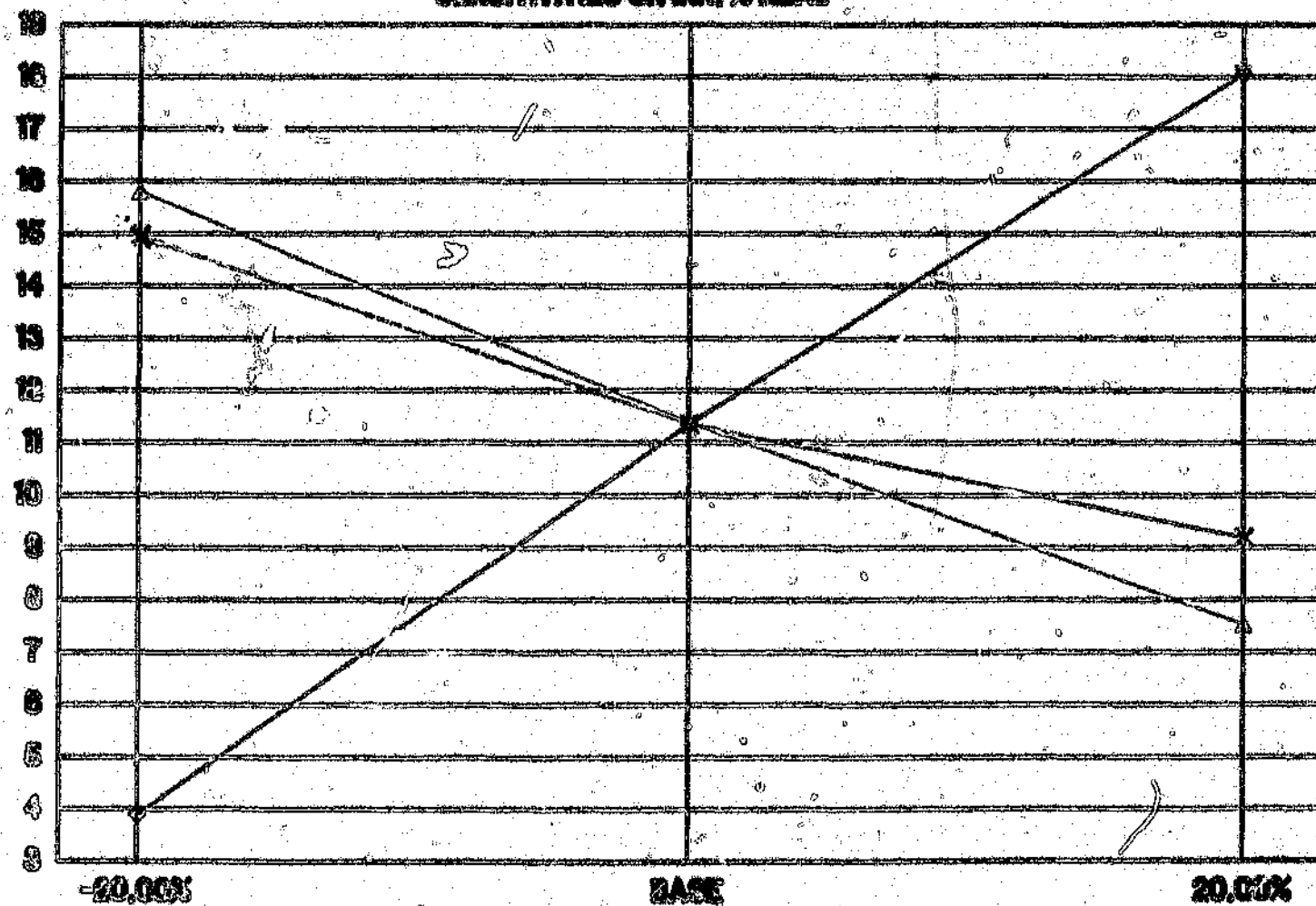
SENSITIVITIES ON MAX EXPOSURE (ESCAL)



□ WORST CASE + BEST CASE ◇ RANGE
 ▼ METAL PRICES △ WORKING COSTS x CAPEX
 RECOVERED GRADES

HARTLEY EVALUATION, JULY 1991

SENSITIVITIES ON IRR, % REAL



■ WORST CASE + BEST CASE ◆ RANGE
 ♦ METAL PRICES ▲ WORKING COSTS × CAPEX
 ▼ RECOVERED GRADES

4.3 RISK ANALYSIS RESULTS

Page 21 also shows the upper and lower potentials for input parameters ("upside" and "downside") in percentage terms assumed for the Hartley Project. The following should be noted :-

- (i) The potential for metal prices to vary from forecast is based on recent variations of metal prices.
- (ii) Working costs appear to be extremely low by South African standards. At R86/ton milled, compared to between R95 and R160/ton milled at South African operations, this is probably a justified concern. For this reason, the upside potential is assumed to be greater than the downside potential⁷.
- (iii) Capex also appears to be low in the Delta evaluation, especially when one considers the relatively high cost of capital goods in Zimbabwe. At R5 575 per annual oz Pt, compared to, say R5 703 per annual oz Pt (in July 1991 terms) for the original underground option at Potgietersrus Platinum (which has now opted for an opencast operation), it is not too low by South African terms, but the concern at high capital costs in Zimbabwe still remains. Again, therefore, the upside potential is assumed to be greater than the downside potential on this item⁷.
- (iv) General economic conditions for Zimbabwe may have a greater potential for being worse than being better than the forecasts shown on page 13. The upsides for SACPI and exchange rates have thus been given greater weighting than their downsides.

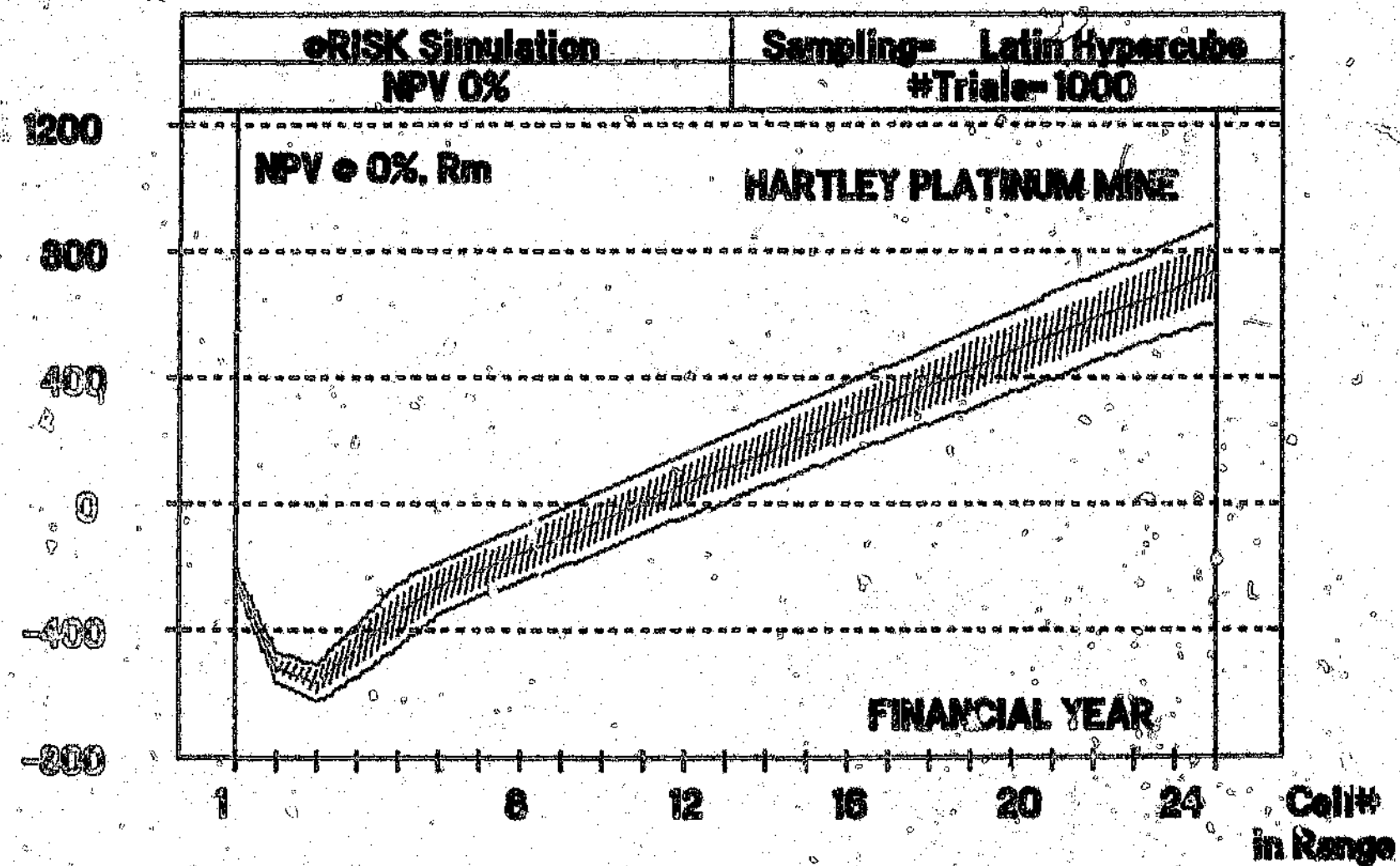
- (v) It is also assumed that tax rates have a greater potential to increase than to decrease because of possible future Zimbabwean government intervention coupled with their possible need to increase fiscal spending on socio-economic programmes. Thus, the political risk of the project in Zimbabwe is addressed.
- (vi) The timing and production build-up phase at Hartley appears to be extremely rapid. For example, Potgietersrus Platinum's original underground option was forecast to reach full production over five to six years, compared to three to four years for Hartley. Potgietersrus Platinum's original underground option is used as a comparison because it was also a shallow operation at a similar production rate. It has thus been assumed that there is a greater potential for a delay in production than there is for an acceleration.

The results of the risk analysis for Hartley are shown graphically on pages 43 to 54. In summary, they are as follows :-

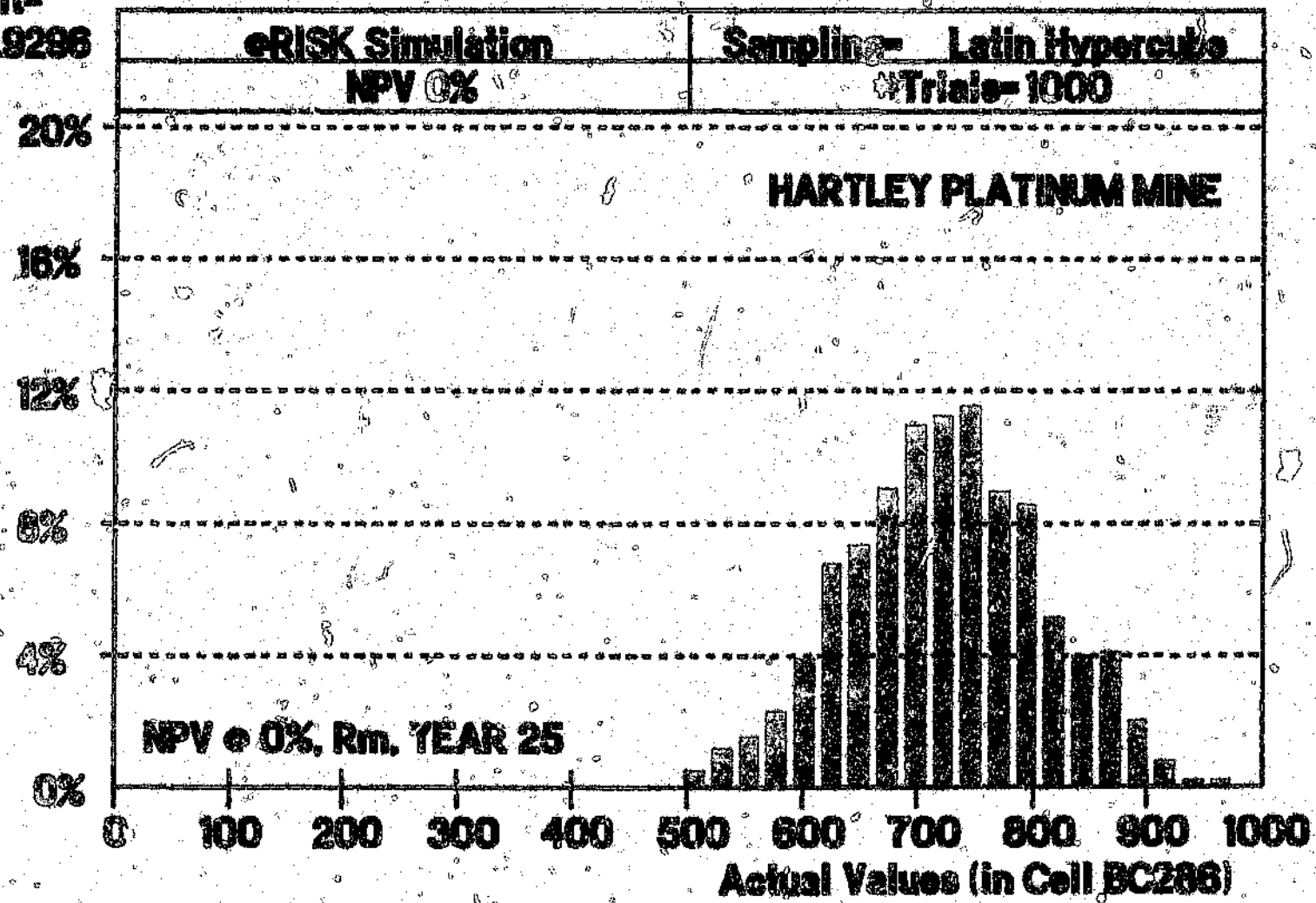
	Expected Result	Standard Deviation
Real IRR, %, 25 years :	8,826	1,010
NPV, R million, 25 years, @ 0% discount :	725,9	84,5
@ 3% discount :	351,8	58,0
@ 5% discount :	191,6	48,0
Maximum Exposure, escalated, R million :	639,8	38,8
Maximum Exposure, base date, R million :	553,8	31,3
Payback Period, years, escalated money :	7,0	0,8
Payback Period, years, base date money :	10,4	1,1

The above expected result for Real IRR after 25 years of 8,83% is 2,53% less than the conventional result of 11,36%. This amount could be considered to be the risk discount rate to be applied over and above a "normal" hurdle rate for an NPV analysis.

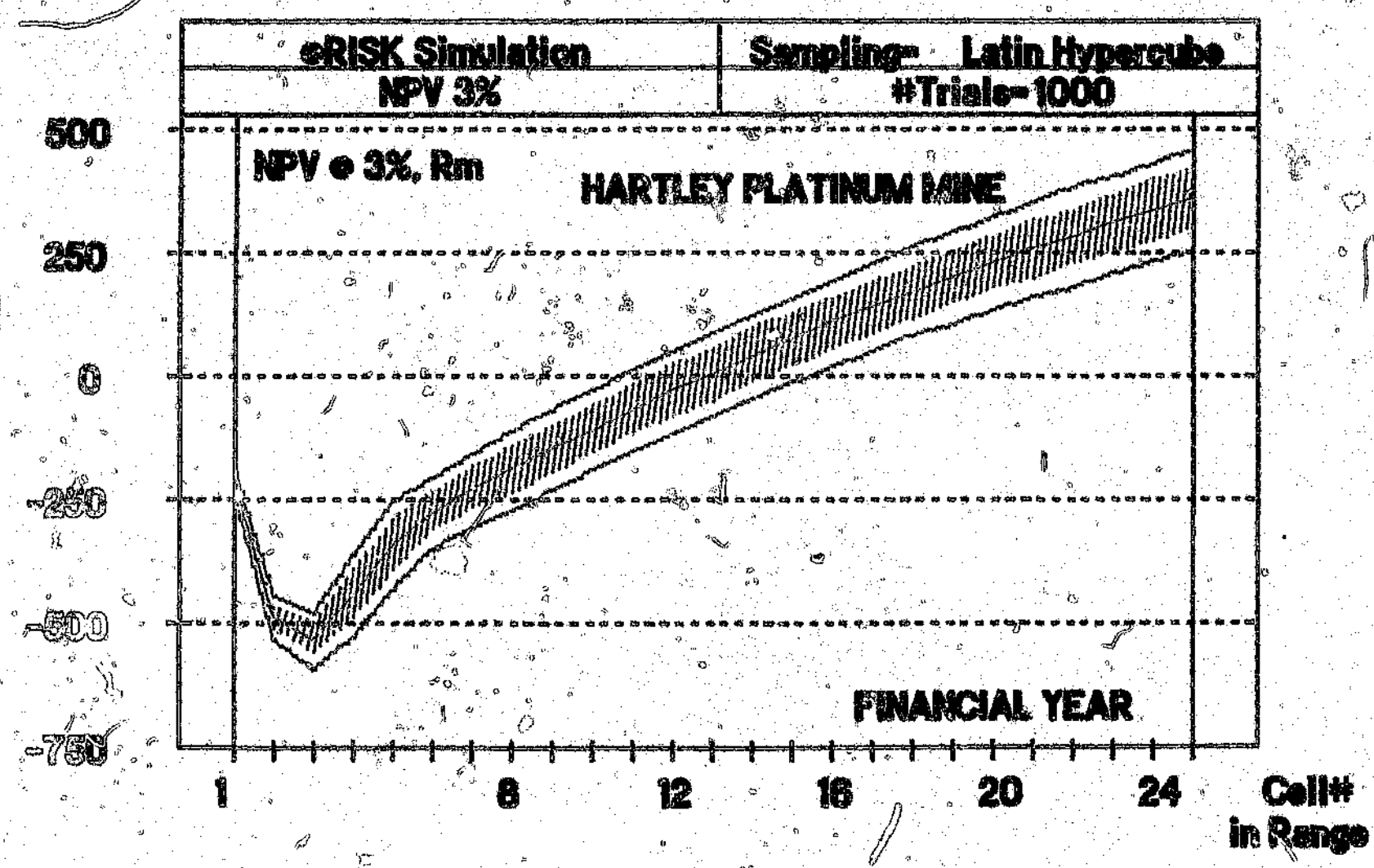
Trend in Mean.
1 Std Dev.
5/95 Perc.



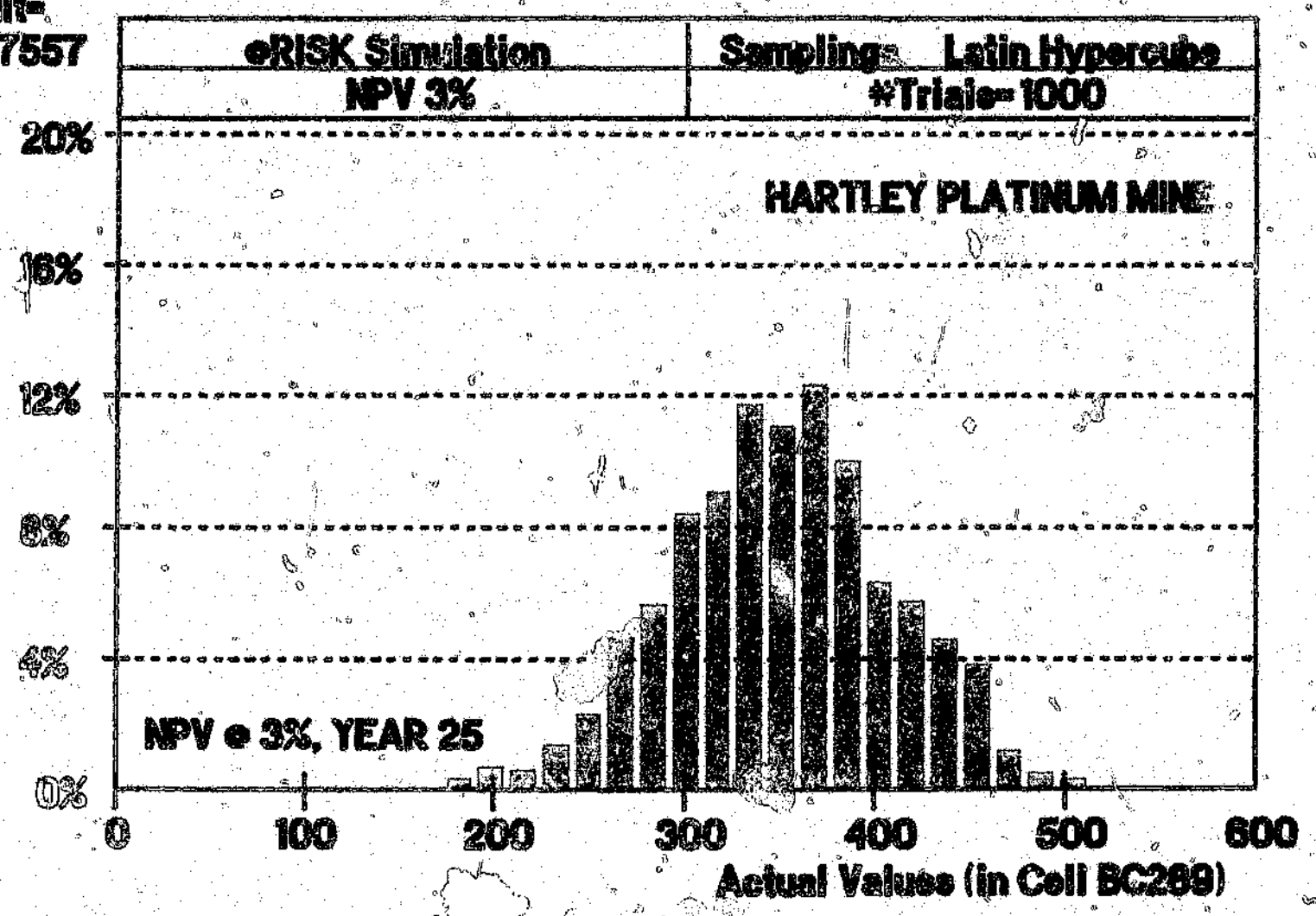
Expected
Result=
725.9296



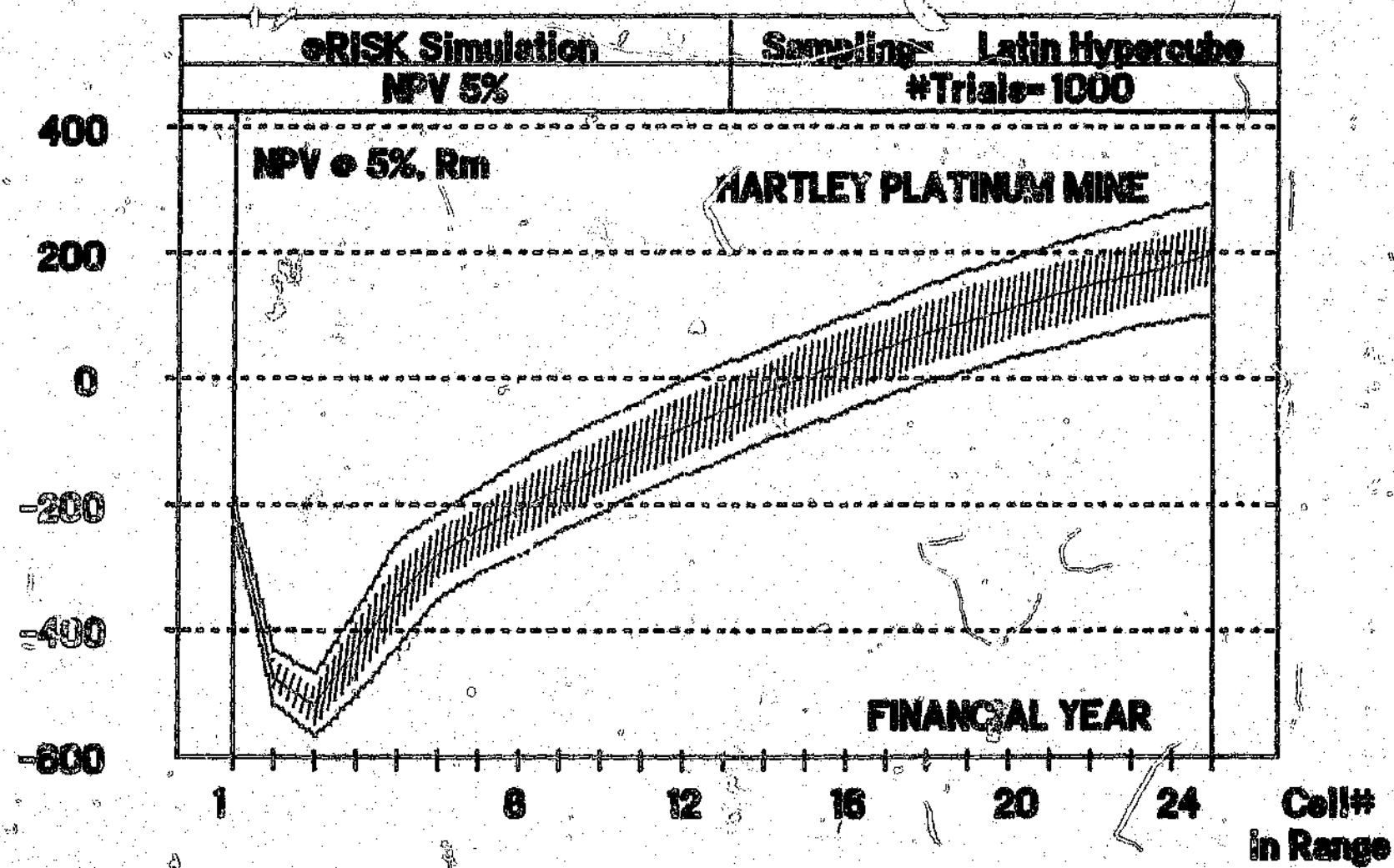
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



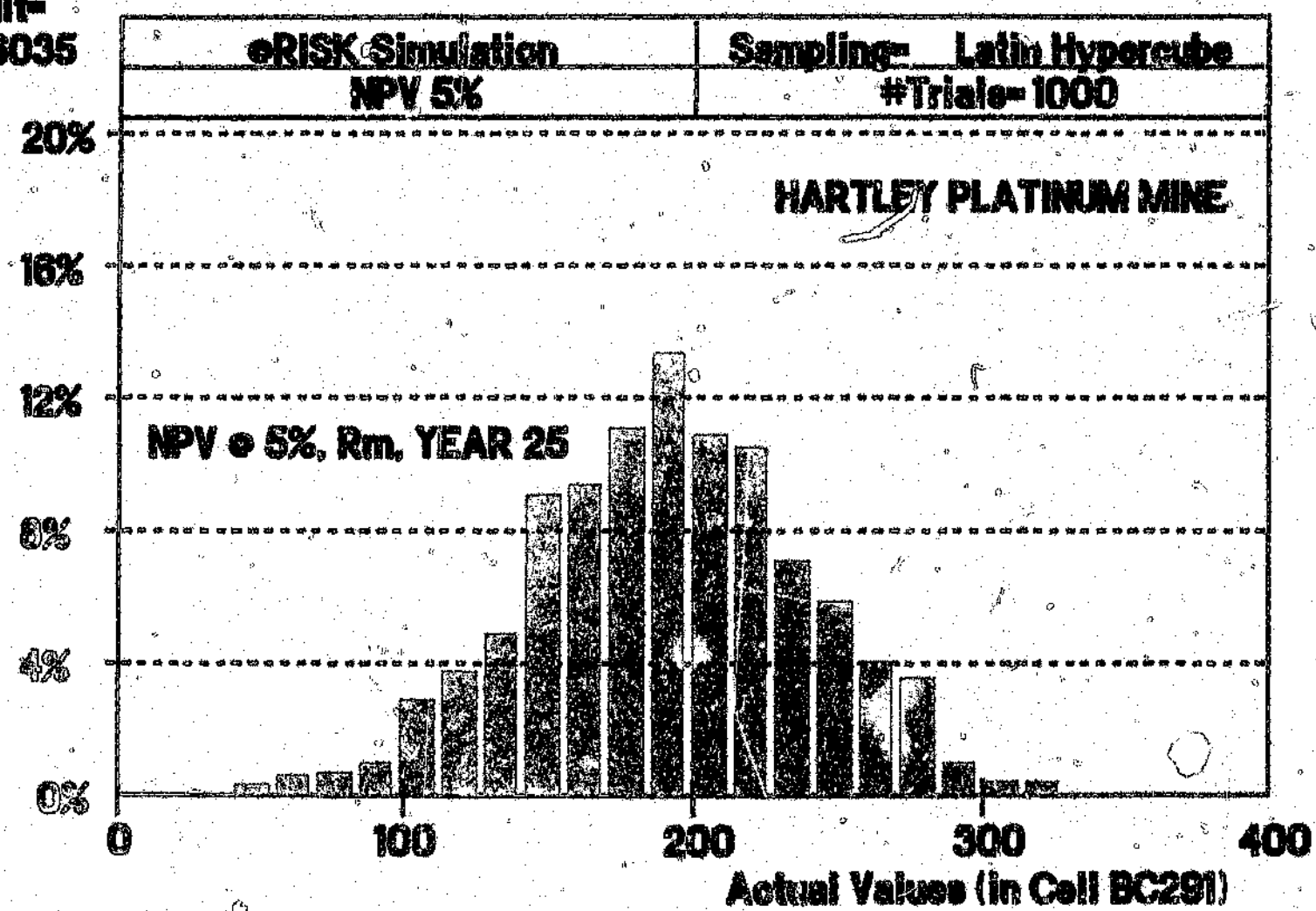
Expected
Result=
351.7557



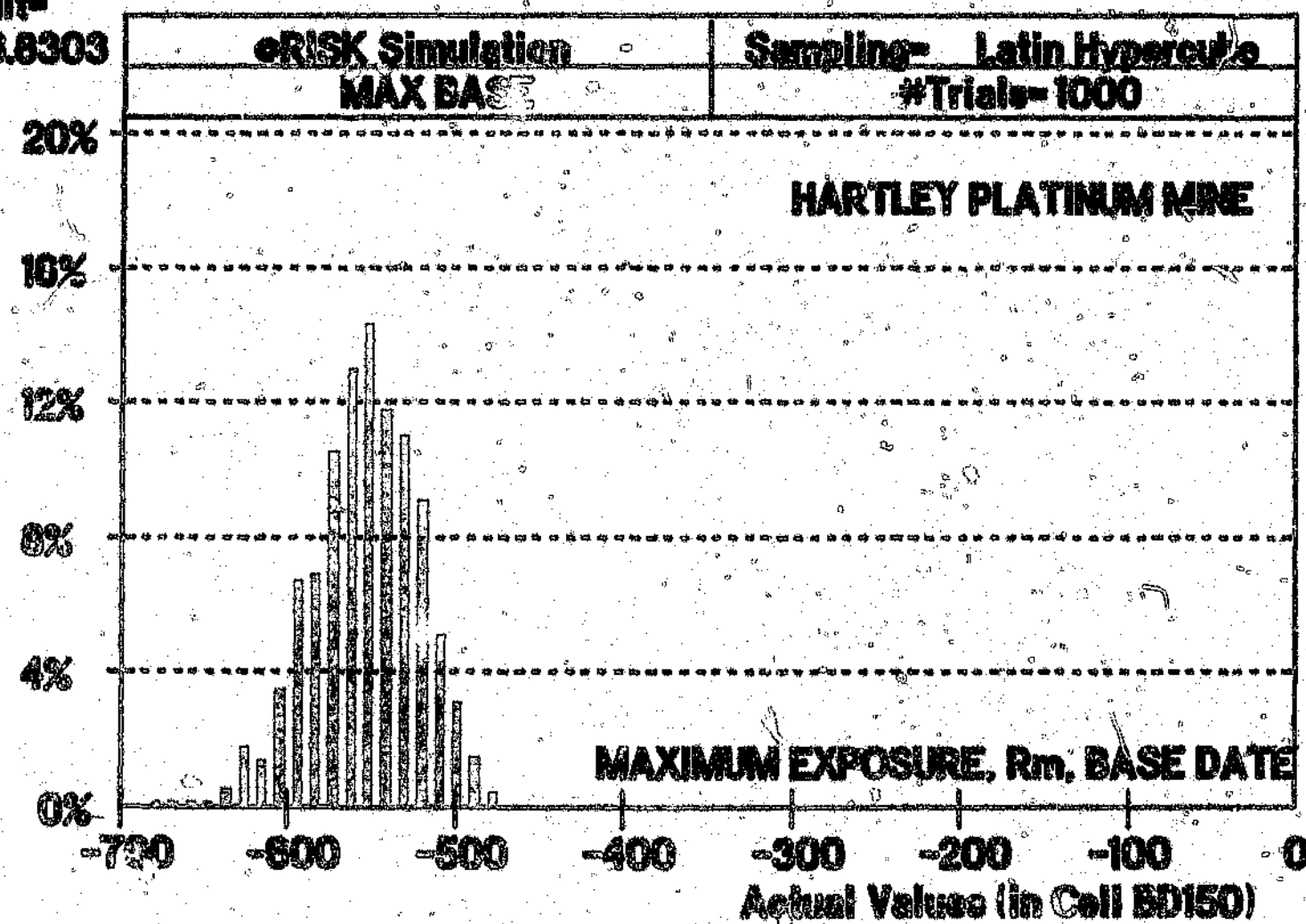
Trend in Mean,
1 StdDev.,
5/95 Perc.



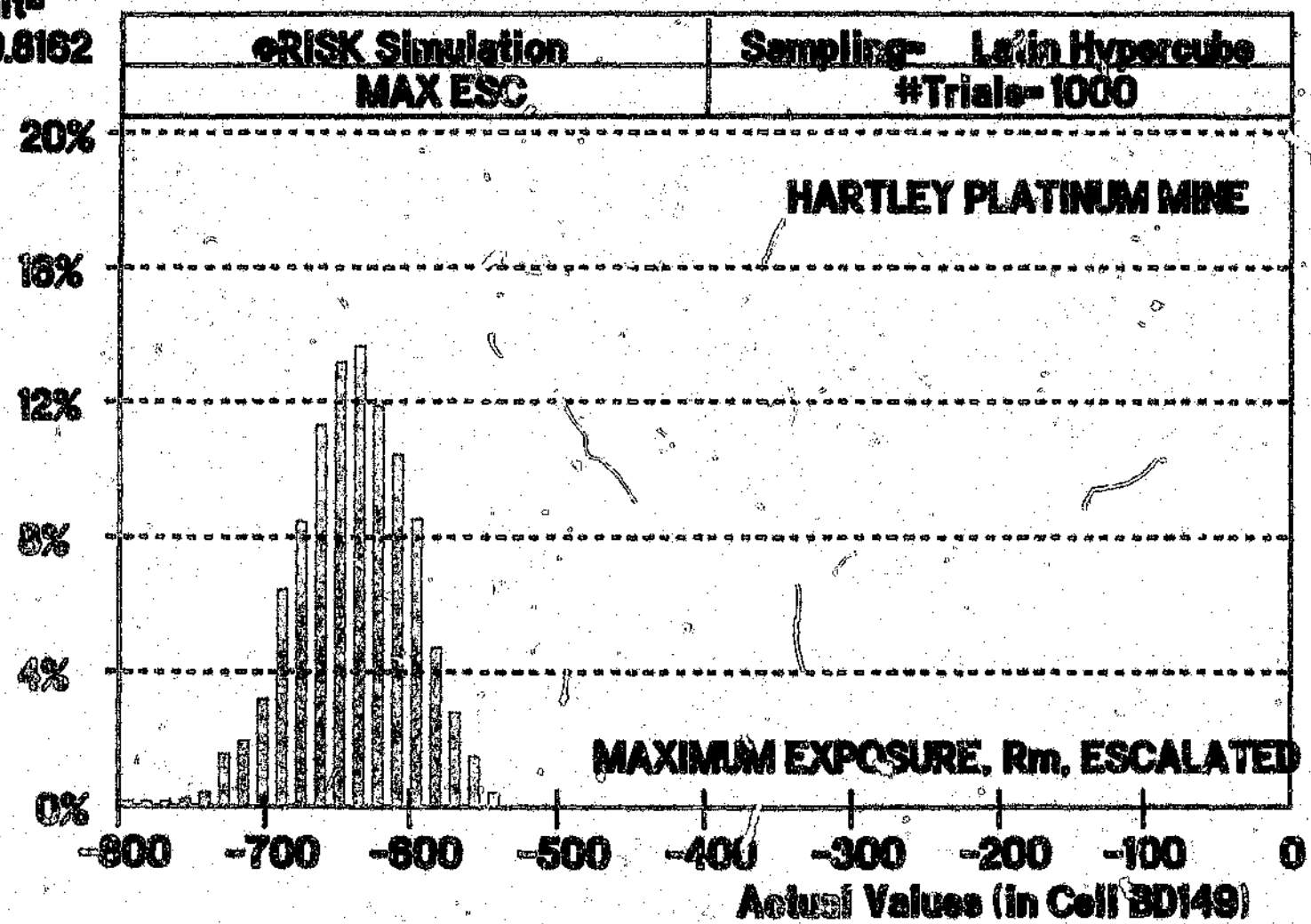
Expected
Result=
191.6035



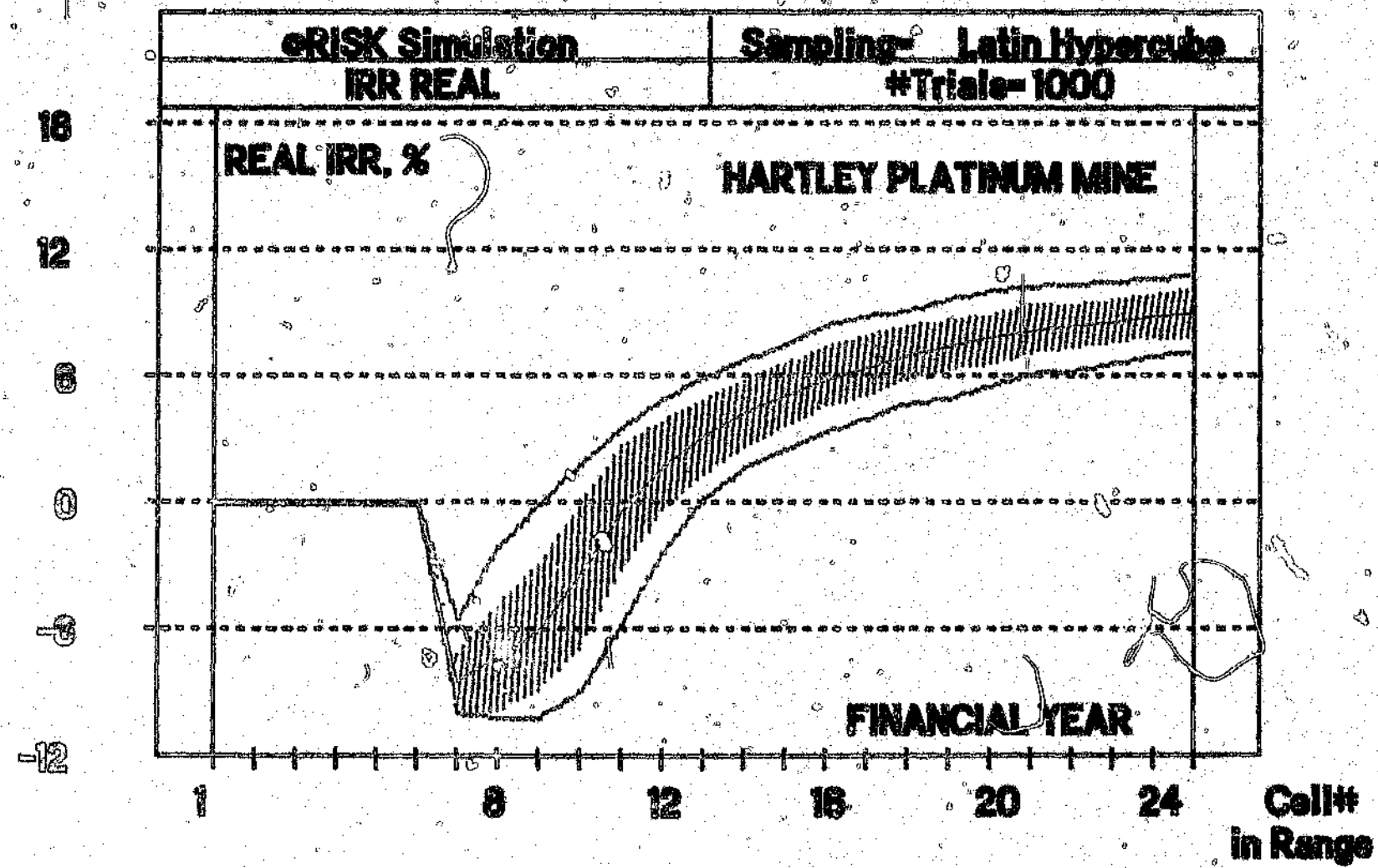
Expected
Result-
-553.8303



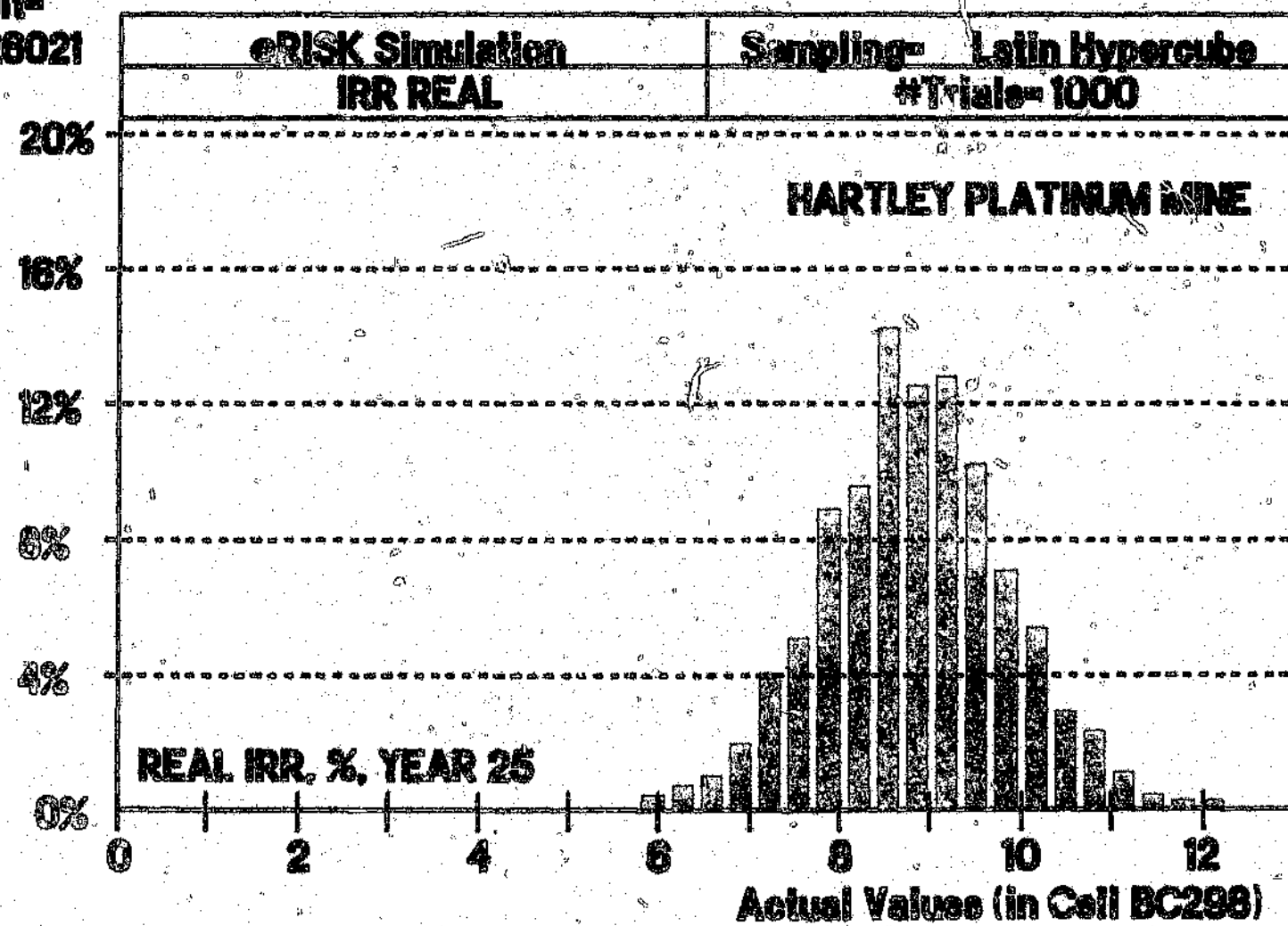
Expected
Result=
-639.8162



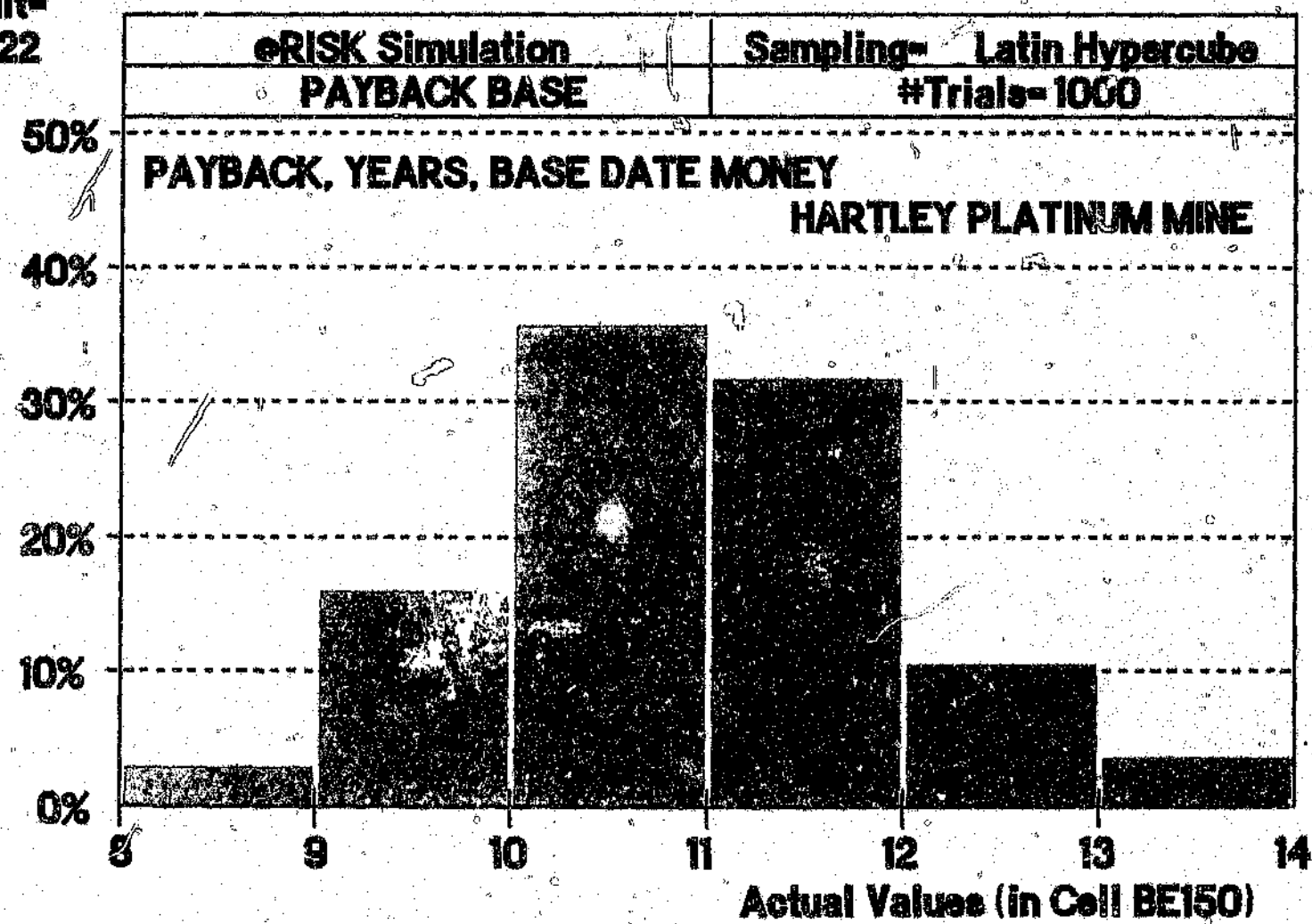
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



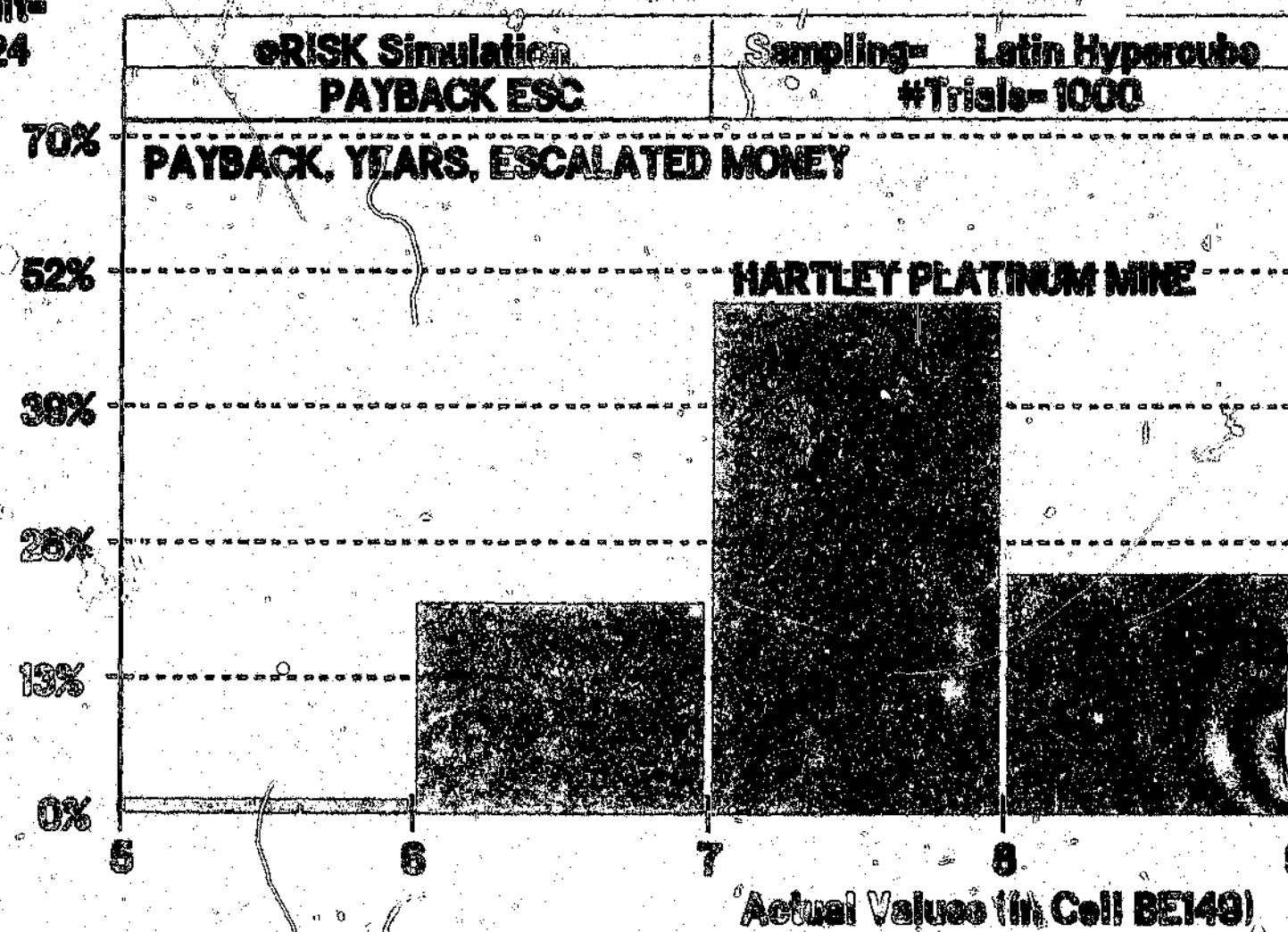
Expected
Result=
8.826021



Expected
Result=
10.422



Expected
Result=
7.024



4.4 ROBUSTNESS CRITERIA

As mentioned in section 3.4, the objective is to find the variable, V, with an expected result closest to zero and with the smallest standard deviation.

The following robustness criteria were examined :-

N°	Robustness Criterion
1	Working costs per ton milled net of by-product revenue (R/t)
2	Working costs per ounce of platinum produced net of by-product revenue (R/oz Pt)
3	Profit per ton milled (R/t)
4	Profit per ounce of platinum produced (R/oz Pt)
5	Cut-off head grade (g PGM/t)
6	Cash margin (%)

The following results were produced (see pages 58 to 69 for graphical representations of these results), where E is the expected result and SD is the standard deviation for V for that year :-

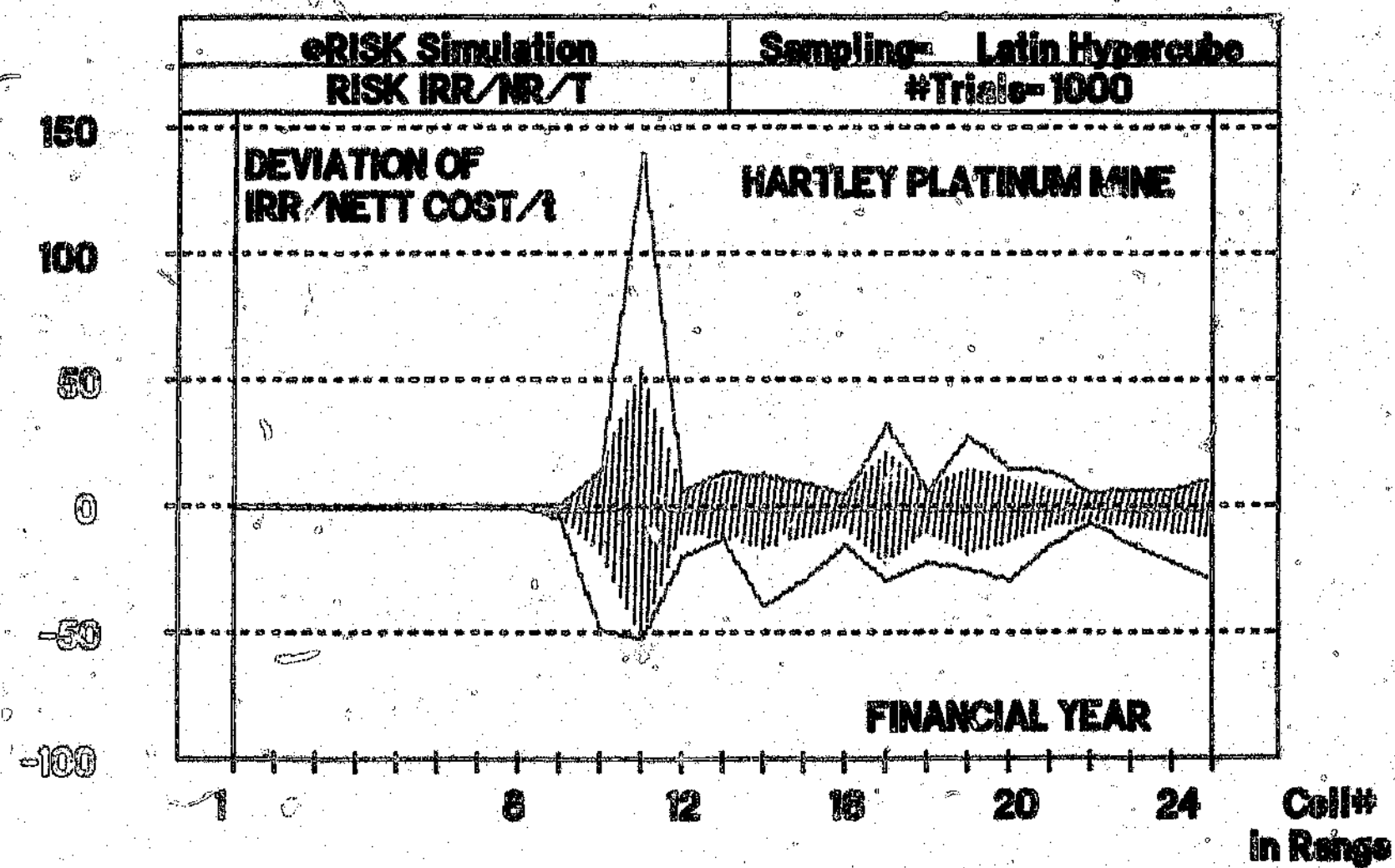
RESULTS FOR x/y = REAL IRR DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criterion	1 Net Cash (R)		2 Net Cost (R/ea P)		3 Profit (R/P)		4 Profit (R/ea P)		5 Cash-off Hold Grade (R/ea P)		6 Cash Margin (%)	
	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
9	(1,042)	2,089	(1,045)	2,106	(0,229)	0,357	(0,242)	0,366	(0,249)	0,410	(0,251)	0,472
10	(1,411)	16,016	(1,403)	16,321	0,542	1,769	0,529	1,735	0,348	1,391	0,474	1,605
11	1,348	32,017	1,233	31,606	(0,697)	21,247	(0,560)	15,220	(1,336)	2,223	(1,057)	13,508
12	(1,208)	8,197	(1,213)	8,032	(0,250)	1,925	(0,260)	1,737	(0,281)	0,625	(0,275)	1,345
13	(0,610)	11,561	(0,619)	11,544	(0,078)	0,977	(0,065)	0,905	(0,152)	0,556	(0,113)	0,738
14	(1,258)	13,503	(1,278)	14,193	(0,040)	0,534	(0,051)	0,321	(0,117)	0,350	(0,074)	0,444
15	(1,230)	10,763	(1,240)	10,873	(0,003)	0,712	(0,011)	0,649	(0,091)	0,304	(0,046)	0,630
16	(0,859)	6,186	(0,845)	6,184	0,002	0,524	(0,002)	0,436	(0,071)	0,284	(0,031)	0,378
17	(0,246)	21,314	(0,386)	21,478	0,082	1,721	0,067	1,476	(0,363)	0,245	0,023	1,098
18	(1,138)	7,633	(1,156)	7,898	0,621	0,710	0,011	0,363	(0,059)	0,223	(0,030)	0,534
19	(0,916)	10,220	(0,929)	17,019	0,045	0,515	0,037	0,470	(0,050)	0,317	0,007	0,384
20	(0,953)	12,454	(0,992)	12,767	0,063	0,618	0,054	0,553	(0,048)	0,202	0,016	0,421
21	(0,837)	7,693	(0,830)	7,759	0,059	0,548	0,051	0,456	(0,043)	0,205	0,019	0,373
22	(0,490)	5,288	(0,483)	5,466	0,077	0,563	0,058	0,531	(0,040)	0,192	0,031	0,399
23	(0,813)	7,067	(0,821)	7,104	0,084	0,826	0,071	0,715	0,031	0,183	0,018	0,569
24	(1,370)	8,376	(1,406)	8,893	0,139	1,093	0,120	0,948	(0,036)	0,180	0,076	0,256
25	(0,968)	10,185	(0,009)	10,445	-0,133	0,702	0,109	0,673	(0,057)	0,170	0,070	0,489
OVERALL	(0,842)	12,734	(0,849)	12,920	(0,011)	2,052	(0,029)	1,840	(0,140)	0,345	(0,066)	1,448

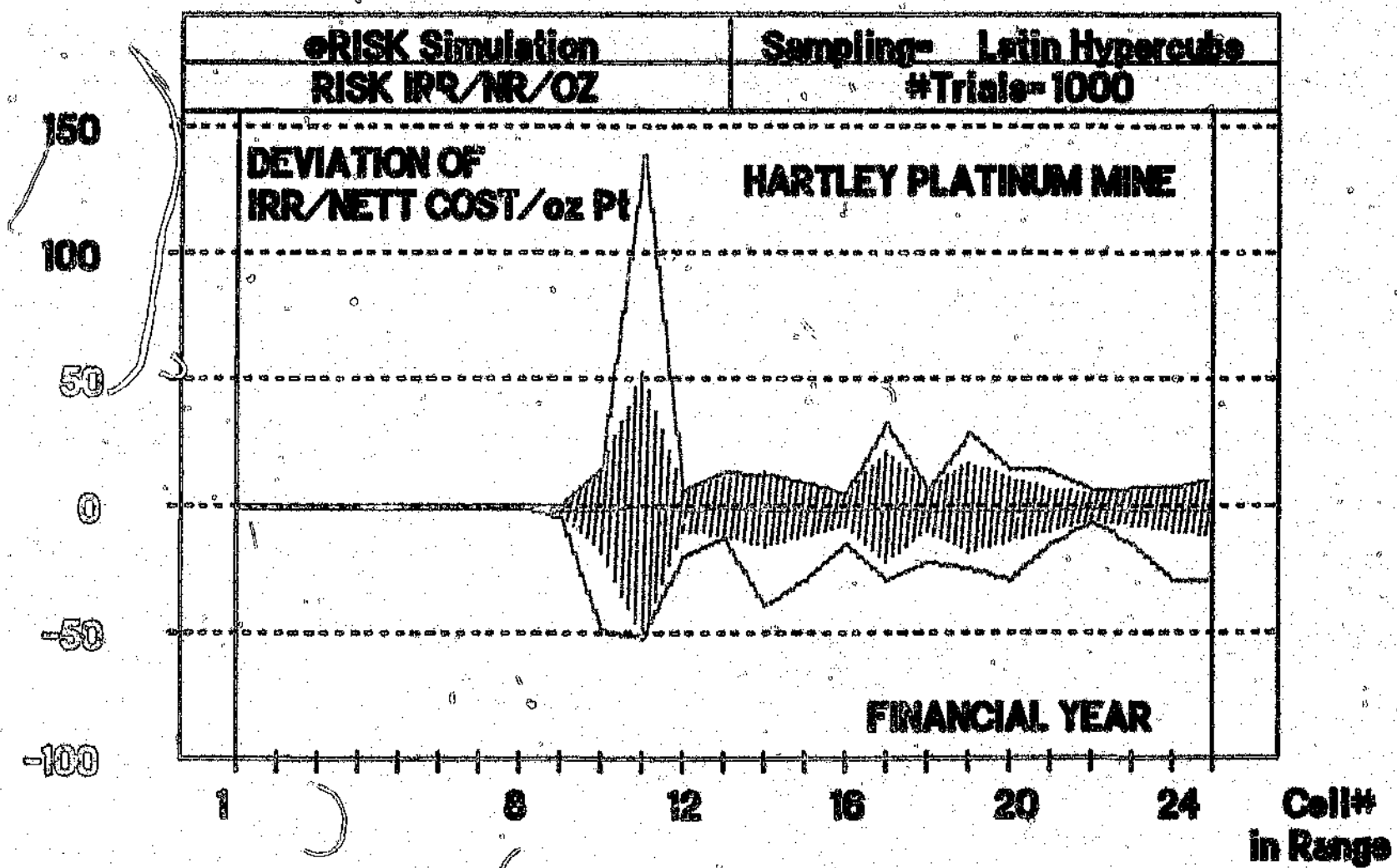
RESULTS FOR $x/y = NPV @ 0\%$ DISCOUNT DIVIDED BY ROBUSTNESS
CRITERIA 1 TO 6

Robustness Criterion	1 Net Cost (\$/Y)		2 Net Cost (\$/ton-Pb)		3 Profit (\$/Y)		4 Profit (\$/ton-Pb)		5 Cleaner Heat Grade (% PQMA)		6 Cost Margin (%)	
	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
3	0,076	0,378	0,031	0,390	(0,034)	19,040	(0,037)	19,915	<u>0,003</u>	<u>0,105</u>	(0,646)	18,264
4	0,243	12,052	0,256	12,123	0,176	0,681	0,173	0,642	<u>0,023</u>	<u>0,107</u>	0,128	0,492
5	(1,509)	24,434	(1,612)	25,000	0,210	0,146	0,199	0,630	<u>0,041</u>	<u>0,159</u>	0,139	0,192
6	(0,850)	6,654	(0,951)	6,603	0,192	1,144	0,178	0,991	<u>0,073</u>	<u>0,171</u>	0,152	0,134
7	(1,024)	0,711	(1,025)	0,712	0,173	0,622	0,163	0,570	<u>0,048</u>	<u>0,240</u>	0,131	0,131
8	(0,658)	7,143	(0,676)	7,136	0,234	0,973	0,240	0,919	<u>0,079</u>	<u>0,341</u>	0,182	0,182
9	(0,931)	5,572	(0,946)	5,746	0,358	1,318	0,342	1,220	<u>0,150</u>	<u>0,545</u>	0,226	0,165
10	(1,547)	50,228	(1,637)	52,635	0,913	2,770	0,904	2,635	<u>0,475</u>	<u>1,705</u>	0,713	2,319
11	(0,939)	5,929	(0,951)	5,884	(0,845)	2,723	(0,845)	2,654	<u>0,685</u>	<u>2,269</u>	(0,824)	2,484
12	(0,933)	3,438	(0,953)	3,389	(0,238)	0,046	(0,255)	(0,022)	<u>0,022</u>	<u>0,783</u>	(0,257)	0,779
13	(1,130)	6,047	(1,123)	6,298	(0,120)	0,590	(0,123)	0,567	(0,153)	<u>0,504</u>	(0,141)	0,507
14	(0,845)	6,855	(0,871)	7,139	<u>0,003</u>	0,514	(0,071)	0,483	(0,116)	<u>0,384</u>	(0,092)	0,412
15	(0,878)	3,224	(0,879)	3,281	<u>0,031</u>	0,512	(0,036)	0,474	(0,090)	<u>0,317</u>	(0,061)	0,338
16	(0,778)	13,403	(0,820)	14,354	<u>0,006</u>	1,238	<u>0,009</u>	1,033	(0,605)	<u>0,284</u>	(0,030)	0,112
17	(0,942)	4,983	(0,946)	5,204	<u>0,019</u>	0,425	(0,022)	0,392	(0,074)	<u>0,269</u>	(0,043)	0,300
18	(0,718)	8,280	(0,744)	8,092	0,033	1,641	0,066	1,454	(0,072)	<u>0,230</u>	<u>0,022</u>	1,066
19	(0,542)	119,252	(0,715)	124,524	0,016	0,472	<u>0,010</u>	0,433	(0,064)	<u>0,233</u>	(0,018)	0,330
20	0,604	90,942	0,629	93,310	0,035	0,634	0,027	0,564	(0,080)	<u>0,217</u>	<u>0,009</u>	0,425
21	(1,101)	25,788	(1,107)	26,269	0,045	0,387	0,037	0,341	(0,039)	<u>0,216</u>	<u>0,005</u>	0,405
22	(0,845)	11,824	(0,849)	12,102	0,047	0,974	0,040	0,877	(0,034)	<u>0,207</u>	<u>0,001</u>	0,827
23	(2,051)	28,259	(2,105)	30,721	0,054	0,796	0,043	0,680	(0,033)	<u>0,200</u>	<u>0,013</u>	0,552
24	(0,658)	11,956	(0,663)	12,283	0,067	0,695	0,038	0,659	(0,050)	<u>0,190</u>	<u>0,023</u>	0,477
25	0,142	24,133	0,051	21,466	0,053	0,353	0,060	0,514	(0,070)	<u>0,182</u>	<u>0,020</u>	0,632
OVERALL	(0,934)	20,345	(0,979)	21,090	0,057	1,792	0,049	1,731	(0,047)	<u>0,430</u>	(0,011)	1,525

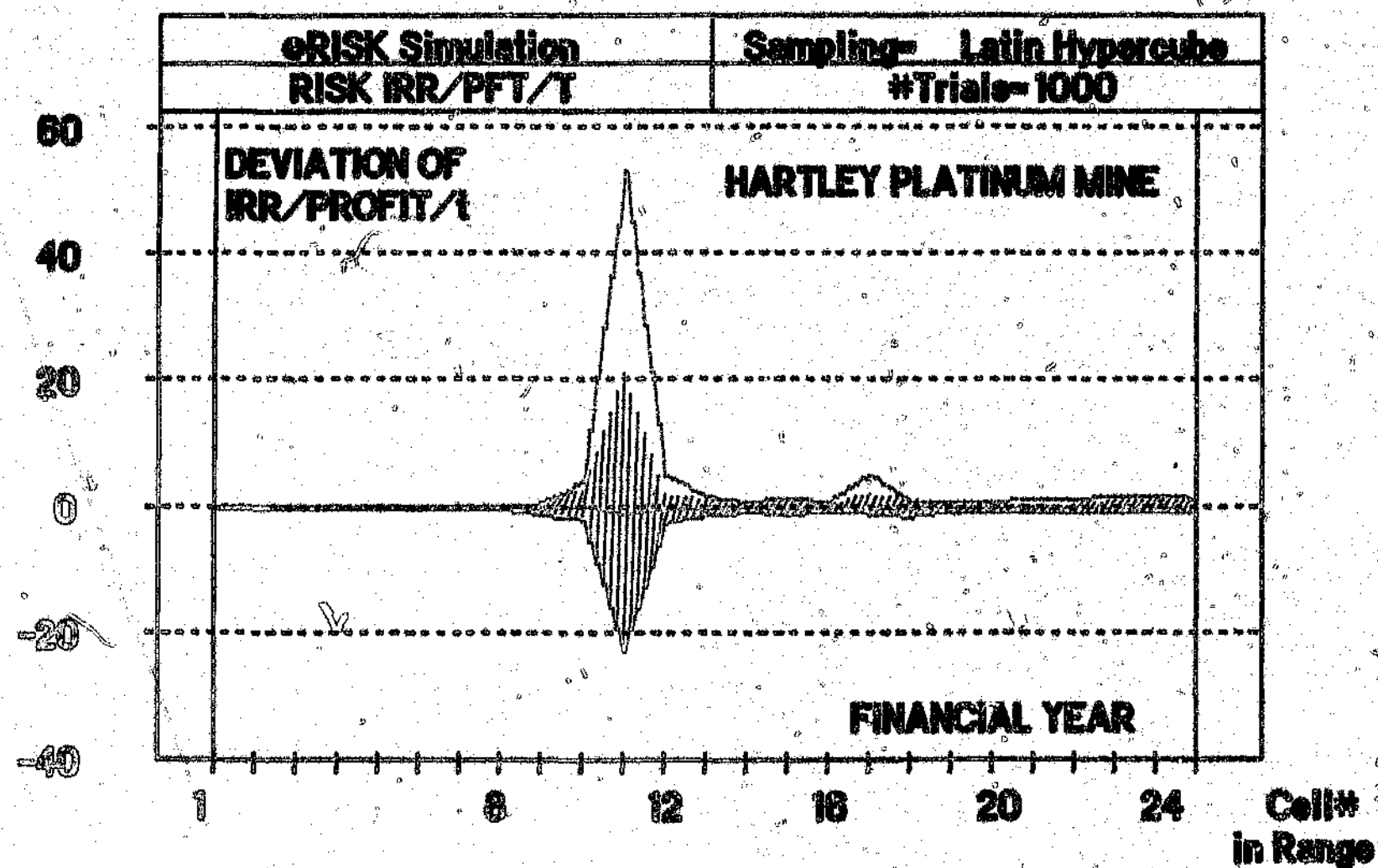
Trend in Mean,
1 Std Dev.,
5/95 Perc.



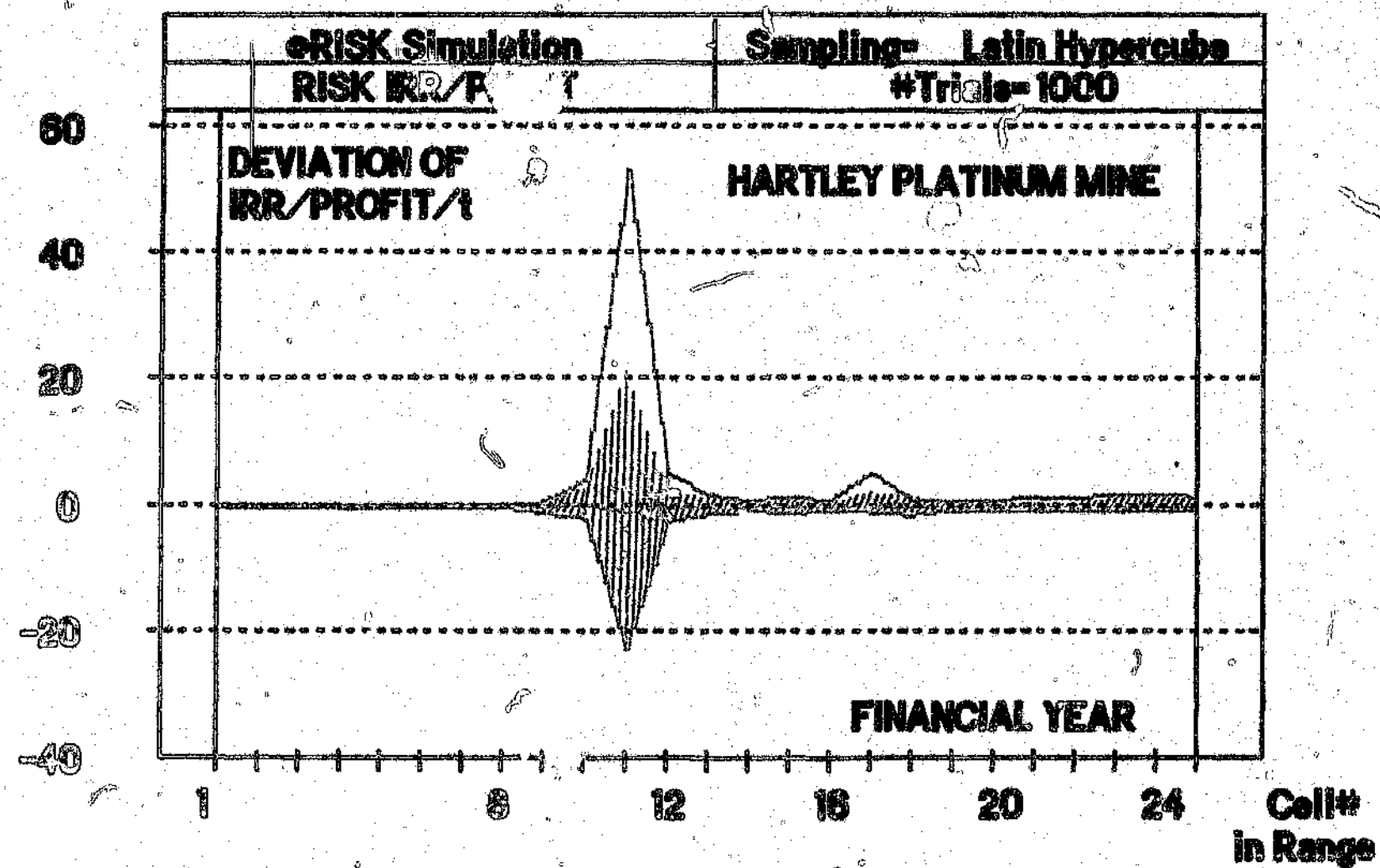
Trend in Mean.
1 Std.Dev.,
5/95 Perc.



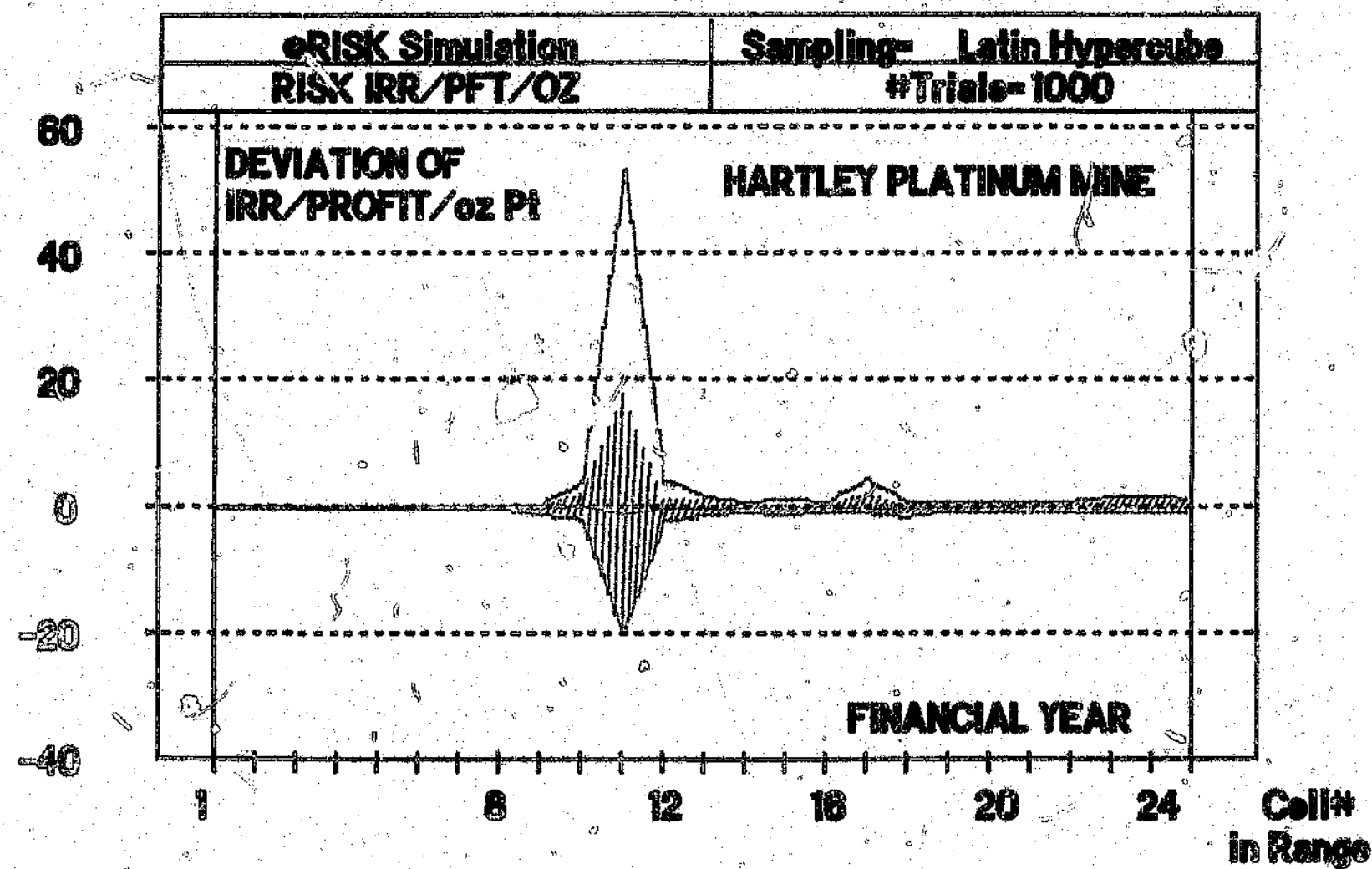
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



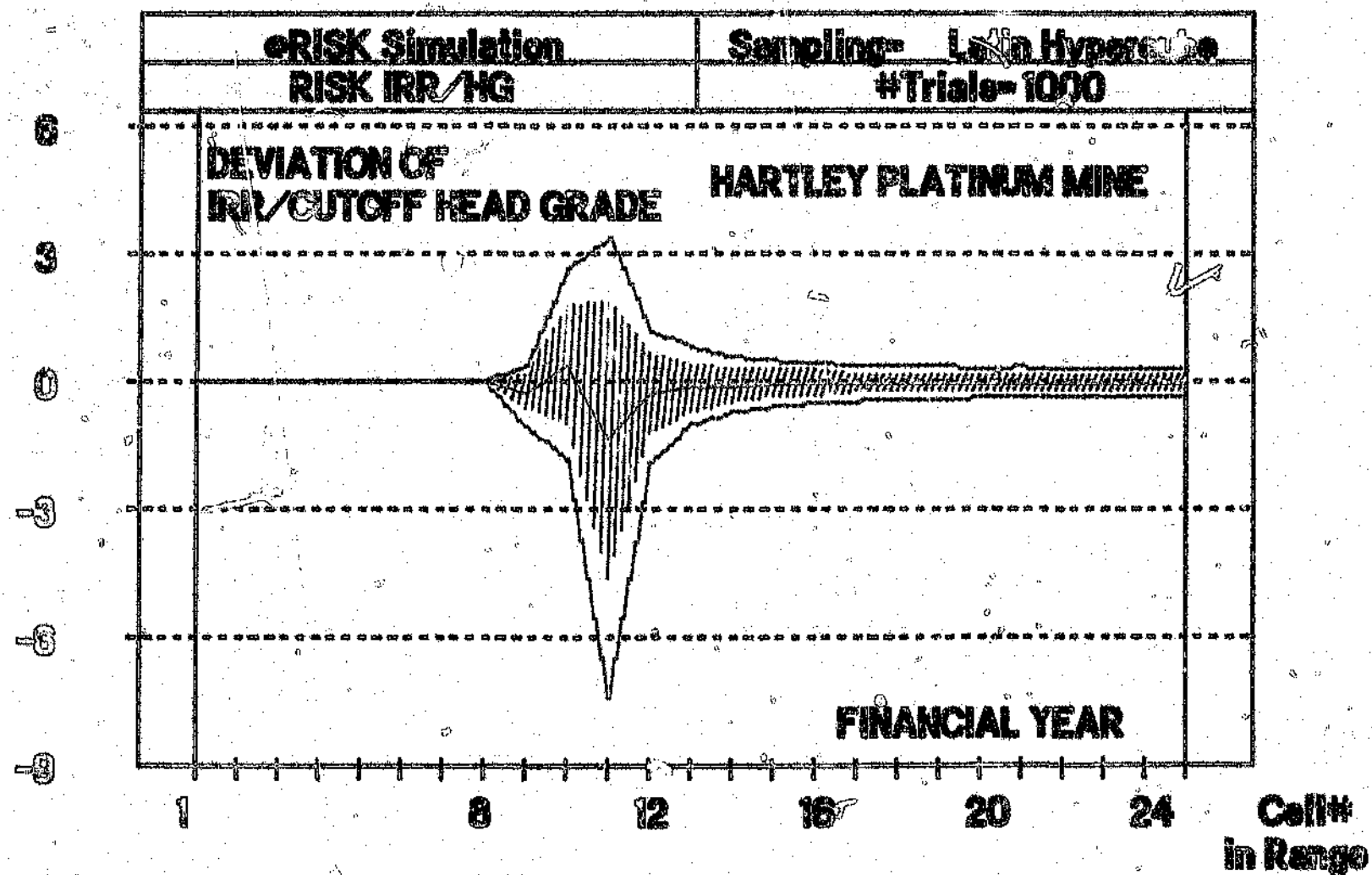
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



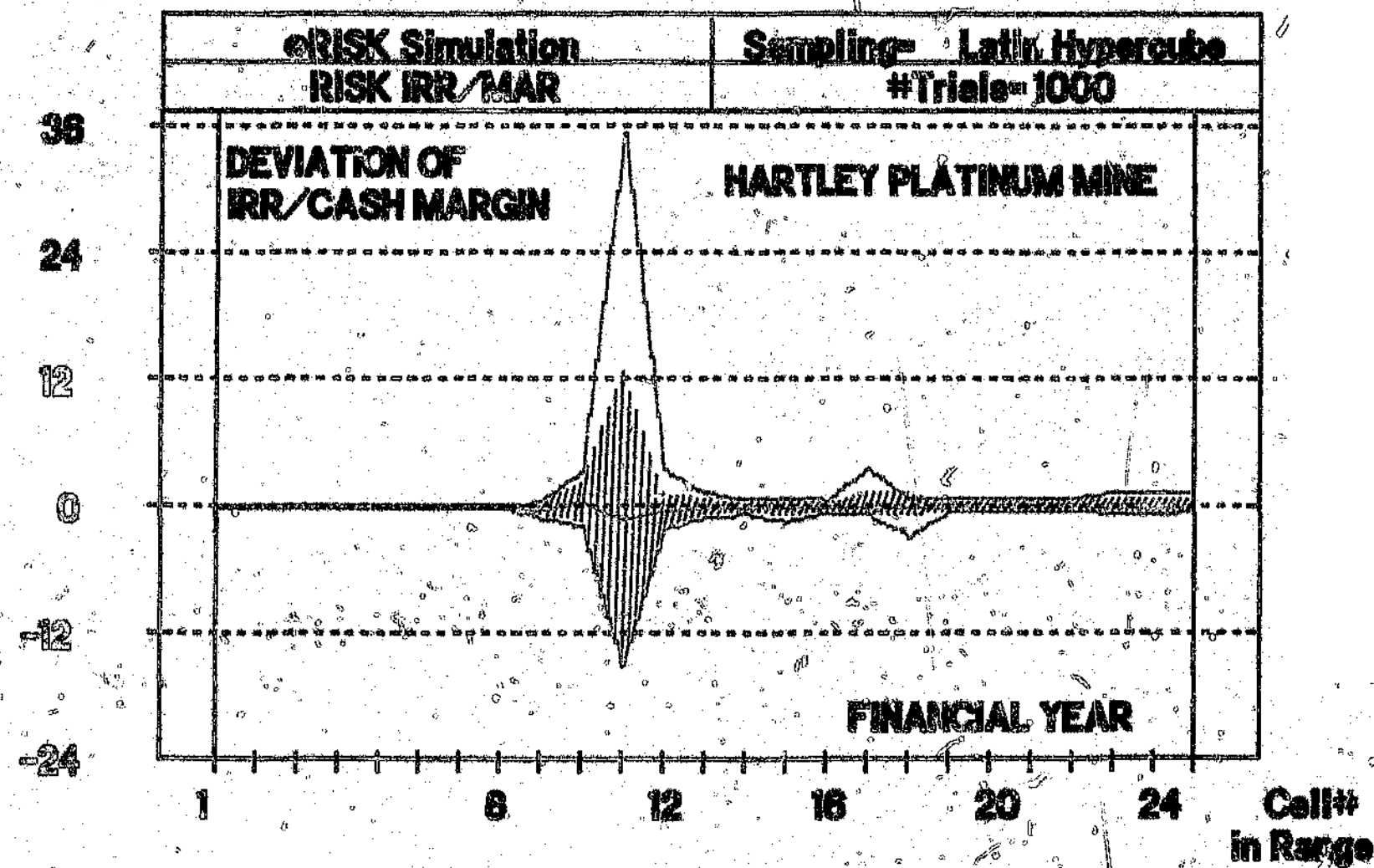
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



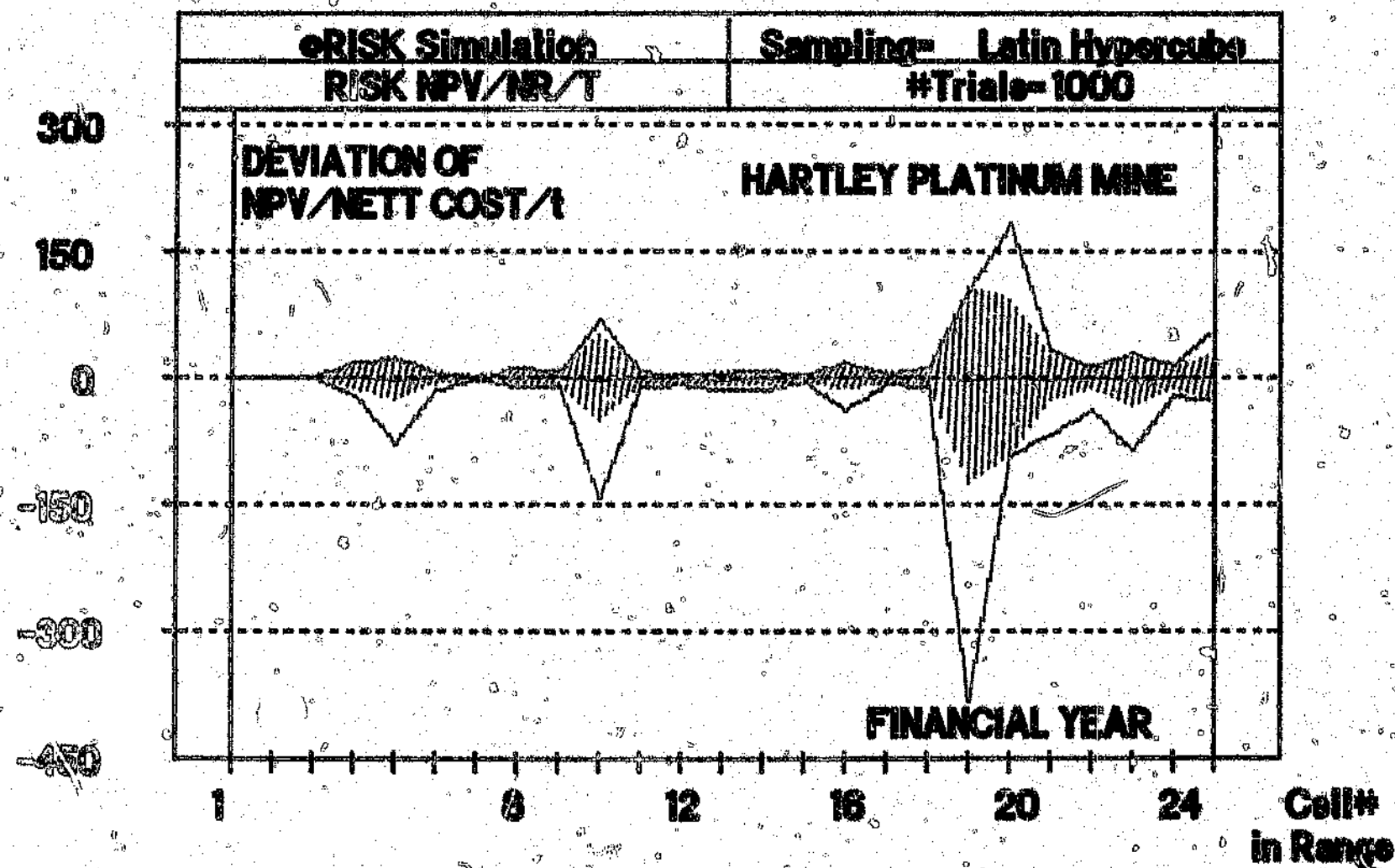
Trend in Mean,
1 Std Dev.,
5/95 Perc.



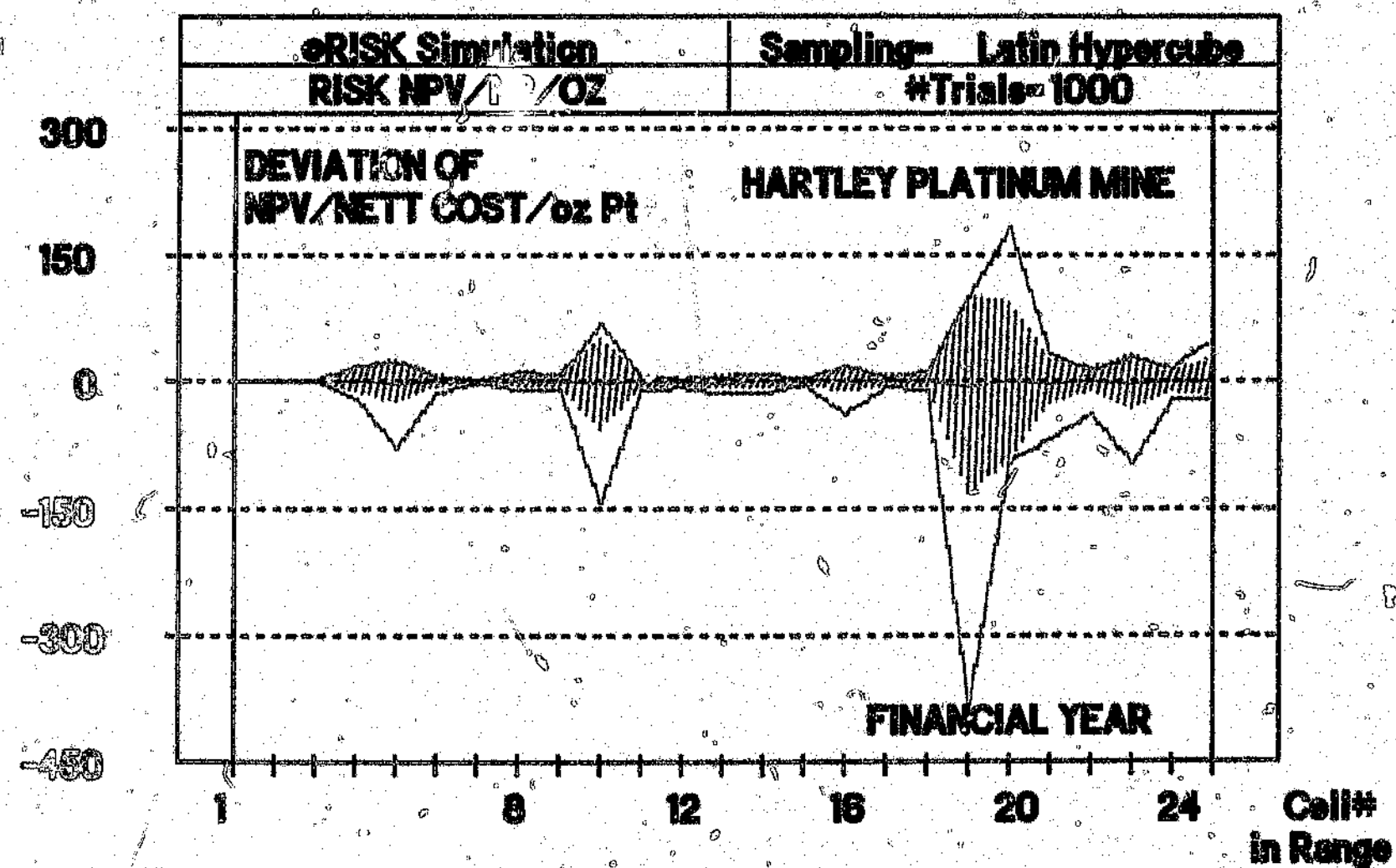
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



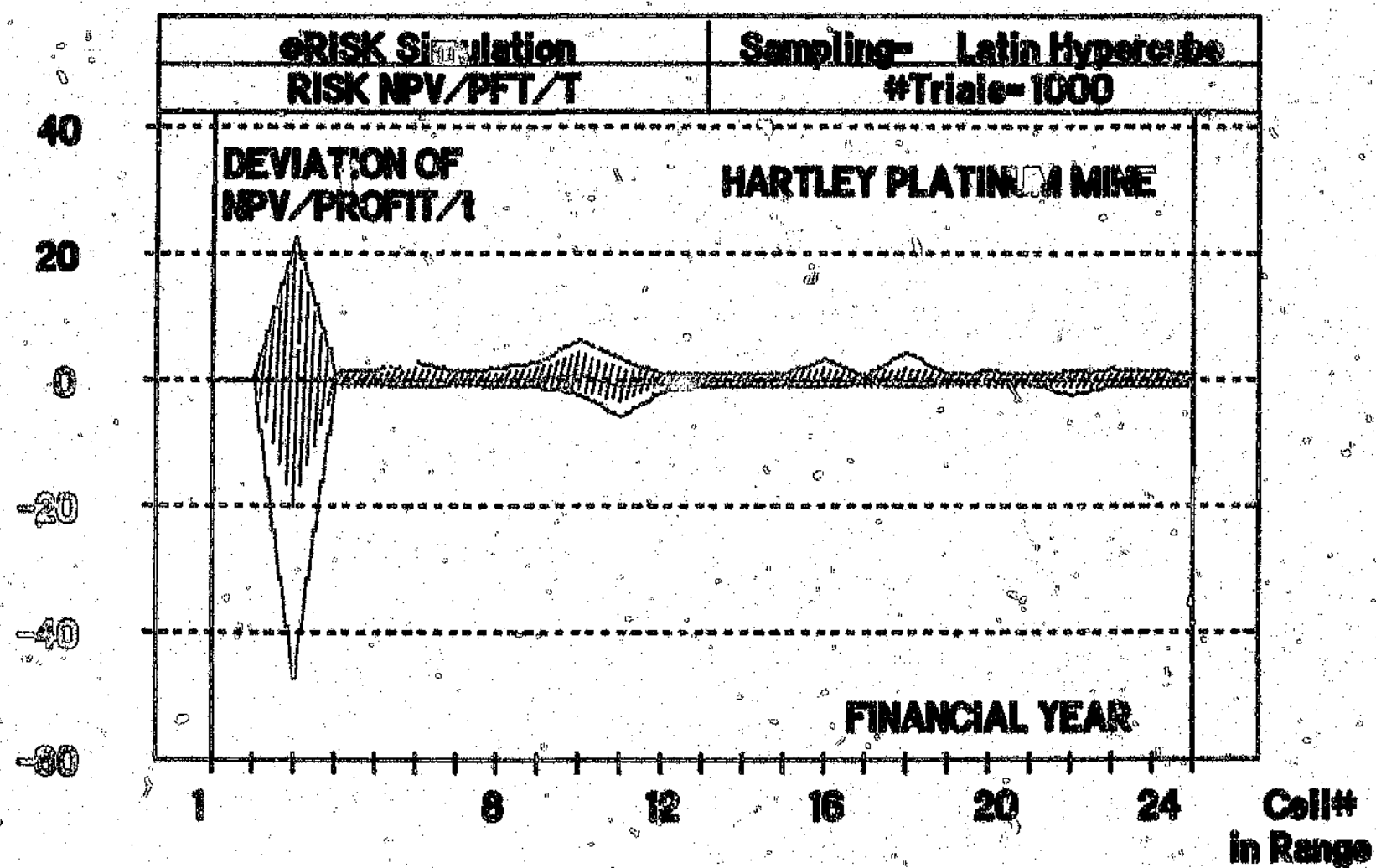
Trend in Mean,
1 Std Dev.,
5/95 Perc.



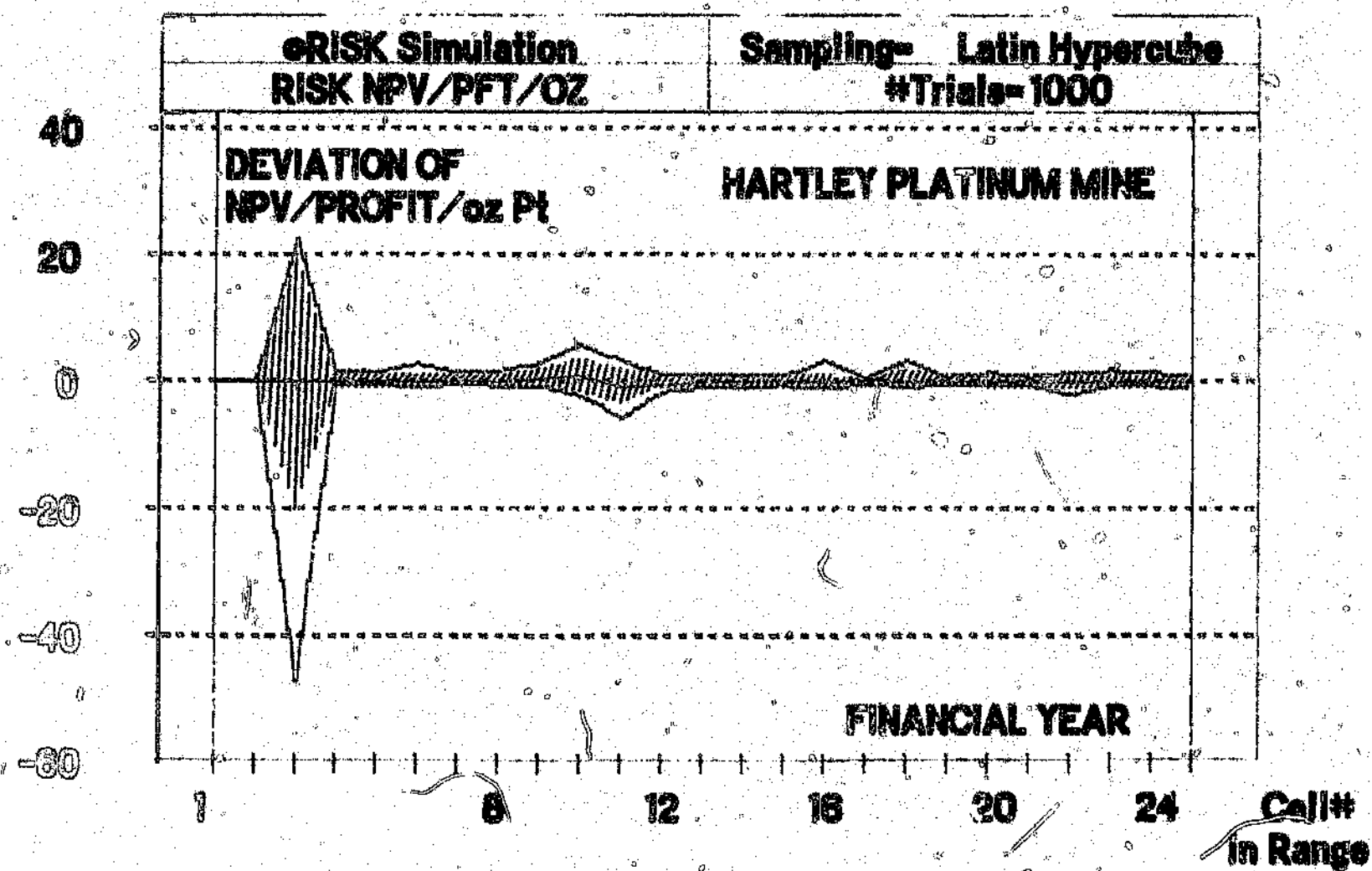
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



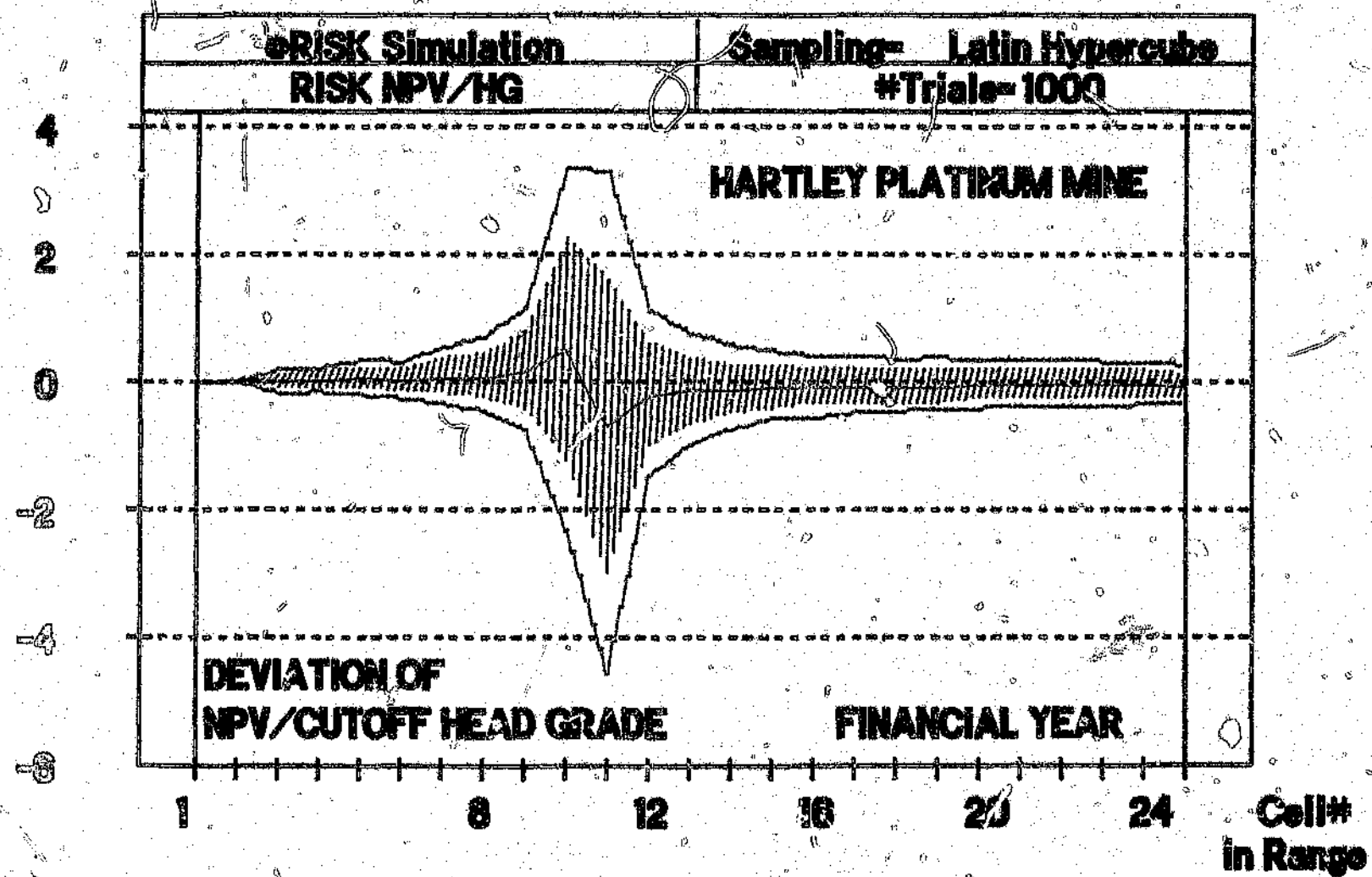
Trend in Mean,
1 Std Dev.,
5/95 Perc.



Trend in Mean,
1 Std Dev.,
5/95 Perc.



Trend in Mean,
1 Std.Dev.,
5/95 Perc.



91-07-23

INPUT PARAMETERS

Company : XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

METAL 1ST YR PIPELINE & INPUT FACTORS :

PL 75.00%
PD 75.00%
AU 75.00%
RN 50.00%
RU 50.00%
IR 50.00%
NI 50.00%
CU 50.00%

LEASE FORMULA : Y =
12.50 MINUS
ROYALTY PERCENTAGE
TAX RATE
TAX BASE? (Y/N) N

BASE DATE CALCULATION : JUL. 1991 TERMS
MONTHS FROM JULY 1991?

SALES CONTRACTS :

PL PRICE 97.30%
PD PRICE 97.30%
AU PRICE 97.30%
RN PRICE 97.30%
RU PRICE 97.30%
IR PRICE 97.30%
NI PRICE 97.30%
CU PRICE 97.30%

SENSITIVITIES :

PL PRICE : 100.00%
PD PRICE : 100.00%
AU PRICE : 100.00%
RN PRICE : 100.00%
RU PRICE : 100.00%
IR PRICE : 100.00%
NI PRICE : 100.00%
CU PRICE : 100.00%
ALL PRICES : 100.00%
WORKING COSTS : 100.00%
CAPEX : 100.00%
RECOVERED GRADE : 100.00%
MILLED TONNAGES : 100.00%
USCPT : 100.00%
R/US\$ EXCHANGE RATE : 100.00%
R/E EXCHANGE RATE : 100.00%
LEASE PAYMENT : 100.00%
ROYALTY PAYMENT : 100.00%
TAX RATE : 100.00%
TIMING : 100.00%

STARTING POINTS :

80/91
MERENSKY HEAD GRADE, g/t
C32 HEAD GRADE, g/t
MERENSKY TONS MILLED
802 TONS MILLED
UNDEVELOPED CAPEX, R million

ESTIMATED LIMITS

	BOTTOM	MIDDLE	TOP
PL PRICE :	75.00%	100.00%	130.00%
PD PRICE :	75.00%	100.00%	130.00%
AU PRICE :	75.00%	100.00%	130.00%
RN PRICE :	50.00%	100.00%	130.00%
RU PRICE :	50.00%	100.00%	130.00%
IR PRICE :	50.00%	100.00%	130.00%
NI PRICE :	50.00%	100.00%	130.00%
CU PRICE :	50.00%	100.00%	130.00%
WORKING COSTS :	100.00%	100.00%	110.00%
CAPEX :	100.00%	100.00%	120.00%
RECOVERED GRADE :	100.00%	100.00%	100.00%
MILLED TONNAGES :	100.00%	100.00%	110.00%
USCPT :	100.00%	100.00%	125.00%
R/US\$ EXCHANGE RATE :	100.00%	100.00%	125.00%
R/E EXCHANGE RATE :	100.00%	100.00%	125.00%
LEASE PAYMENT :	100.00%	100.00%	150.00%
ROYALTY PAYMENT :	100.00%	100.00%	120.00%
TAX RATE :	100.00%	100.00%	150.00%
TIMING :	100.00%	100.00%	110.00%

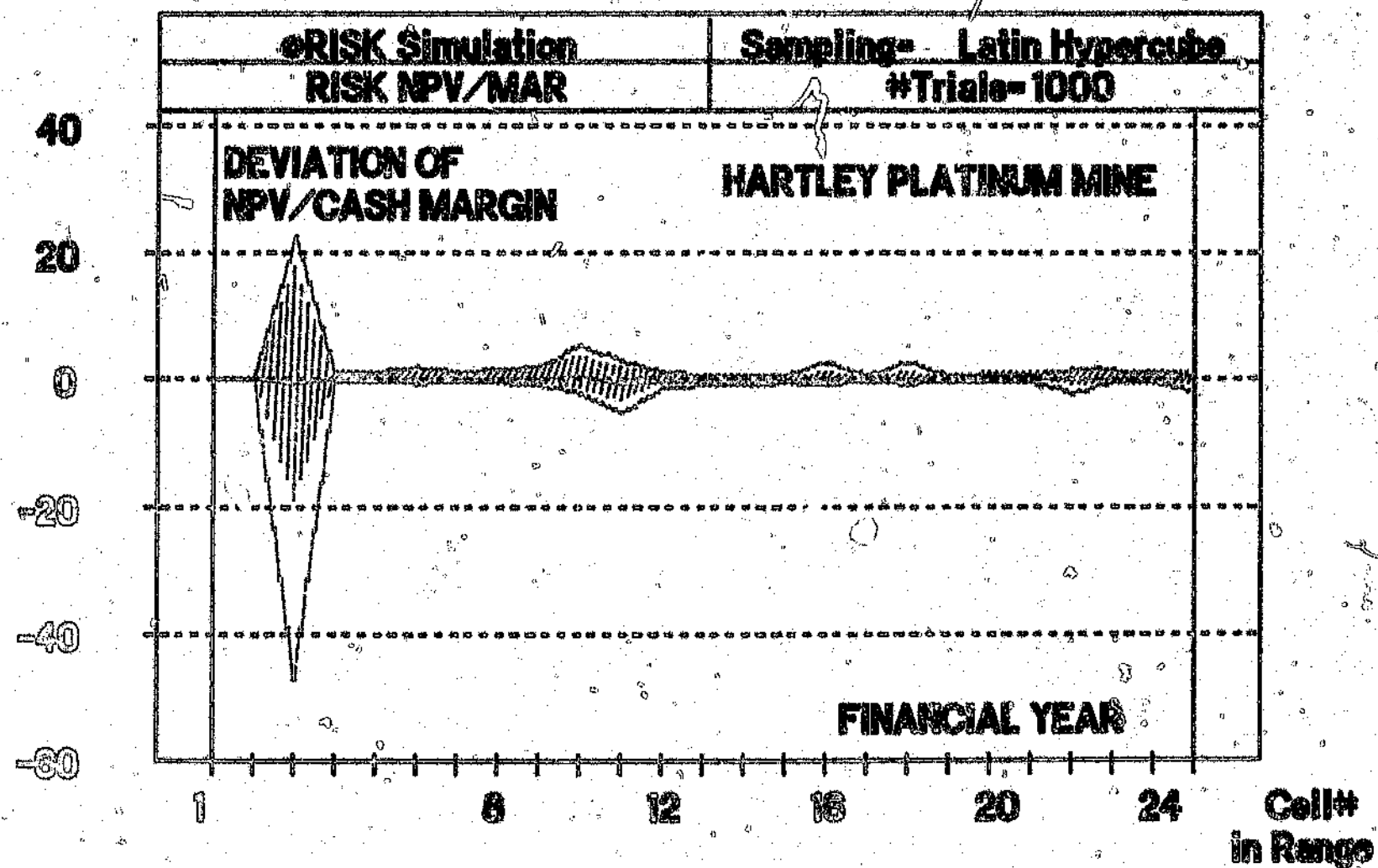
RISK ANALYSIS (Y/N) N

91-07-23

INPUT DATA

XYZ.WK1		FINANCIAL YEARS												
		91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
SACPI		12.75%	12.80%	11.25%	12.75%	18.25%	18.80%	10.80%	10.80%	10.80%	10.80%	10.80%	10.80%	10.80%
SA DISCOUNT FACTOR		1.062	1.189	1.323	1.465	1.615	1.777	1.955	2.150	2.365	2.602	2.862	3.148	3.463
MERENSKY HEAD GRADE		g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t	g/t
UQ2 HEAD GRADE		5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200
MERENSKY MILLED		t	t	t	t	t	t	t	t	t	t	t	t	t
UQ2 MILLED		0	0	0	0	0	750 000	1 500 000	2 000 000	2 300 000	2 600 000	2 750 000	2 750 000	2 750 000
TOTAL MILLED		0	0	0	0	0	750 000	1 500 000	2 000 000	2 300 000	2 600 000	2 750 000	2 750 000	2 750 000
PERCENTAGE UQ2		0.00	0.00	0.00	0.00	0.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PL PRODUCED		oz	oz	oz	oz	oz	33 964	70 249	113 213	134 346	152 461	163 702	166 846	166 846
PD PRODUCED		oz	oz	oz	oz	oz	22 809	53 497	76 296	90 538	102 745	110 375	111 901	111 901
AR PRODUCED		oz	oz	oz	oz	oz	716	1 871	2 387	2 832	3 214	3 453	3 531	3 581
RD PRODUCED		oz	oz	oz	oz	oz	2 285	9 615	14 857	18 376	20 940	22 969	23 584	23 584
RU PRODUCED		oz	oz	oz	oz	oz	5 704	17 112	26 818	32 782	37 285	40 687	41 020	41 820
JR PRODUCED		oz	oz	oz	oz	oz	680	2 883	3 116	3 820	4 362	4 753	4 896	4 896
N1 PRODUCED		t	t	t	t	t	187	218	295	344	389	414	419	419
CU PRODUCED		t	t	t	t	t	51	108	148	172	195	207	208	208
PL PRICE, FREE MARKET		US\$/oz	385.93	455.23	613.80	575.00	613.00	639.00	665.00	680.00	720.00	761.61	831.81	868.95
PD PRICE, FREE MARKET		US\$/oz	97.51	119.88	193.05	148.00	163.00	175.00	185.00	195.00	210.00	219.45	239.64	250.43
AR PRICE, FREE MARKET		US\$/oz	273.83	428.89	478.00	490.00	518.00	530.00	555.00	562.00	605.00	715.33	761.70	818.88
RD PRICE, FREE MARKET		US\$/oz	3 325.00	3 628.49	4 064.50	4 372.00	4 625.00	4 875.00	5 250.00	4 058.00	5 250.00	5 488.25	5 793.13	6 091.12
RU PRICE, FREE MARKET		US\$/oz	37.51	50.00	81.00	64.00	68.00	69.00	73.00	77.00	81.00	84.85	88.45	92.45
JR PRICE, FREE MARKET		US\$/oz	290.13	305.00	310.00	320.00	335.00	352.00	369.00	388.00	407.00	425.32	444.45	464.45
N1 PRICE, FREE MARKET		US\$/t	8 133.47	8 481.32	8 808.00	9 200.00	9 688.00	10 108.00	10 650.00	11 200.00	11 750.00	12 320.75	12 911.25	13 488.76
CU PRICE, FREE MARKET		\$/t	1 294.26	1 381.61	1 525.00	1 575.00	1 625.00	1 675.00	1 725.00	1 775.00	1 825.00	1 880.00	1 934.99	2 023.41
EXCHANGE RATE		R/US\$	2.08	3.93	3.89	3.13	3.24	3.42	3.58	3.80	4.89	5.21	4.43	4.87
EXCHANGE RATE		R/£	5.45	5.69	5.73	6.00	6.33	6.51	6.78	7.16	7.53	8.28	9.64	9.61

Trend in Mean.
1 Std Dev.
5/95 Perc.



The underlined numbers on pages 56 and 57 are the lowest SD figures or the E figures closest to zero for V for each particular year and overall. The following notes can be made :-

- the Net R/t and Net R/oz Pt criteria produce the worst SD and E results of the ones considered. Net R/oz Pt is slightly worse than Net R/t.
- Although the actual numbers are different, criteria 3 to 6 show similar patterns over time for SD and E. This is probably to be expected since all of these are related to profit.
- Cut-off head grade, however, stands out as producing the lowest SD for V, especially in years 3, 9 - 11 and 17 - 19.
- The Profit/t, Cash Margin and Cut-Off Head Grade criteria stand out as producing values for E closest to zero.
- Years 3, 9 - 11 and 17 - 19 are the periods when (1) production starts, (2) Real IRR and NPV @ 0% discount first become positive and (3) a fresh capital injection is required, respectively.

5. XYZ PGM MINE

5.1 GENERAL

XYZ acts as a test of the results produced for Hartley. It is a fictitious South African UG2 mine, although it is loosely based on several declared results of UG2 project evaluations. No inference can or should be drawn from the results for XYZ on anyone's view of any particular project.

UG2 Reef was chosen as the reef to be mined at XYZ since Hartley mines a reef more similar to the Bushveld Igneous Complex's Merensky Reef. It is a deeper mine than Hartley with consequently higher capex and working costs. Maximum production is 2 750 000 t milled pa and 166 000 oz Pt pa.

The forecast economic parameters used are as per page 13. Refer to pages 72 to 75 for details of all input parameters used.

[illegible]

01-07-23

INPUT DATA

XYZ.WK1	FINANCIAL YEARS	04/05	05/06	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
SACPI		10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%
SA DISCOUNT FACTOR		3.089	4.190	4.689	5.070	5.577	6.135	6.748	7.423	8.165	8.992	9.880	10.888
MERENSKY HEAD GRADE	g/t	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000
DSZ HEAD GRADE	g/t	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200	5,200
MERENSKY MILLED	t	0	0	0	0	0	0	0	0	0	0	0	0
USZ MILLED	t	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000
TOTAL MILLED	t	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000	2,750,000
PERCENTAGE USZ	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PL PRODUCED	oz	186,846	186,846	186,846	186,846	186,846	186,846	186,846	186,846	186,846	186,846	186,846	186,846
PD PRODUCED	oz	111,901	111,901	111,901	111,901	111,901	111,901	111,901	111,901	111,901	111,901	111,901	111,901
AD PRODUCED	oz	3,501	3,501	3,501	3,501	3,501	3,501	3,501	3,501	3,501	3,501	3,501	3,501
RH PRODUCED	oz	23,504	23,504	23,504	23,504	23,504	23,504	23,504	23,504	23,504	23,504	23,504	23,504
RU PRODUCED	oz	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828	41,828
IF PRODUCED	oz	4,896	4,896	4,896	4,896	4,896	4,896	4,896	4,896	4,896	4,896	4,896	4,896
NI PRODUCED	oz	416	416	416	416	416	416	416	416	416	416	416	416
CU PRODUCED	oz	208	208	208	208	208	208	208	208	208	208	208	208
PL PRICE, FREE MARKET	US\$/oz	988.47	949.35	992.87	1,029.71	1,033.38	1,132.11	1,183.86	1,236.30	1,291.83	1,350.87	1,413.02	1,474.31
PD PRICE, FREE MARKET	US\$/oz	281.70	273.47	295.78	290.64	313.00	326.12	349.80	356.14	372.16	388.91	405.41	424.70
AD PRICE, FREE MARKET	US\$/oz	893.63	832.05	932.19	974.14	1,017.90	1,053.76	1,111.85	1,181.60	1,213.85	1,280.58	1,325.67	1,395.32
RH PRICE, FREE MARKET	US\$/oz	6,542.46	6,836.87	7,144.52	7,468.03	7,882.00	8,163.89	8,519.98	8,903.90	9,264.03	9,722.71	10,168.29	10,617.44
RU PRICE, FREE MARKET	US\$/oz	100.34	165.40	119.23	115.18	120.37	175.79	131.45	137.37	143.55	150.01	156.76	163.91
IF PRICE, FREE MARKET	US\$/oz	507.29	530.07	593.67	578.79	604.84	632.95	650.50	690.22	721.28	753.74	787.66	823.10
NI PRICE, FREE MARKET	US\$/oz	14,842.84	15,301.56	15,898.13	16,788.60	17,461.62	18,247.35	19,080.52	19,928.61	20,823.30	21,769.35	22,739.57	23,762.05
CU PRICE, FREE MARKET	US\$/oz	2,167.53	2,243.39	2,321.91	2,403.19	2,487.29	2,574.34	2,664.44	2,757.70	2,854.22	2,954.12	3,057.61	3,164.52
EXCHANGE RATE	R/US\$	5.17	5.44	5.73	6.03	6.35	6.68	7.03	7.40	7.79	8.20	8.63	9.09
EXCHANGE RATE	1/£	18.21	18.09	17.58	17.26	16.83	16.35	15.72	15.04	14.62	14.07	13.58	13.05

5.2 CONVENTIONAL RESULTS

Pages 77 to 84 show the detailed results, with graphs, of the standard project evaluation of XYZ. In summary, they are as follows :-

Real IRR, %, 25 years :	6,85
NPV, R million, 25 years, @ 0% discount :	928
@ 3% discount :	363
@ 5% discount :	139
Maximum Exposure, escalated, R million :	1 305
Maximum Exposure, base date, R million :	851
Payback Period, years, escalated money :	11
Payback Period, years, base date money :	15

In addition, sensitivities were run (see pages 85 to 91), showing that the project was most sensitive to variations in metal prices and recovered grade.

ANALYSIS RESULTS

NZT WCT	FINANCIAL YEARS	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
ESCALATED	\$ million													
REVENUE		0	0	0	0	0	145	416	540	823	1 802	1 380	1 458	1 605
TOTAL WORKING COST		0	0	0	0	0	119	262	305	407	505	704	775	852
WORKING PROFIT		0	0	0	0	0	26	154	235	386	497	505	683	752
WORKING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX		37	120	156	182	275	368	215	82	35	30	24	26	29
CLOSING CAPEX		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL CAPEX		37	120	156	182	275	368	215	82	35	30	24	26	29
LEASE PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
ROYALTY PAYMENT		0	0	0	0	0	0	0	0	0	0	0	0	0
TAX PAYABLE		0	0	0	0	0	0	0	0	0	147	243	279	387
TOTAL GOVERNMENT		0	0	0	0	0	0	0	0	0	147	243	279	387
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(37)	(120)	(156)	(182)	(275)	(368)	(215)	(82)	(35)	(30)	(24)	(26)	(29)
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY		(35)	(101)	(110)	(124)	(232)	(295)	(20)	150	395	318	269	883	339
ESCALATED CUMULATIVE CASH FLOW	\$ million	(37)	(187)	(313)	(495)	(770)	(1 235)	(1 305)	(1 187)	(802)	(487)	(223)	79	417
BASE DATE CUMULATIVE CASH FLOW	\$ million	(35)	(186)	(254)	(376)	(616)	(616)	(651)	(778)	(592)	(510)	(410)	(322)	(226)
BASE DATE REVENUE PER t MILLED	R/t	0.00	0.00	0.00	0.00	0.00	130.98	341.05	150.05	168.05	161.47	165.17	180.49	166.40
BASE DATE REVENUE PER oz Pt	R/oz Pt	0	0	0	0	0	2 307	2 605	2 661	2 740	2 754	2 773	2 791	2 701
BASE DATE TOTAL COSTS PER t MILLED	R/t	0.00	0.00	0.00	0.00	0.00	92.51	92.51	92.51	92.51	92.51	92.51	92.51	92.51
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	0	0	0	0	0	2 043	1 791	1 694	1 594	1 578	1 553	1 532	1 532
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	0.00	0.00	0.00	0.00	0.00	54.49	79.03	62.05	55.42	91.06	93.66	96.00	96.00
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	0	0	0	0	0	1 283	1 492	1 400	1 540	1 533	1 579	1 599	1 599
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	0.00	0.00	0.00	0.00	0.00	38.02	13.69	6.66	2.99	1.45	(1.15)	(3.40)	(3.48)
BASE DATE NETT TOTAL COSTS PER oz Pt	R/oz Pt	0	0	0	0	0	340	259	174	96	25	(19)	(50)	(58)
BASE DATE WORKING PROFIT PER t MILLED	R/t	0.00	0.00	0.00	0.00	0.00	16.05	49.34	58.14	69.64	68.96	72.66	75.00	75.90
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	0	0	0	0	0	354	934	1 027	1 168	1 176	1 220	1 250	1 258
CASH MARGIN, PROFIT/REVENUE	%	0.00	0.00	0.00	0.00	0.00	14.70	34.70	30.69	42.38	42.35	43.58	44.59	44.59
HERRICKY CUT-OFF HEAD GRADE	g PGH/t	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WEZ CUT-OFF HEAD GRADE	g PW/t	0.000	0.000	0.000	0.000	0.000	4.431	3.891	3.193	2.990	2.979	2.912	2.855	2.855
TOTAL CUT-OFF HEAD GRADE	g PGW/t	0.000	0.000	0.000	0.000	0.000	4.431	3.891	3.193	2.990	2.979	2.912	2.855	2.855
NPV CASH FLOW, 0%	R million	(35)	(186)	(254)	(376)	(616)	(616)	(631)	(778)	(592)	(510)	(410)	(322)	(226)
NPV CASH FLOW, 1%	R million	(34)	(181)	(249)	(367)	(598)	(598)	(727)	(743)	(584)	(491)	(396)	(306)	(211)
NPV CASH FLOW, 2%	R million	(34)	(181)	(249)	(367)	(587)	(587)	(701)	(711)	(570)	(476)	(382)	(292)	(200)
NPV CASH FLOW, 3%	R million	(34)	(180)	(247)	(364)	(580)	(580)	(691)	(700)	(562)	(468)	(374)	(284)	(192)
NPV CASH FLOW, 4%	R million	(34)	(179)	(246)	(363)	(574)	(574)	(683)	(691)	(556)	(463)	(369)	(279)	(188)
NPV CASH FLOW, 5%	R million	(33)	(178)	(245)	(362)	(568)	(568)	(675)	(683)	(549)	(459)	(365)	(275)	(186)
NPV CASH FLOW, 6%	R million	(33)	(177)	(244)	(361)	(562)	(562)	(667)	(675)	(543)	(453)	(360)	(271)	(184)
NPV CASH FLOW, 7%	R million	(33)	(176)	(243)	(360)	(556)	(556)	(659)	(667)	(537)	(447)	(355)	(267)	(182)
NPV CASH FLOW, 8%	R million	(32)	(175)	(242)	(359)	(550)	(550)	(651)	(659)	(531)	(441)	(350)	(263)	(180)
NPV CASH FLOW, 9%	R million	(32)	(174)	(241)	(358)	(544)	(544)	(643)	(651)	(525)	(435)	(345)	(259)	(178)
NPV CASH FLOW, 10%	R million	(32)	(173)	(240)	(357)	(538)	(538)	(635)	(643)	(519)	(429)	(340)	(255)	(176)
NPV CAPEX, 0%	R million	37	120	156	182	275	368	215	82	35	30	24	26	29
IRR CASH FLOW, %	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	(9.02)

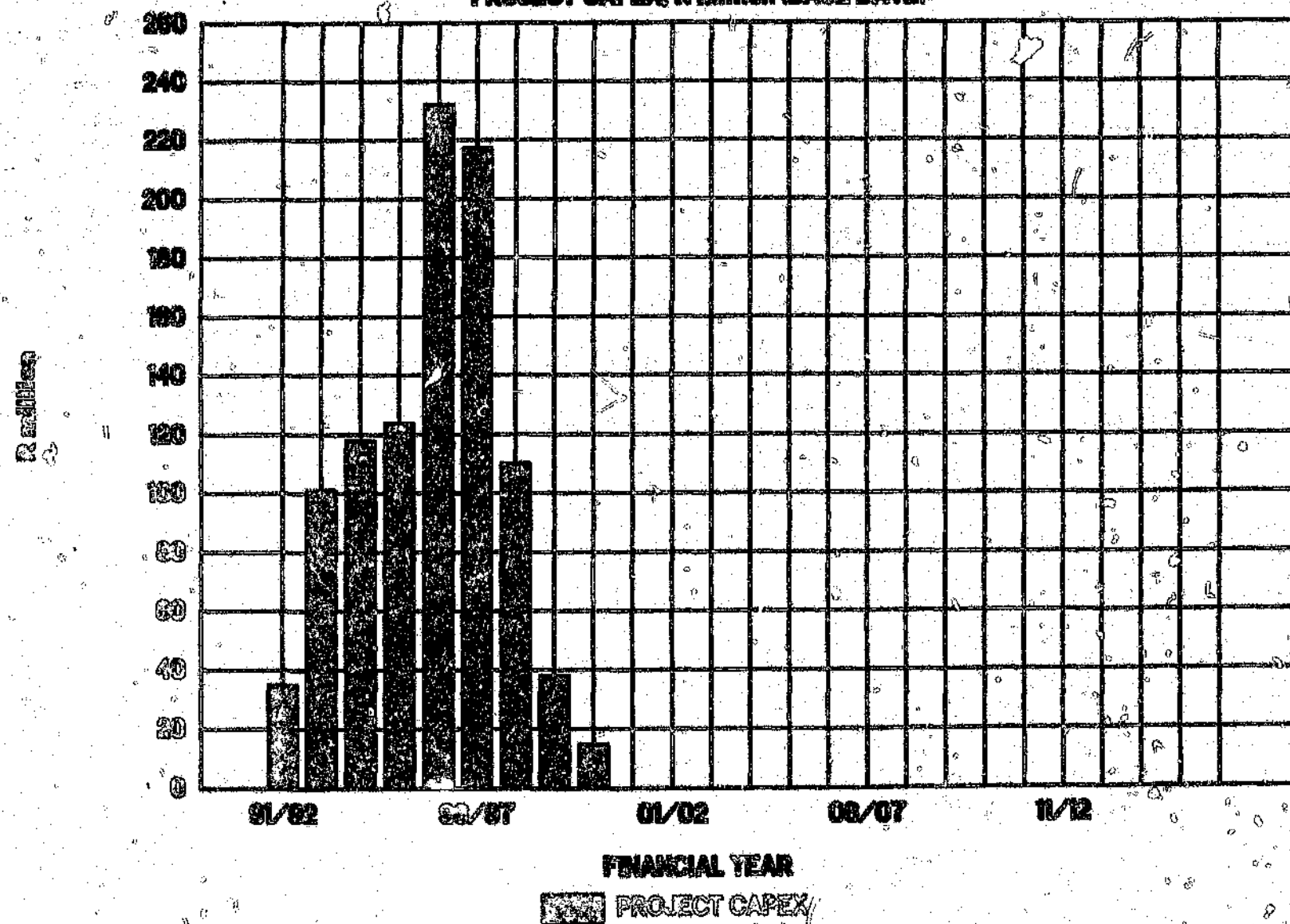
91-07-23

ANALYSIS RESULTS

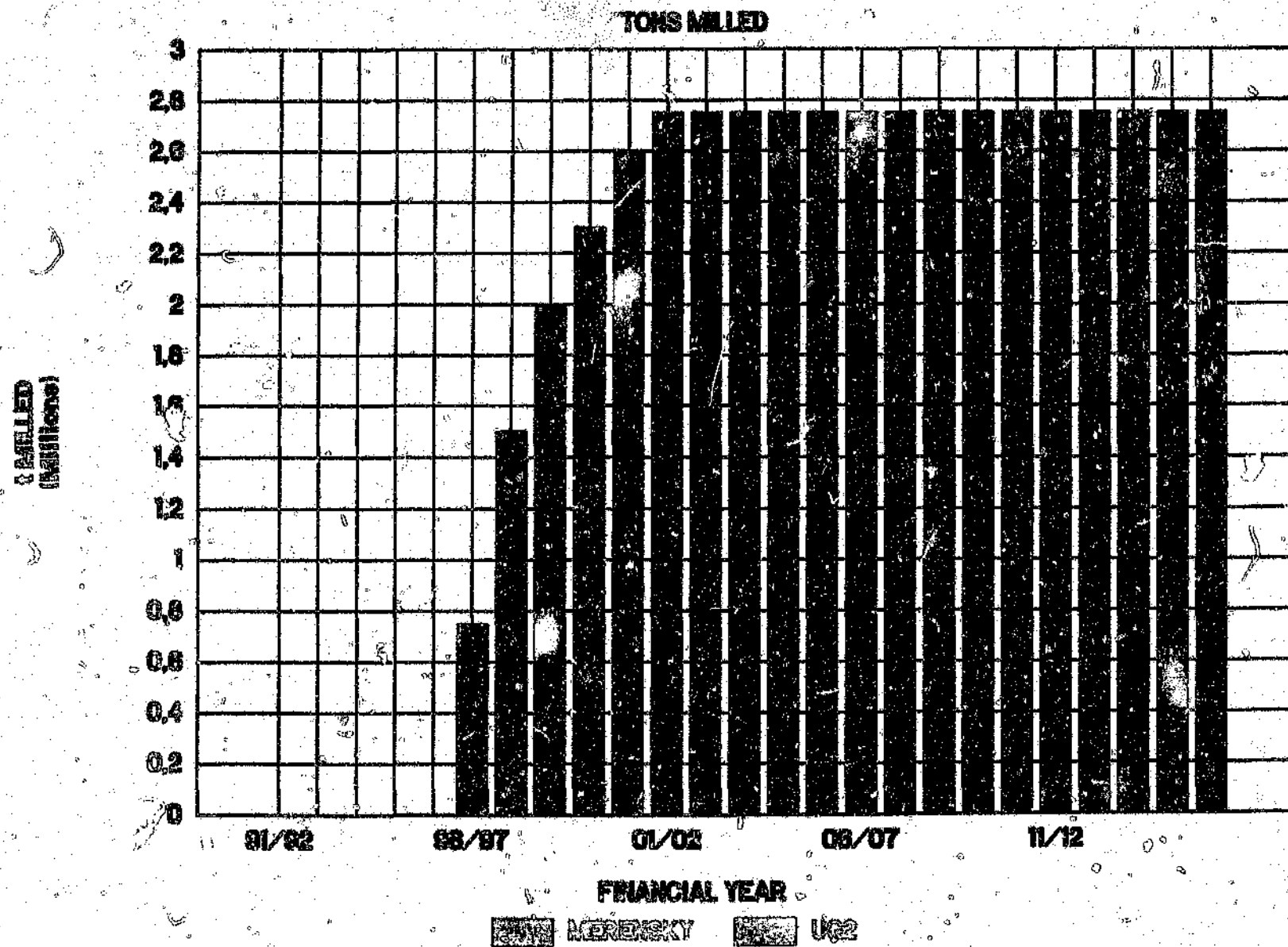
FINANCIAL YEARS	04/85	05/85	06/87	07/89	08/90	09/10	10/11	11/12	12/13	13/14	14/15	15/16
WZ.M1												
ESCALATED	R million											
REVENUE	1 785	1 942	2 136	2 340	2 504	2 843	3 127	3 440	3 784	4 162	4 578	5 036
TOTAL WORKING COST	938	1 091	1 135	1 240	1 373	1 518	1 661	1 827	2 010	2 211	2 432	2 675
WORKING PROFIT	847	851	1 001	1 100	1 131	1 325	1 466	1 613	1 774	1 951	2 146	2 361
WORKING CAPEX	0	0	0	0	0	0	0	0	0	0	0	0
PROJECT CAPEX	0	0	0	0	0	0	0	0	0	0	0	0
ONGOING CAPEX	31	35	38	42	46	51	55	61	67	74	82	89
TOTAL CAPEX	31	35	38	42	46	51	55	61	67	74	82	89
LEASE PAYMENT	63	61	108	116	121	133	147	161	177	195	215	236
ROYALTY PAYMENT	0	13	11	12	13	14	15	17	19	21	23	25
TAX PAYABLE	398	372	499	450	495	544	599	659	725	797	871	955
TOTAL GOVERNMENT	421	463	509	550	586	678	746	820	902	992	1 092	1 281
ESCALATED CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY	366	403	443	487	536	590	648	714	785	864	950	1 045
BASE DATE CASH FLOW, INCLUDING TAX BASE BENEFIT, IF ANY	86	86	86	86	86	86	86	86	86	86	86	86
ESCALATED CUMULATIVE CASH FLOW	R million	778	1 191	1 624	2 112	2 744	3 490	4 348	5 308	6 249	7 199	8 244
BASE DATE CUMULATIVE CASH FLOW	R million	(130)	(34)	62	160	255	351	447	543	639	735	832
BASE DATE REVENUE PER t MILLED	R/t	168.49	168.49	168.49	168.49	168.49	168.49	168.49	168.49	168.49	168.49	168.49
BASE DATE REVENUE PER oz Pt	R/oz Pt	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791	2 791
BASE DATE TOTAL COSTS PER t MILLED	R/t	92.51	92.51	92.51	92.51	92.51	92.51	92.51	92.51	92.51	92.51	92.51
BASE DATE TOTAL COSTS PER oz Pt	R/oz Pt	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532	1 532
BASE DATE BY-PRODUCT CREDITS PER t MILLED	R/t	96.00	96.00	96.00	96.00	96.00	96.00	96.00	96.00	96.00	96.00	96.00
BASE DATE BY-PRODUCT CREDITS PER oz Pt	R/oz Pt	1 590	1 590	1 590	1 590	1 590	1 590	1 595	1 598	1 599	1 599	1 598
BASE DATE NETT TOTAL COSTS PER t MILLED	R/t	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)	(3.49)
BASE DATE NETT TOTAL COSTS R/oz Pt	R/oz Pt	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)
BASE DATE WORKING PROFIT PER t MILLED	R/t	75.98	75.98	75.98	75.98	75.98	75.98	75.98	75.98	75.98	75.98	75.98
BASE DATE WORKING PROFIT PER oz Pt	R/oz Pt	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258	1 258
CASH MARGIN, PROFIT/REVENUE	%	44.59	44.59	44.59	44.59	44.59	44.59	44.59	44.59	44.59	44.59	44.59
MEBENSKY CUT-OFF HEAD GRADE	g PM/t	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UGZ CUT-OFF HEAD GRADE	g PM/t	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055
TOTAL CUT-OFF HEAD GRADE	g PM/t	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055	2.055
NPV CASH FLOW, 0%	R million	(130)	(34)	62	159	255	351	447	543	639	735	832
NPV CASH FLOW, 1%	R million	(169)	(85)	(3)	70	159	236	317	395	472	549	626
NPV CASH FLOW, 2%	R million	(199)	(120)	(59)	11	76	144	209	272	334	395	455
NPV CASH FLOW, 3%	R million	(223)	(164)	(94)	(1)	(1)	66	119	171	221	270	317
NPV CASH FLOW, 4%	R million	(247)	(192)	(142)	(95)	(45)	0	44	97	147	195	240
NPV CASH FLOW, 5%	R million	(264)	(213)	(174)	(122)	(62)	(54)	(10)	17	59	111	159
NPV CASH FLOW, 6%	R million	(278)	(230)	(208)	(154)	(91)	(90)	(40)	(40)	(14)	31	79
NPV CASH FLOW, 7%	R million	(289)	(254)	(221)	(191)	(136)	(111)	(60)	(60)	(66)	(46)	(19)
NPV CASH FLOW, 8%	R million	(297)	(267)	(230)	(213)	(166)	(146)	(127)	(105)	(93)	(78)	(63)
NPV CASH FLOW, 9%	R million	(303)	(277)	(239)	(231)	(188)	(174)	(159)	(144)	(124)	(110)	(95)
NPV CASH FLOW, 10%	R million	(308)	(285)	(244)	(240)	(200)	(189)	(175)	(162)	(142)	(127)	(113)
NPV CAPEX, 0%	R million	000	000	000	000	000	000	000	000	000	000	000
IRR CASH FLOW, %		(4.09)	(1.18)	0.05	2.18	3.18	4.01	4.70	5.28	5.77	6.10	6.35

XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

PROJECT CAPEX, R million (BASE DATE)

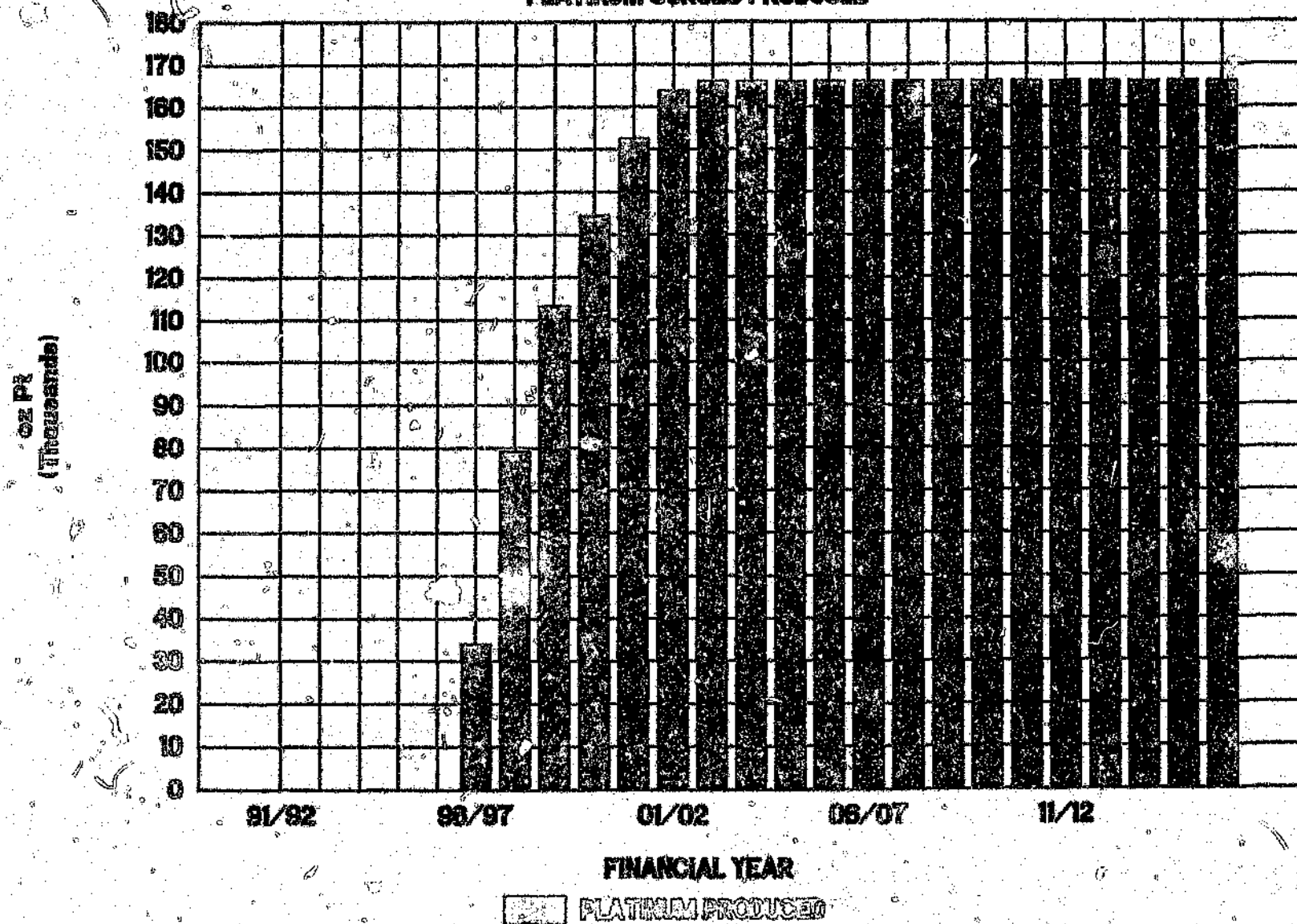


XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE



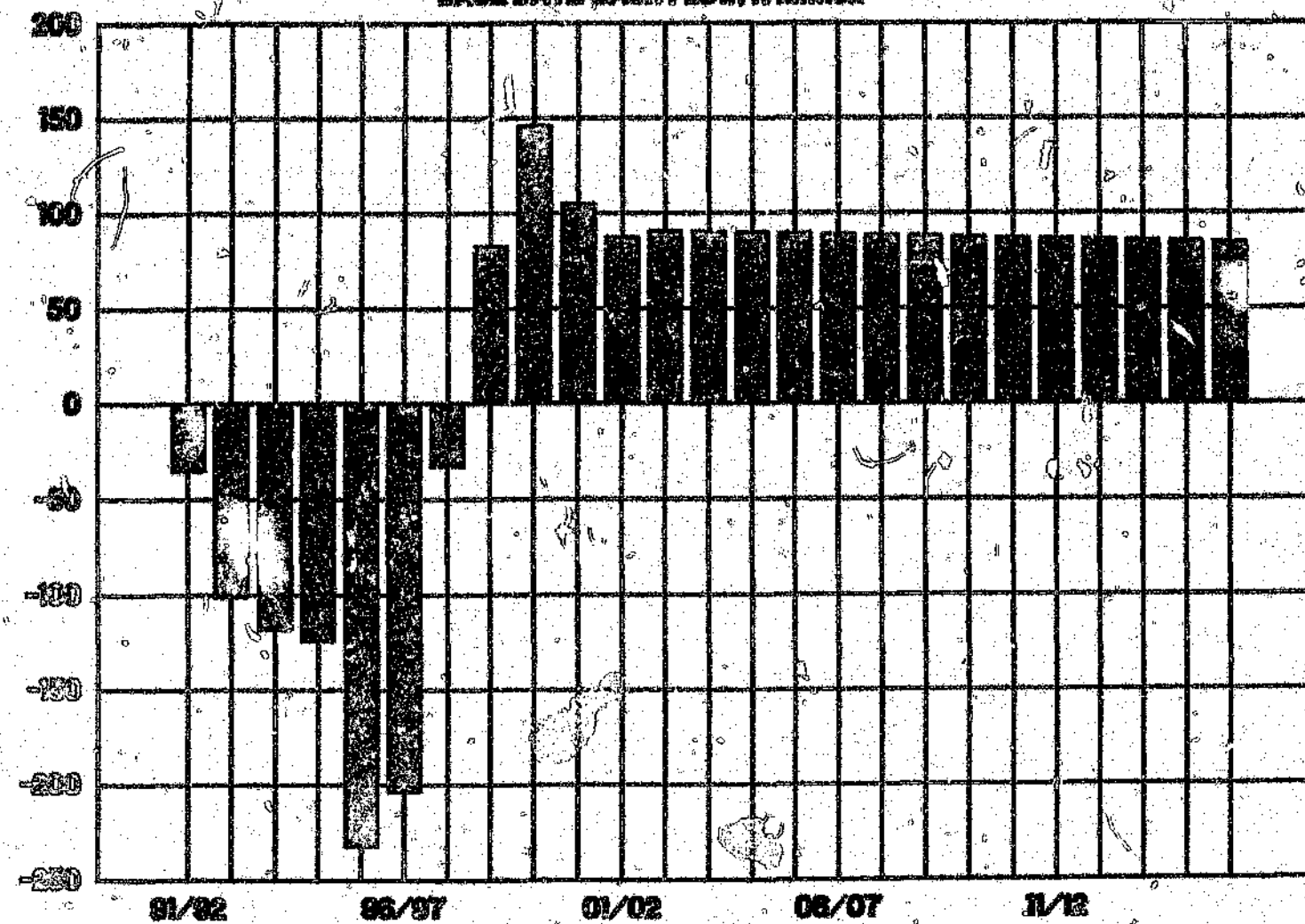
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

PLATINUM OUNCES PRODUCED



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

BASE DATE CASH FLOW, R million

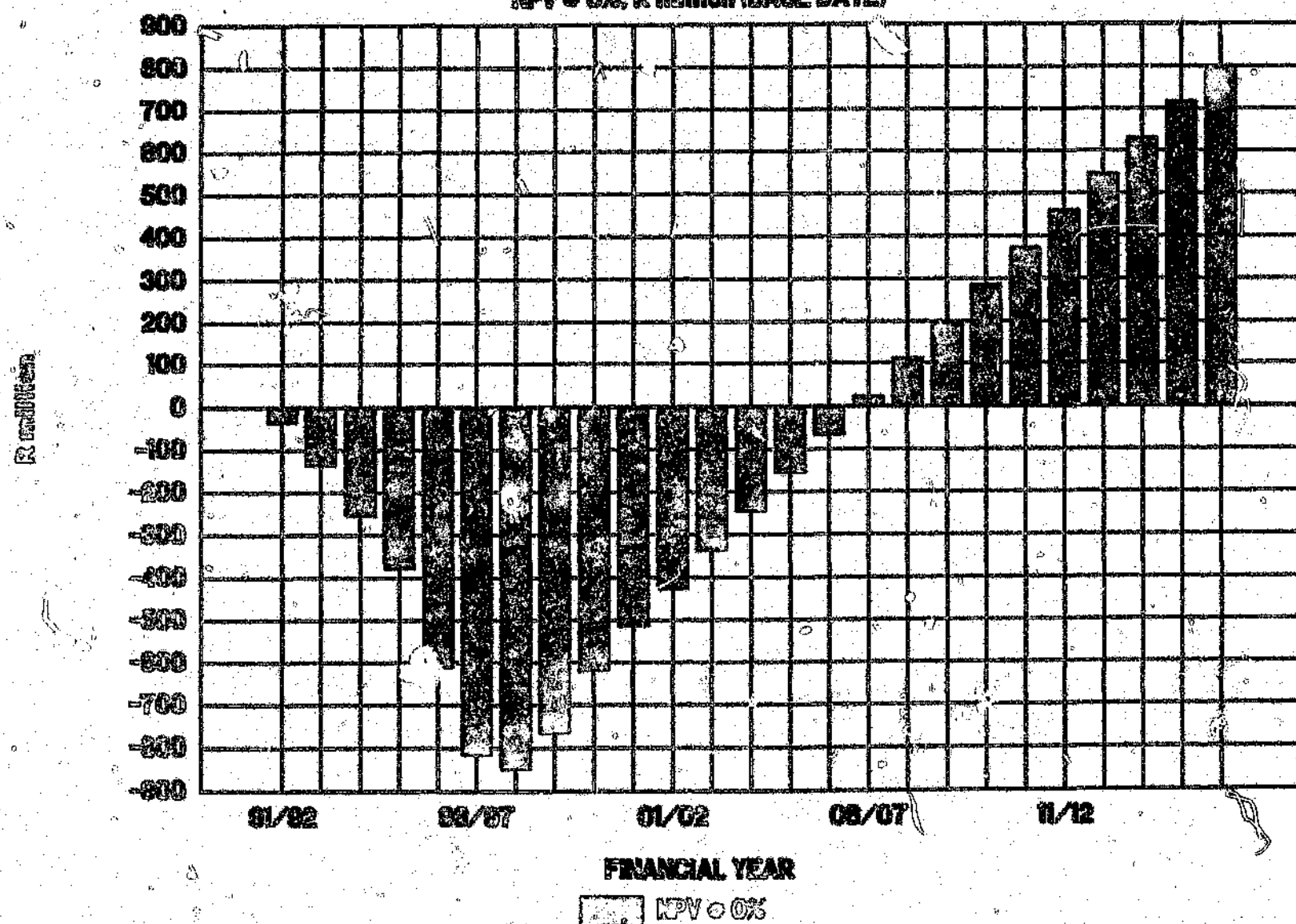


FINANCIAL YEAR

CASH FLOW

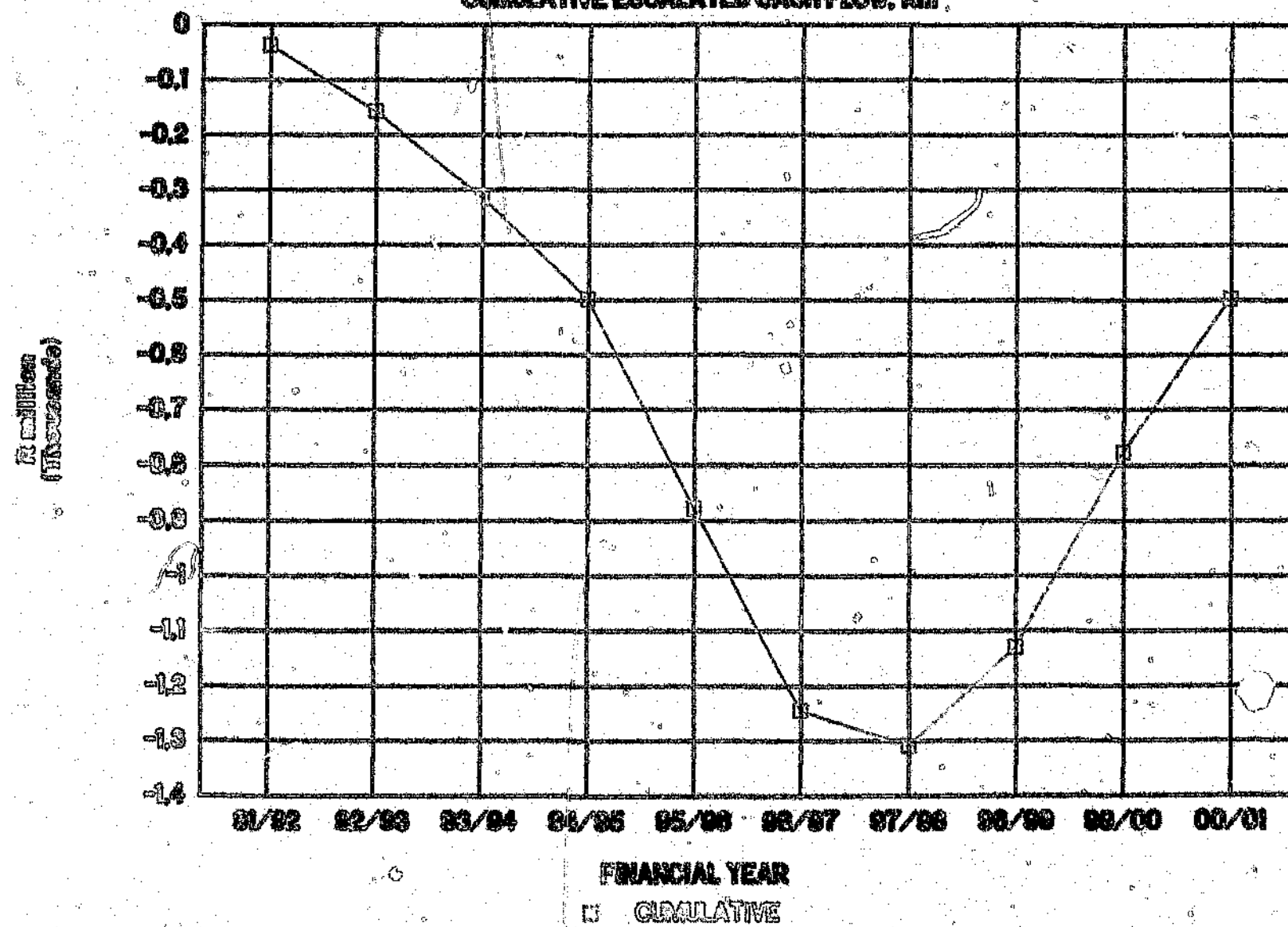
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

NPV = 0%, R million (BASE DATE)



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

CUMULATIVE ESCALATED CASH FLOW, Rm



01-07-23

SENSITIVITIES

* Company : XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

* SENSITIVITIES ON NETT TOTAL COSTS PER t, R/t:

	-5%	BASE	5%
*METAL PRICES	1.11	(3)	(7.85)
*WORK COSTS	(7.52)	(3.12)	1.27
*CAPEX	(3.21)	(3.12)	(2.98)
*REC GRADES	8.95	(3.12)	(7.19)
*MILLED TONS	(3.12)	(3.12)	(3.12)
*SACPI	(3.85)	(3.12)	(3.12)
*USCPI	(3.85)	(3.12)	(3.12)
*RA/US	1.57	(3.12)	(7.76)
*R/E	(3.12)	(3.12)	(3.12)
*LEASE	(3.11)	(3.12)	(3.12)
*ROYALTY	(2.19)	(3.12)	(3.06)
*TAX RATE	(3.12)	(3.12)	(3.12)
*WORST CASE		19.92	
*BEST CASE		(21.60)	

* SENSITIVITIES ON NETT TOTAL COSTS PER oz Pt, R/oz Pt

	-5%	BASE	5%
*METAL PRICES	23	(52)	(127)
*WORK COSTS	(124)	(52)	71
*CAPEX	(54)	(52)	(139)
*REC GRADES	12	(52)	(113)
*MILLED TONS	(52)	(52)	(52)
*SACPI	(51)	(52)	(52)
*USCPI	(51)	(52)	(52)
*RA/US	25	(52)	(139)
*R/E	(52)	(52)	(52)
*LEASE	(52)	(52)	(52)
*ROYALTY	(53)	(52)	(51)
*TAX RATE	(52)	(52)	(52)
*WORST CASE		249	
*BEST CASE		(342)	

* SENSITIVITIES ON CASH MARGIN, %

	-5%	BASE	5%
*METAL PRICES	38.55	41.44	44.85
*WORK COSTS	42.18	41.44	38.55
*CAPEX	41.59	41.44	41.35
*REC GRADES	36.07	41.44	43.77
*MILLED TONS	41.44	41.44	41.44
*SACPI	41.49	41.44	41.48
*USCPI	41.42	41.44	41.48
*RA/US	38.49	41.44	44.11
*R/E	41.44	41.44	41.44
*LEASE	41.43	41.44	41.44
*ROYALTY	41.48	41.44	41.40
*TAX RATE	41.44	41.44	41.44
*WORST CASE		29.35	
*BEST CASE		51.19	

* SENSITIVITIES ON NPV @ 10%, R million

	-20%	BASE	20%
*METAL PRICES	145	928	1 739
*WORK COSTS	1 361	928	496
*CAPEX	1 092	928	788
*REC GRADES	184	928	1 595
*MILLED TONS	998	928	1 374
*SACPI	1 772	928	975
*USCPI	1 168	928	1 335
*RA/US	717	928	1 722
*R/E	928	928	928
*LEASE	951	928	894
*ROYALTY	931	928	944
*TAX RATE	1 284	928	551
*TIMING	988	928	928
*WORST CASE		(1 957)	
*BEST CASE		6 522	

* SENSITIVITIES ON IRR, % REAL

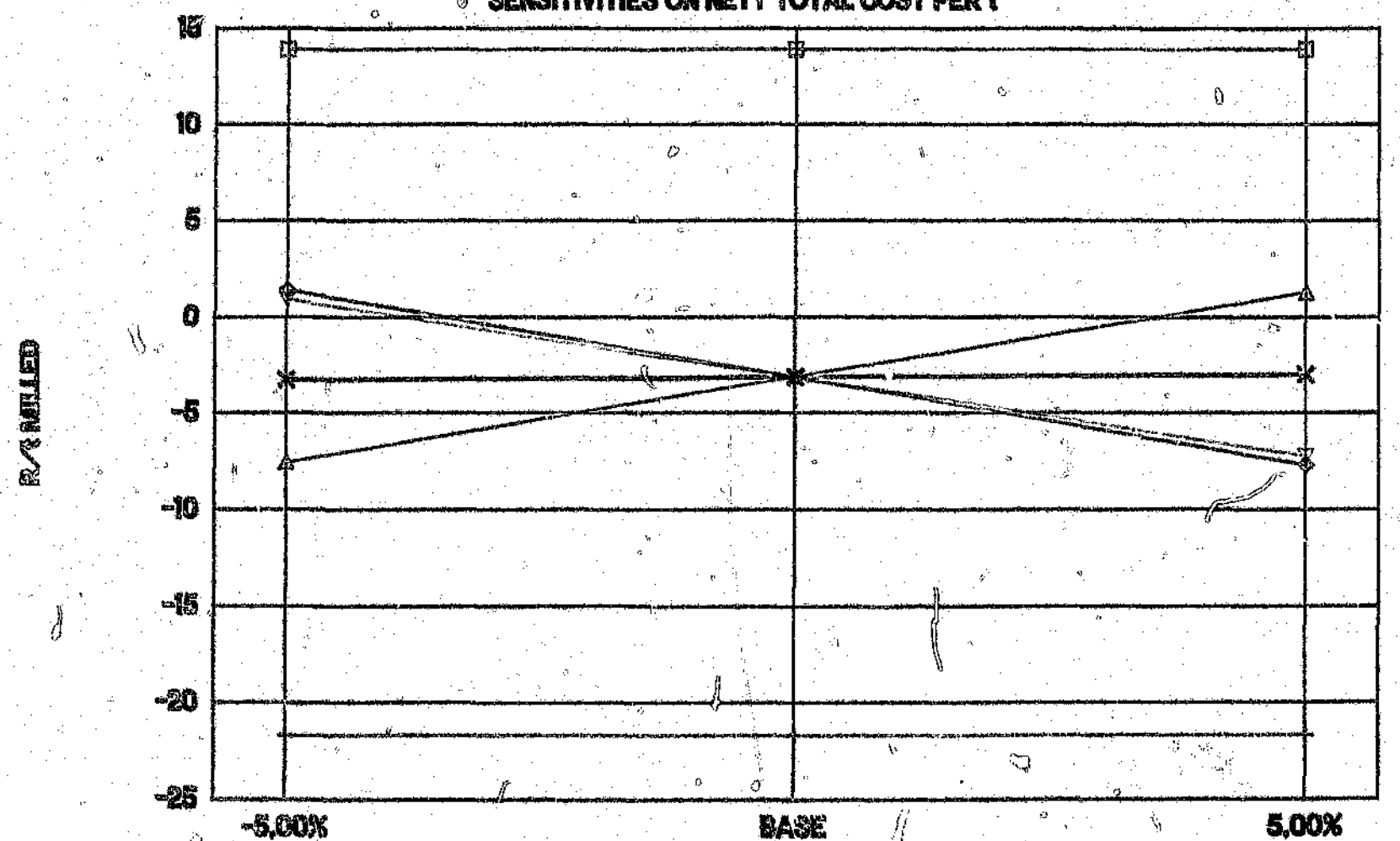
	-20%	BASE	20%
*METAL PRICES	1.29	6.85	11.31
*WORK COSTS	3.49	6.85	4.08
*CAPEX	9.25	6.85	5.21
*REC GRADES	1.52	6.85	11.04
*MILLED TONS	4.75	6.85	6.75
*SACPI	7.80	6.85	6.85
*USCPI	7.54	6.85	6.85
*RA/US	5.13	6.85	6.40
*R/E	6.64	6.85	6.64
*LEASE	7.02	6.85	6.66
*ROYALTY	6.87	6.85	6.83
*TAX RATE	6.20	6.85	5.28
*TIMING	7.61	6.85	6.74
*WORST CASE		ERR	
*BEST CASE		20.11	

* SENSITIVITIES ON MAX EXPOSURE, R million

	-20%	BASE	20%
*METAL PRICES	(1 415)	(1 305)	(1 207)
*WORK COSTS	(1 229)	(1 305)	(1 302)
*CAPEX	(1 011)	(1 305)	(1 688)
*REC GRADES	(1 167)	(1 305)	(1 285)
*MILLED TONS	(1 749)	(1 305)	(1 772)
*SACPI	(1 247)	(1 305)	(1 278)
*USCPI	(1 215)	(1 305)	(1 231)
*RA/US	(1 318)	(1 305)	(1 278)
*R/E	(1 385)	(1 305)	(1 305)
*LEASE	(1 385)	(1 305)	(1 305)
*ROYALTY	(1 385)	(1 305)	(1 385)
*TAX RATE	(1 385)	(1 305)	(1 385)
*TIMING	(1 259)	(1 305)	(1 333)
*WORST CASE		ERR	
*BEST CASE		(750)	

XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE.

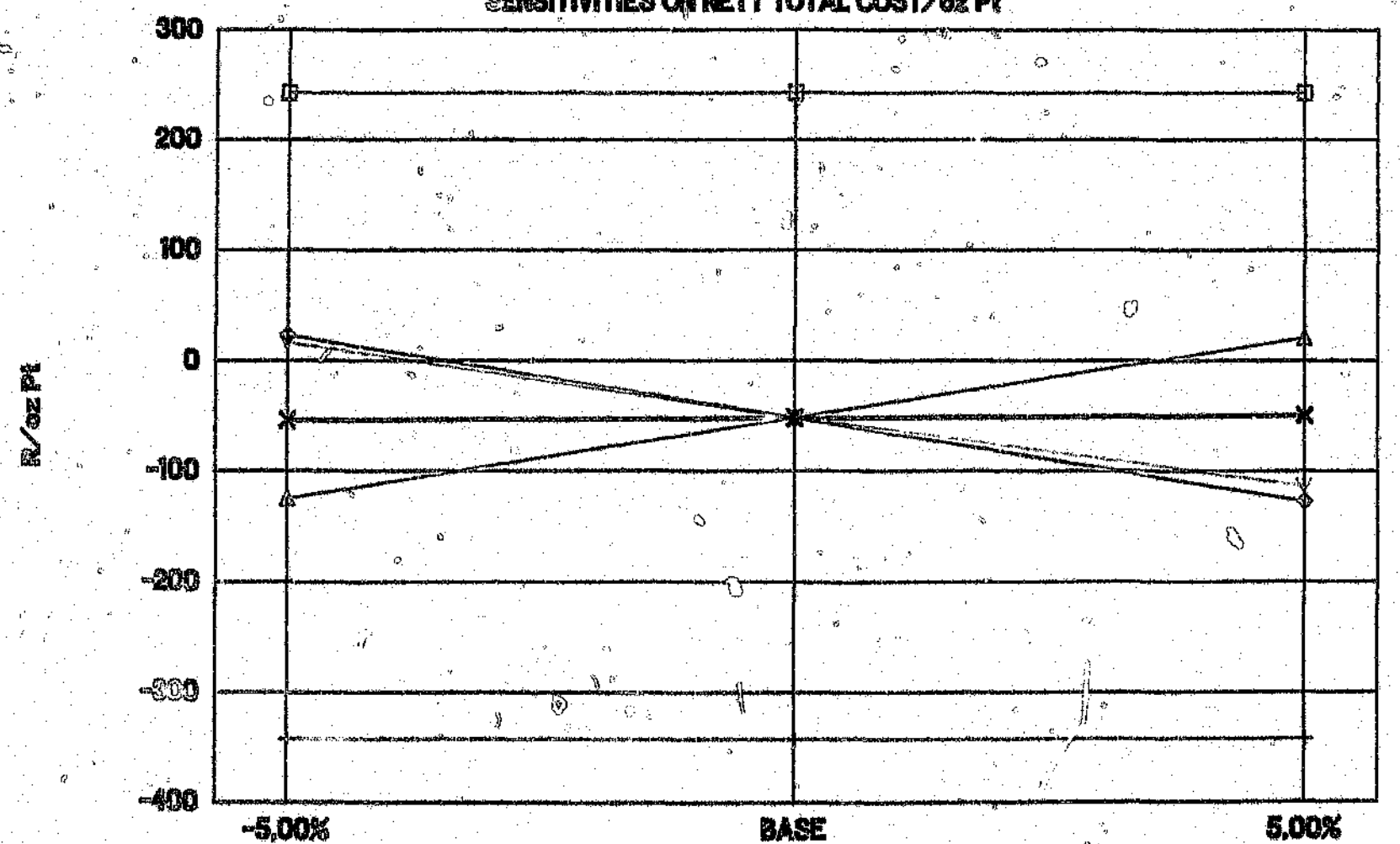
SENSITIVITIES ON NETT TOTAL COST PER t



□ WORST CASE + BEST CASE ◇ METAL PRICES △ WORKING COSTS × CAPEX
 ▽ RECOVERED GRADES

XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

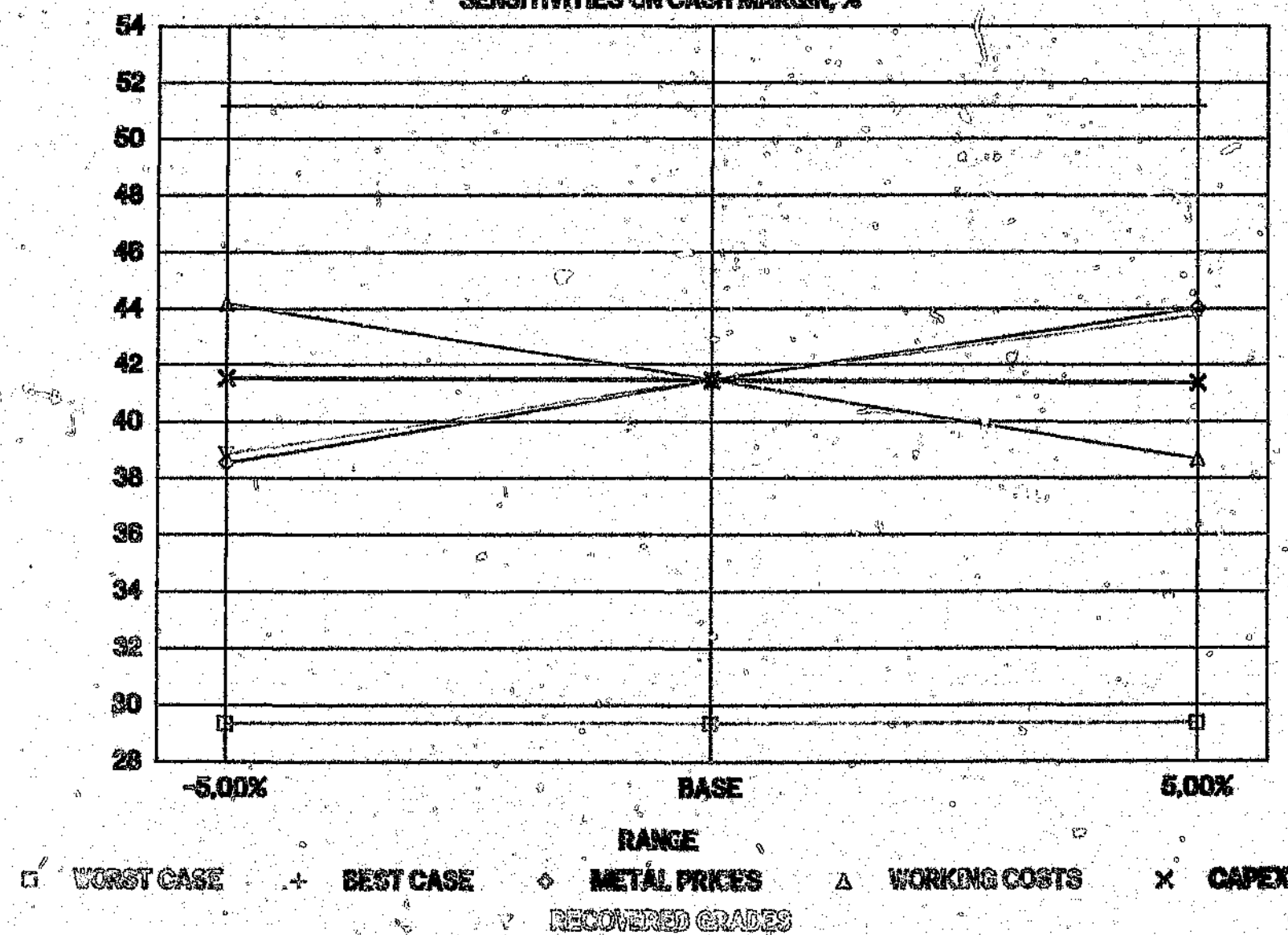
SENSITIVITIES ON NETT TOTAL COST/oz Pt



□ WORST CASE + BEST CASE ◇ METAL PRICES △ WORKING COSTS × CAPEX
 v RECOVERED GRADES

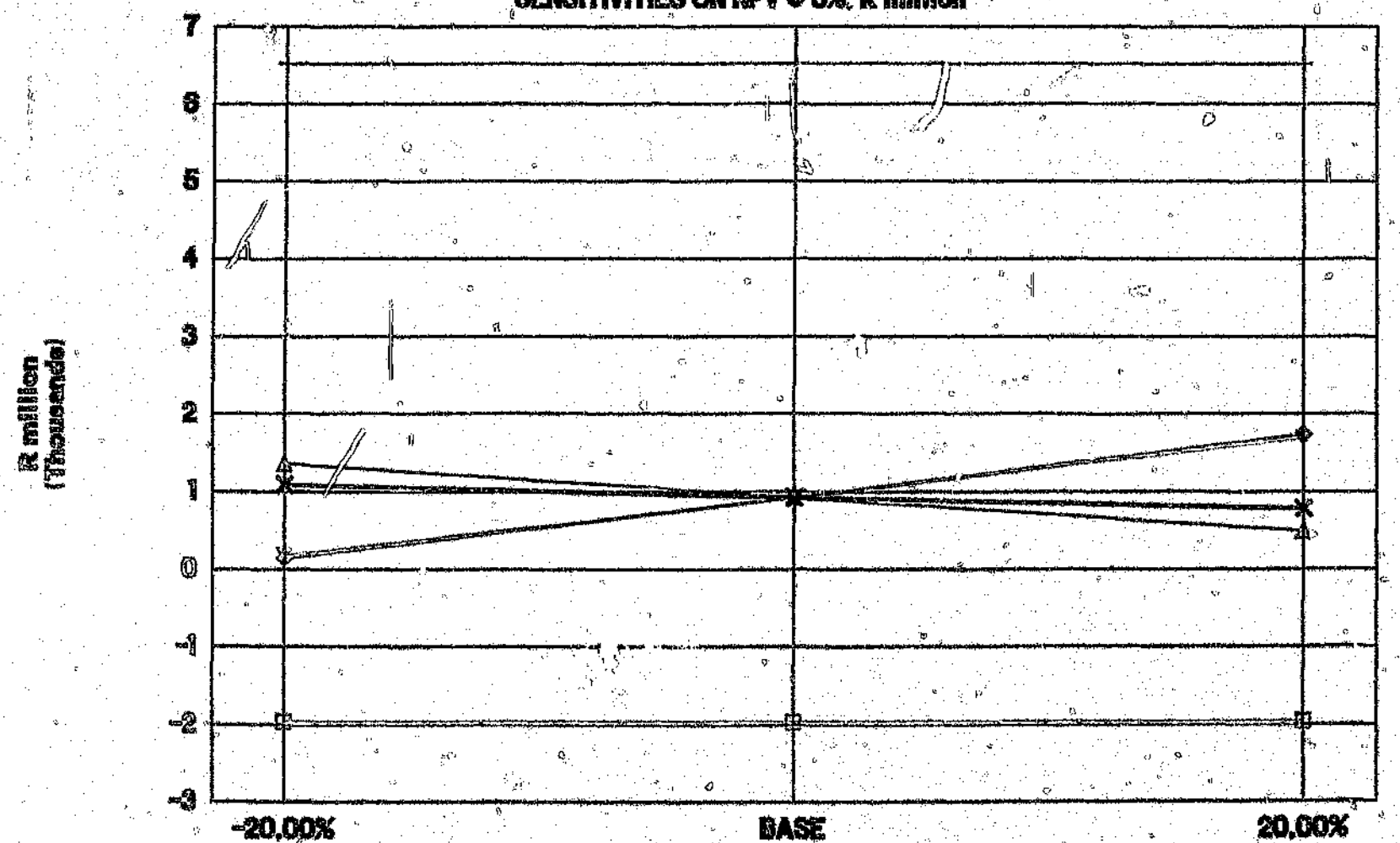
XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

SENSITIVITIES ON CASH MARGIN, %



XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

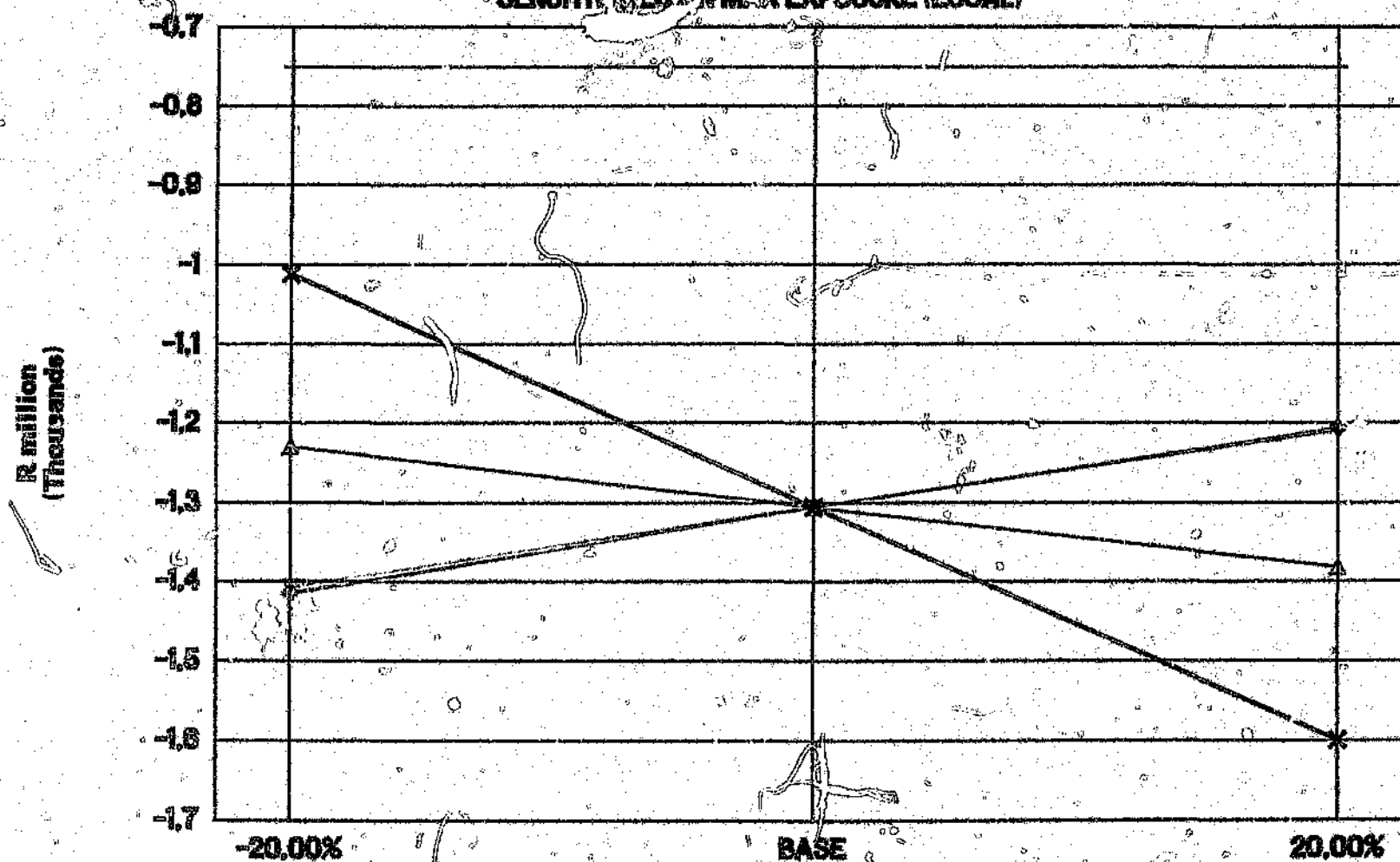
SENSITIVITIES ON NPV @ 0%, R million



□ WORST CASE + BEST CASE ♦ METAL PRICES Δ WORKING COSTS x CAPEX
 RECOVERED GRADES

XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

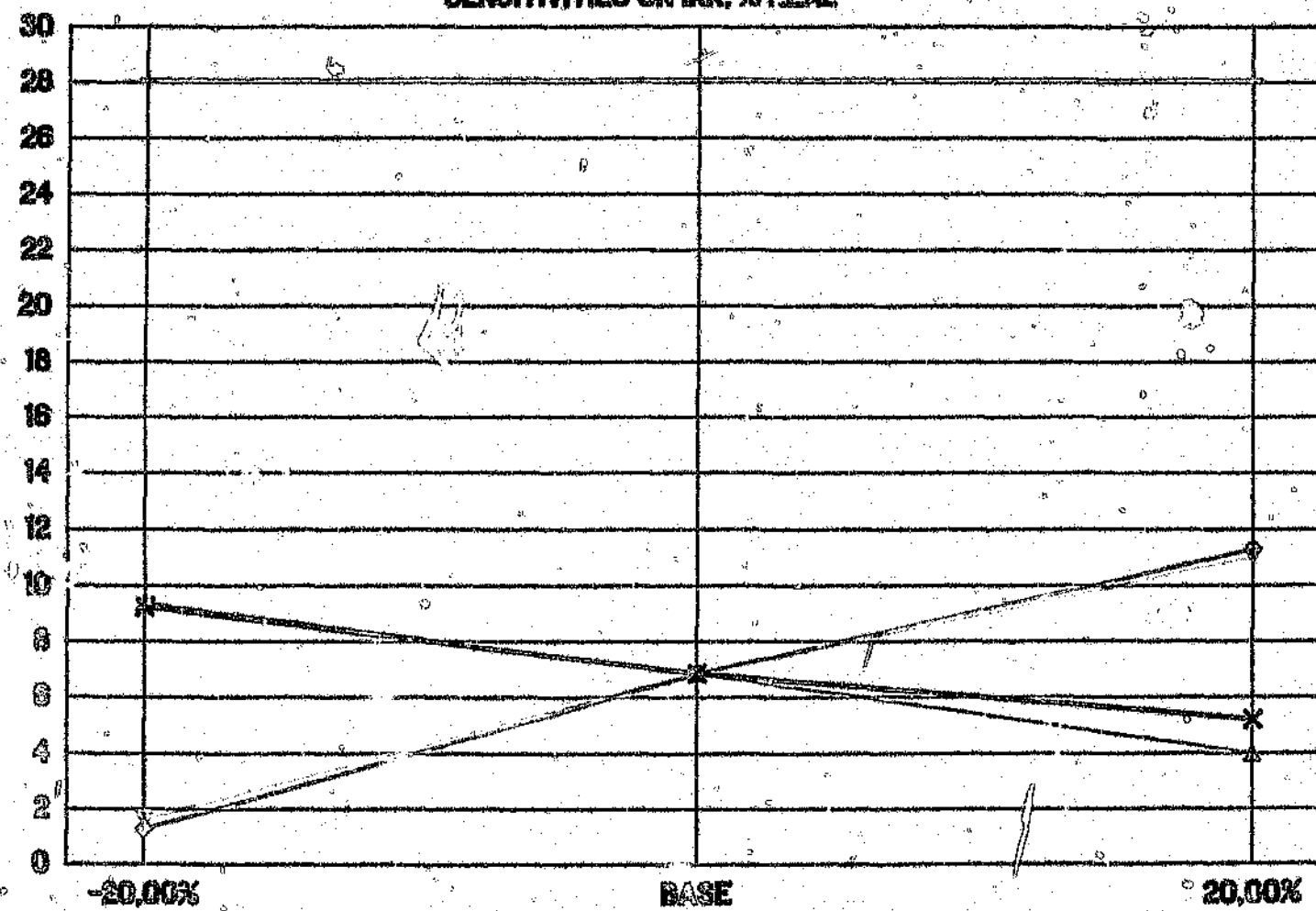
SENSITIVITY ON MAX EXPOSURE (ESCAL)



☐ WORST CASE + ☒ BEST CASE ♦ METAL PRICES Δ WORKING COSTS x CAPEX
 RECOVERED GRADES

XYZ PLATINUM MINE, A FICTITIOUS SOUTH AFRICAN MINE

SENSITIVITIES ON IRR, % DEAL



■ WORST CASE + BEST CASE ♦ METAL PRICES ▲ WORKING COSTS × CAPEX
 ▼ RECOVERED GRADES

5.3 RISK ANALYSIS RESULTS

Page 73 also shows the upside and downside percentages assumed for the XYZ Project. The following should be noted :

- (i) Metal prices variations are the same as those used for Hartley.
- (ii) Working costs are assumed to be known with a fair degree of certainty.
- (iii) Capex is also a relatively certain figure, compared to Hartley.
- (iv) General economic conditions for South Africa may have a greater potential for being worse than being better than the forecasts shown on page 13. The upsides for SACPI and exchange rates have thus been given greater weighting than their downsides, as for Hartley.
- (v) For XYZ mine, there is a possibility of lease agreements being scrapped with the new Minerals Bill. On the other hand, a new government may replace the lease system with another system in order to pay for socio-economic programmes. Thus, both the upside and downside potentials on this item are large.
- (vi) It is also assumed that tax rates have a greater potential to increase in a future dominated by government intervention coupled with their possible need to increase fiscal spending on socio-economic programmes.
- (vii) The timing and production build-up phase at XYZ are considered to be more well-defined than at Hartley.

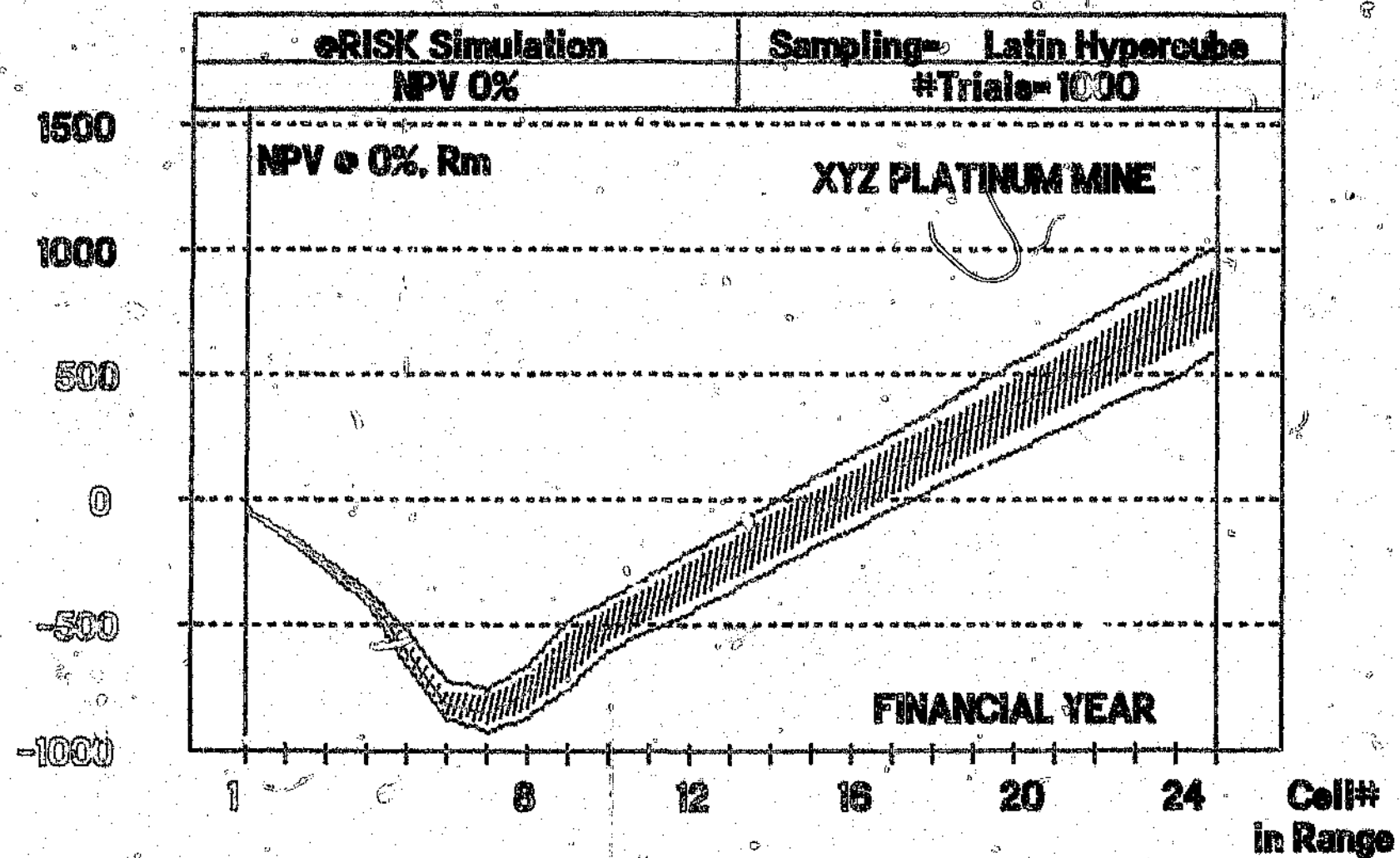
The results of the risk analysis for XYZ are shown graphically on pages 94 to 105.

In summary, they are as follows :-

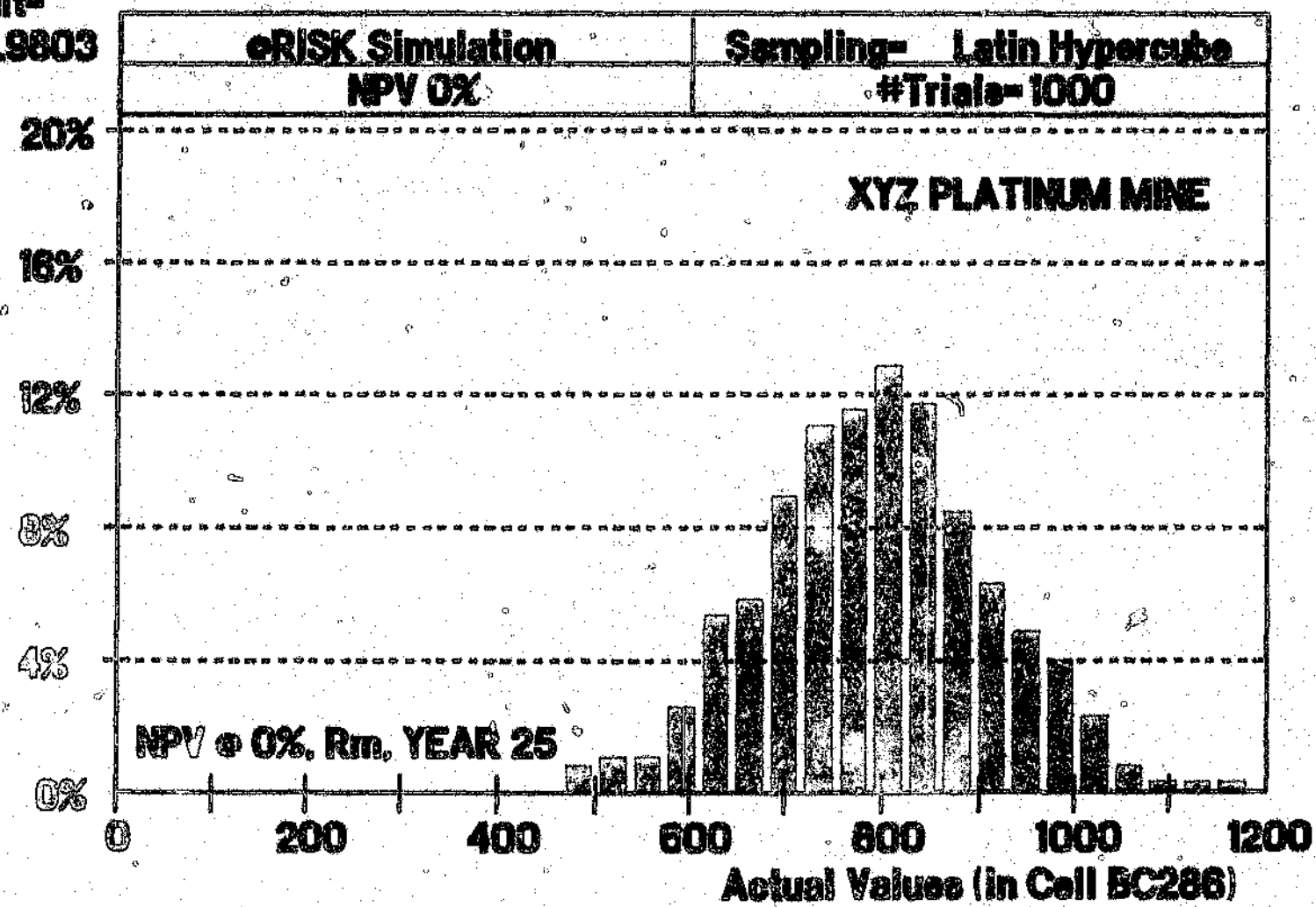
	Expected Result	Standard Deviation
Real IRR, %, 25 years :	6,301	0,873
NPV, R million, 25 years, @ 0% discount :	794,0	118,4
@ 3% discount :	290,8	71,5
@ 5% discount :	91,9	61,1
Maximum Exposure, escalated, R million :-	287,3	83,2
Maximum Exposure, base date, R million :	832,2	46,6
Payback Period, years, escalated money :	11,5	0,6
Payback Period, years, base date money :	15,2	1,0

The above expected result for Real IRR after 25 years of 6,30% is 0,55% less than the conventional result of 6,85%. This amount could be considered to be the risk discount rate to be applied over and above a "normal" hurdle rate for an NPV analysis.

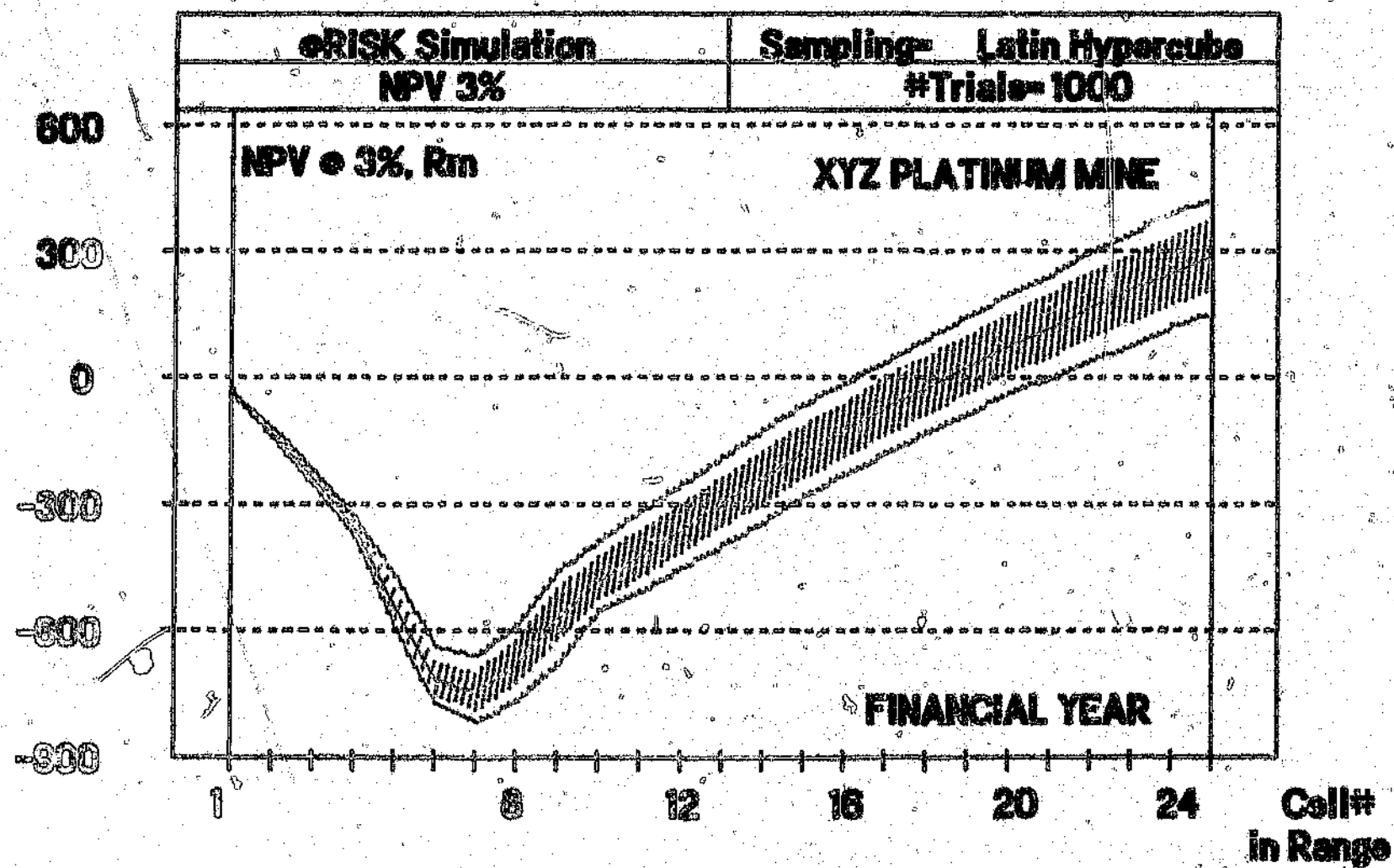
Trend in Mean,
1 Std Dev.,
5/95 Perc.



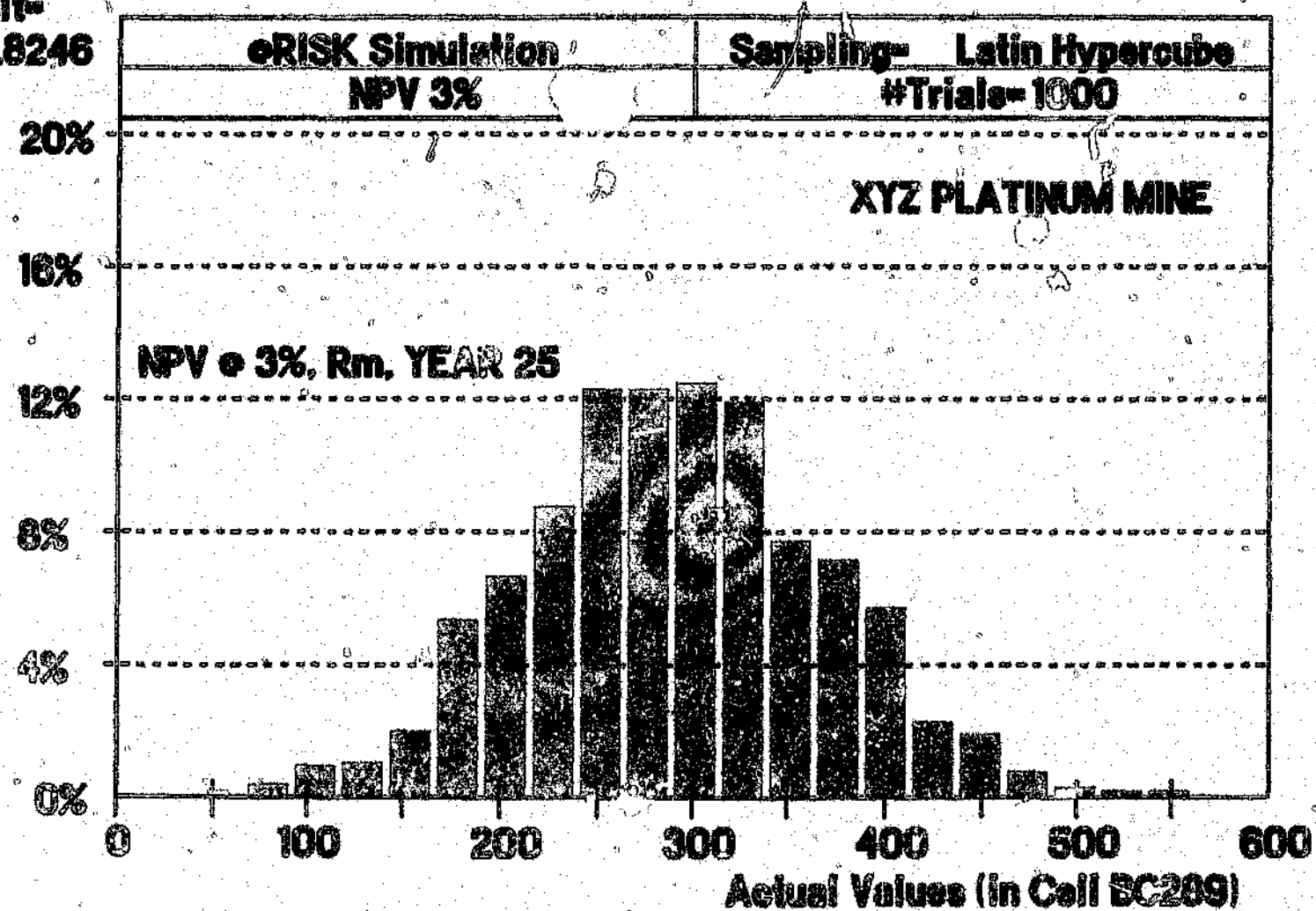
Expected
Result-
793.9803



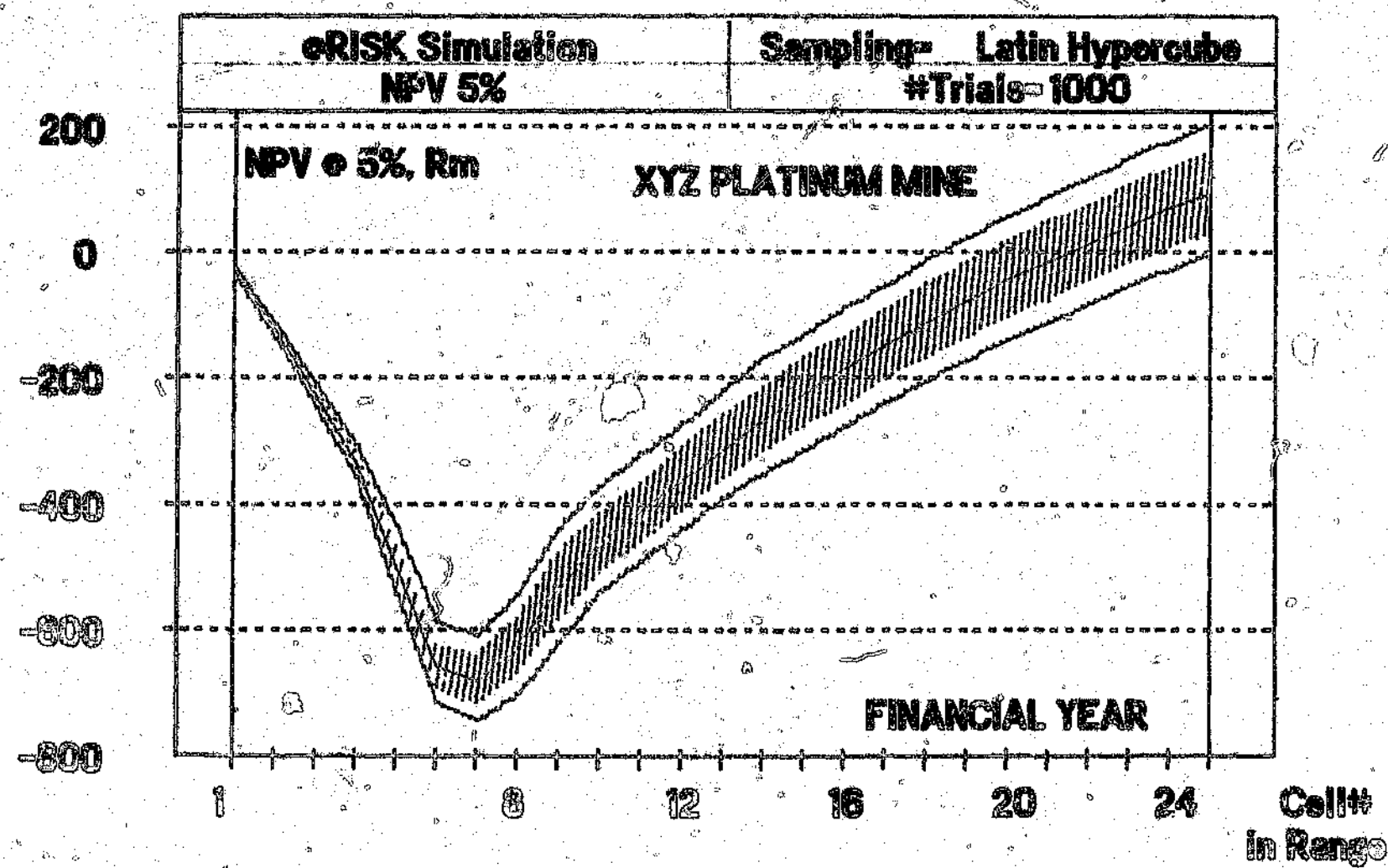
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Expected
Result=
290.8246



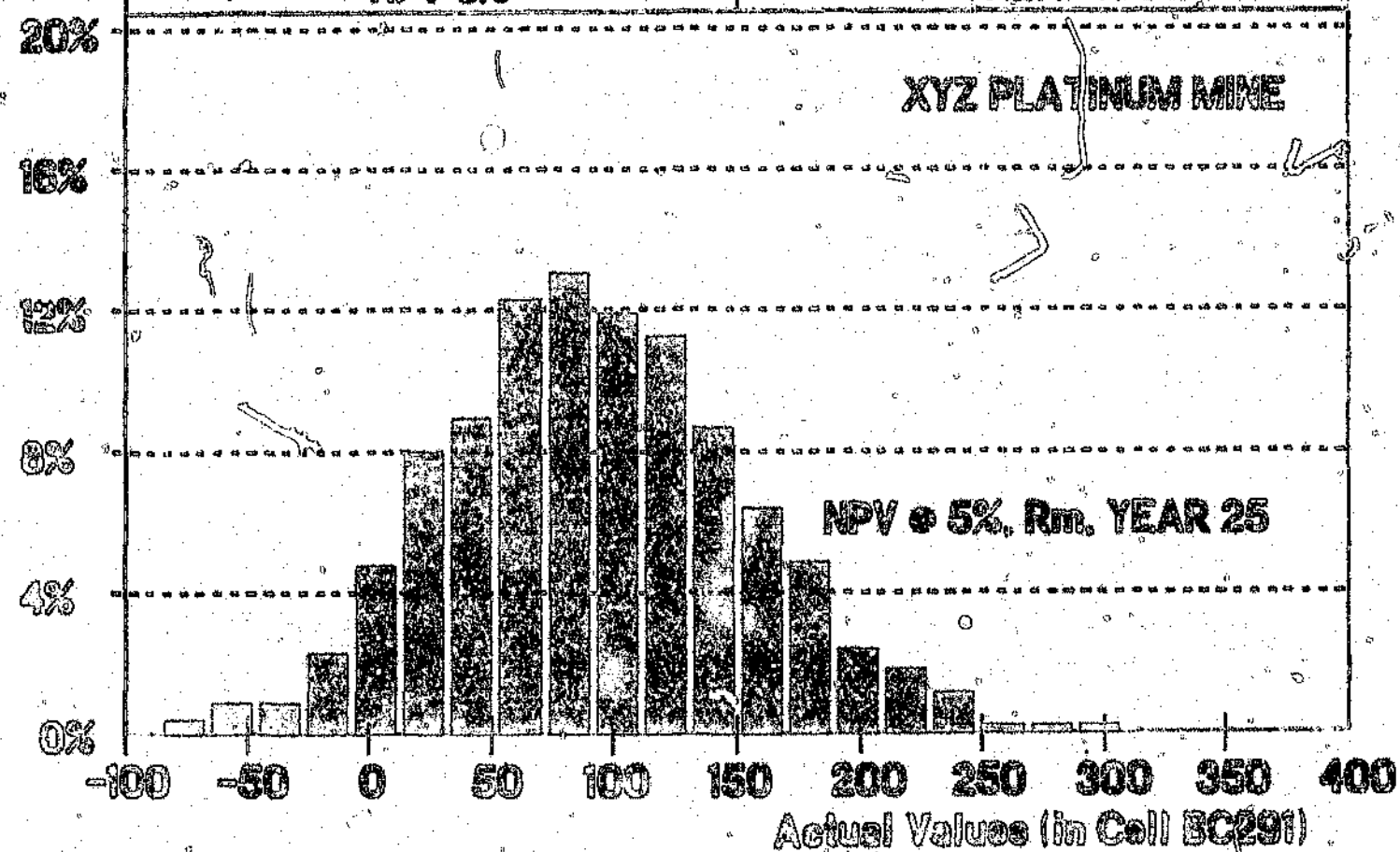
Trend in Mean,
1 Std Dev.,
5/95 Perc.



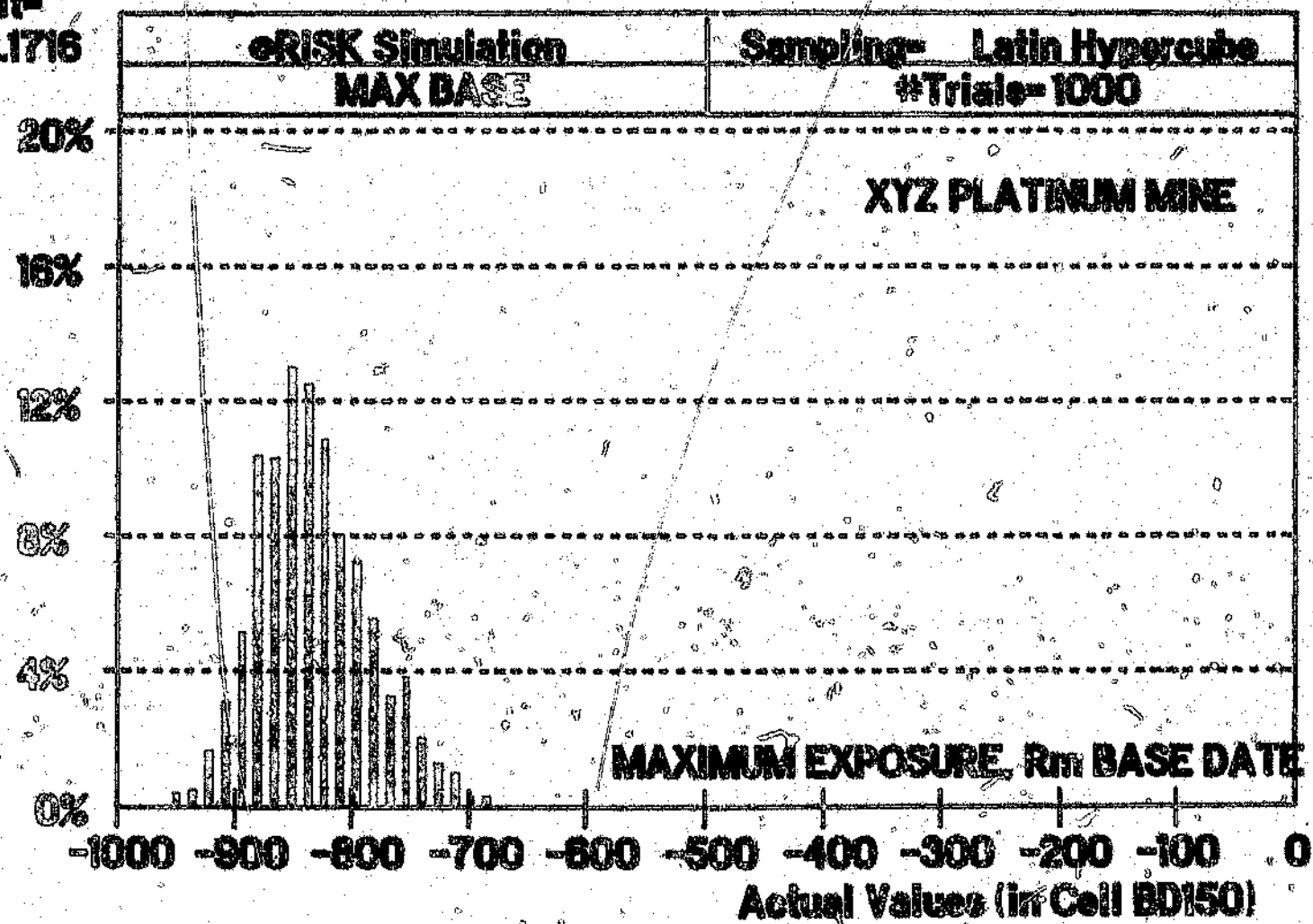
Expected
Result=
91.85538

eRISK Simulation
NPV 5%

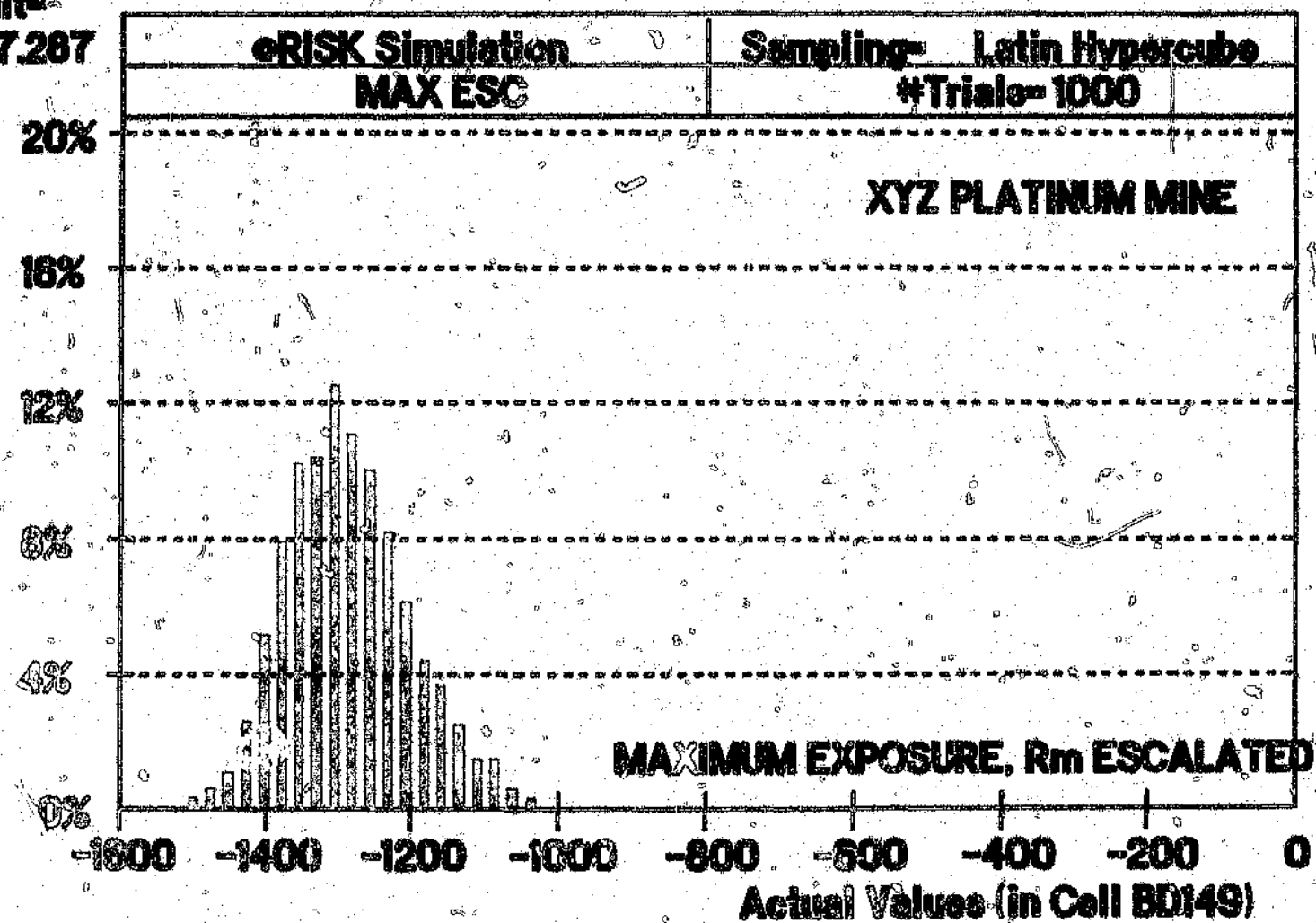
Sampling= Latin Hypercube
#Trials=1000



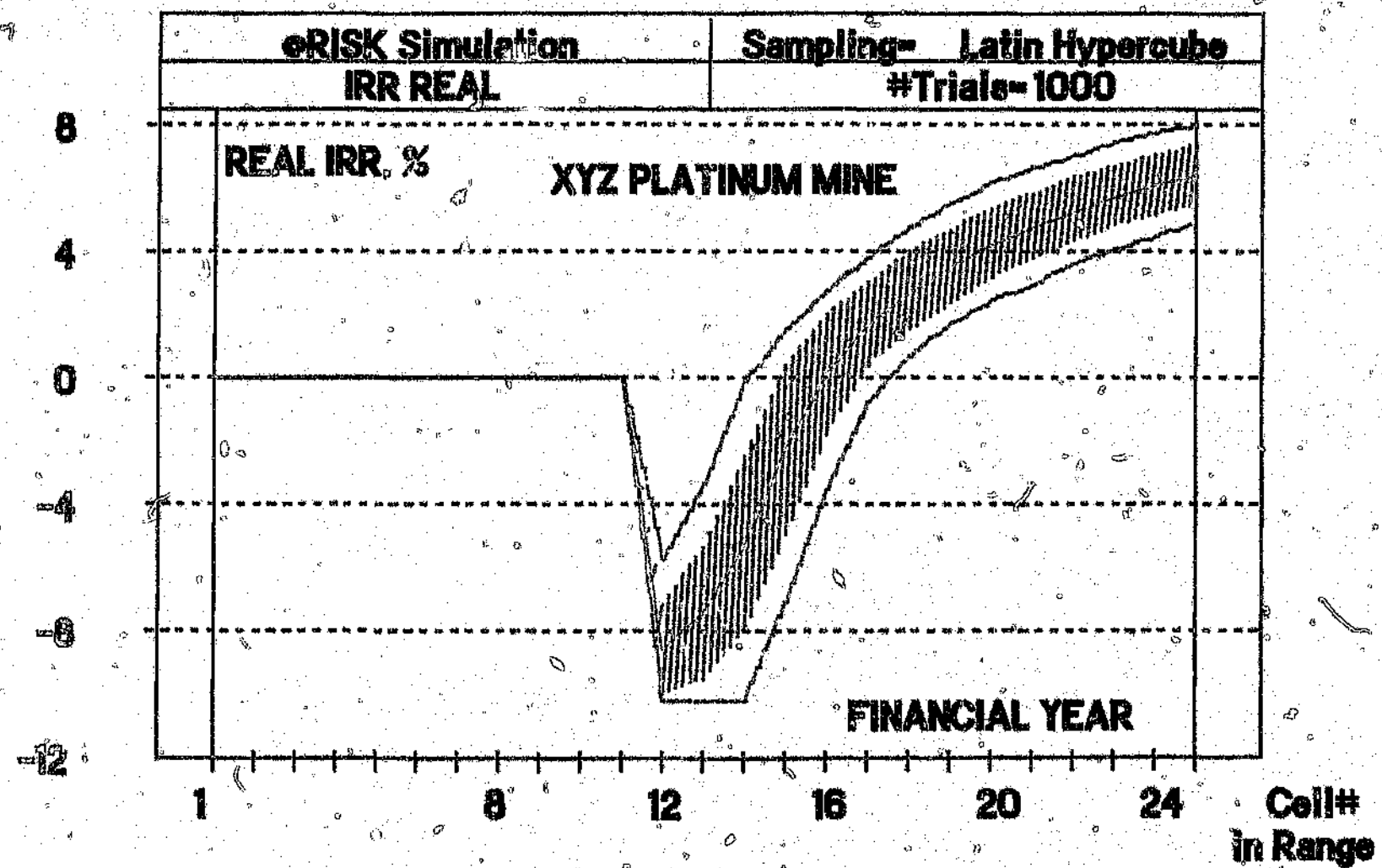
Exported
Result-
-832.1716



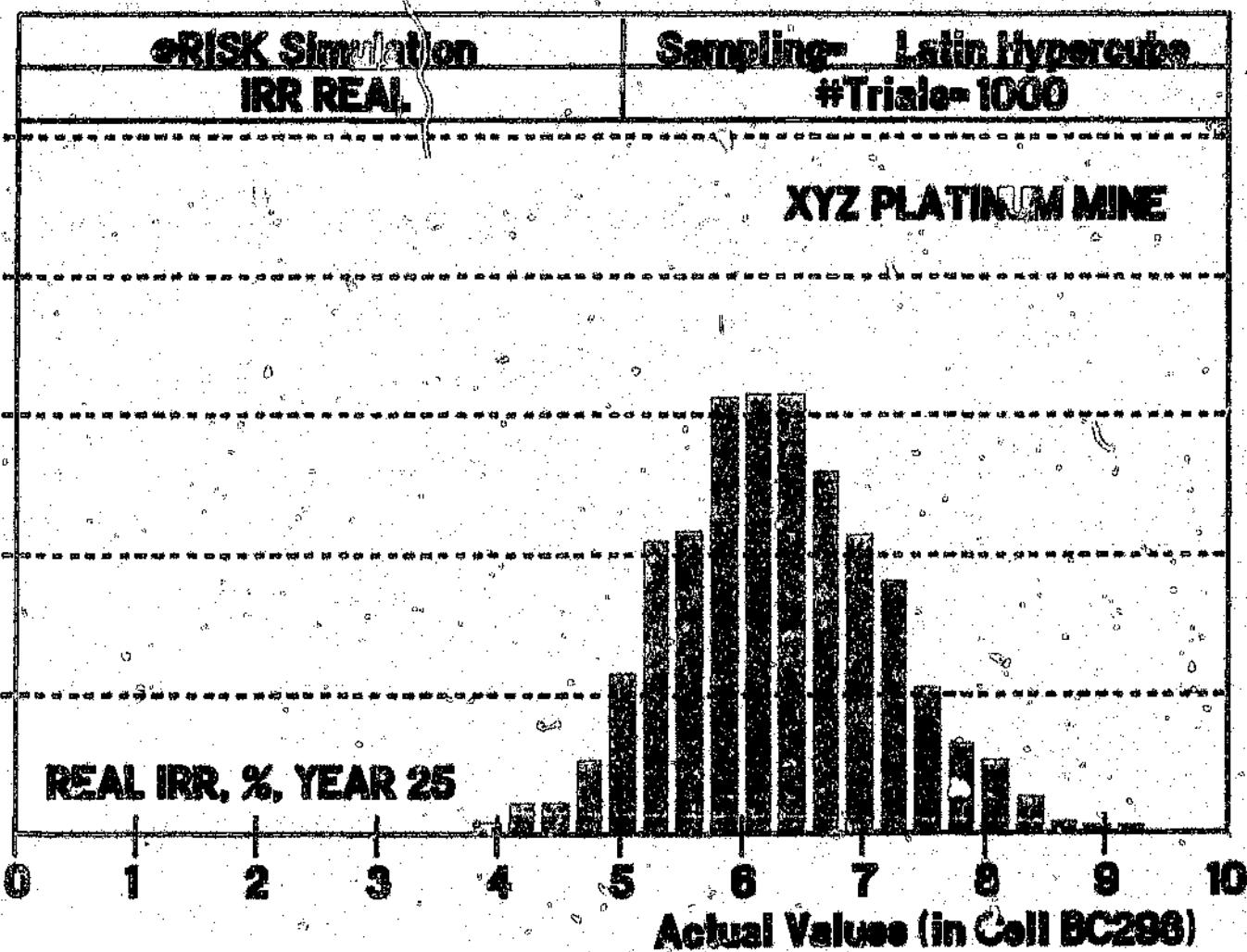
Expected
Result=
-1287.287



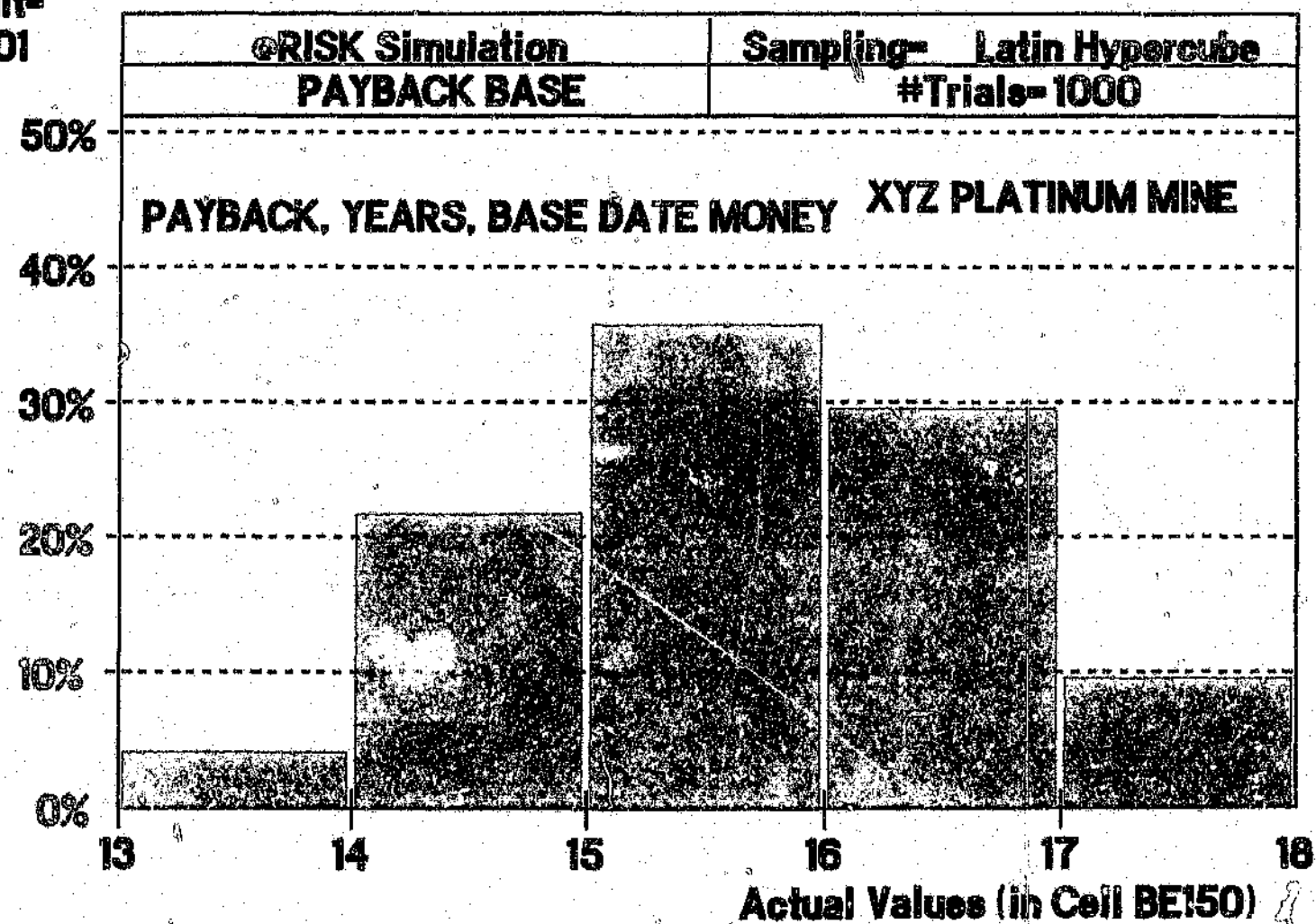
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



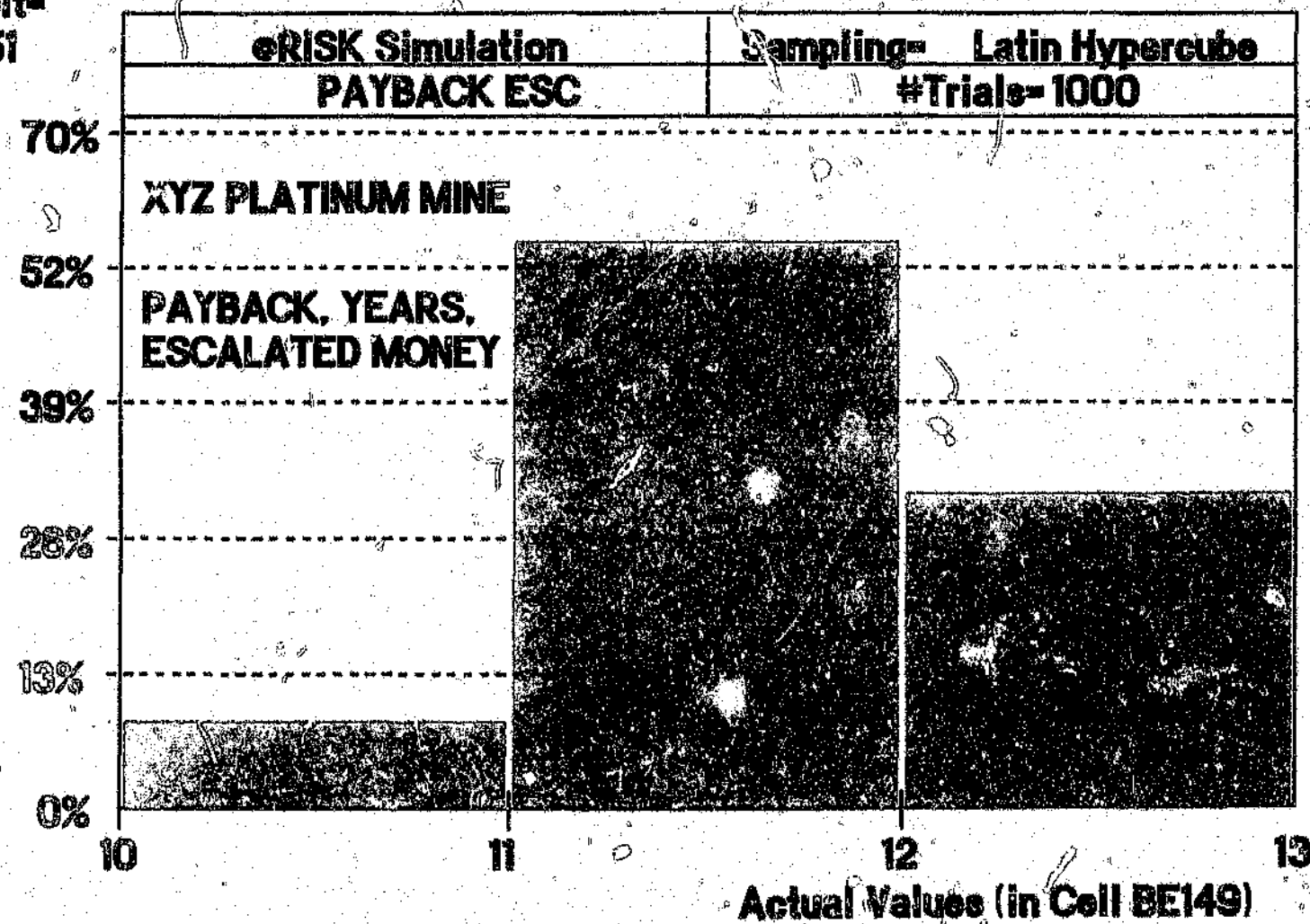
Expected
Result=
6.300794



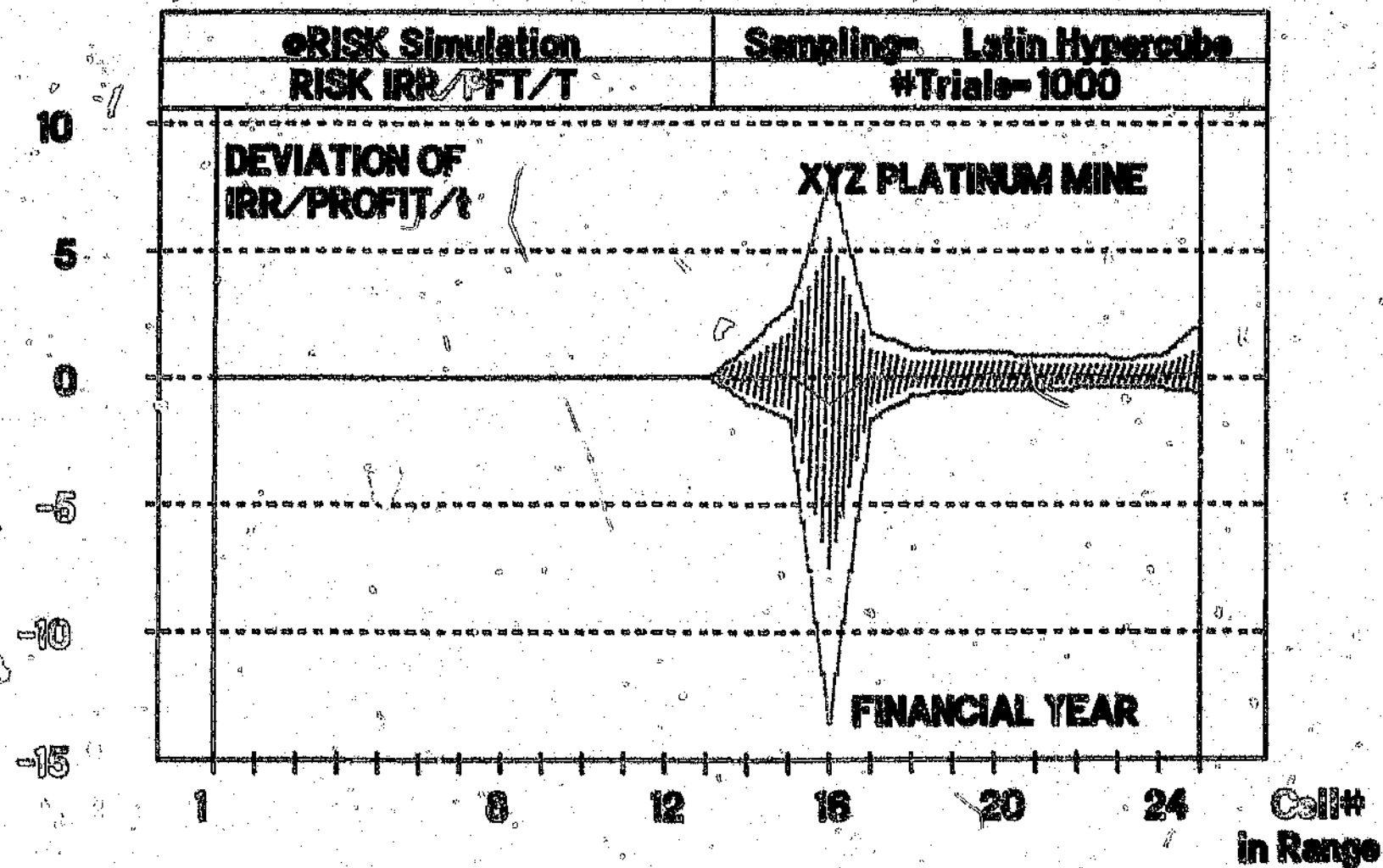
Expected
Result-
15.201



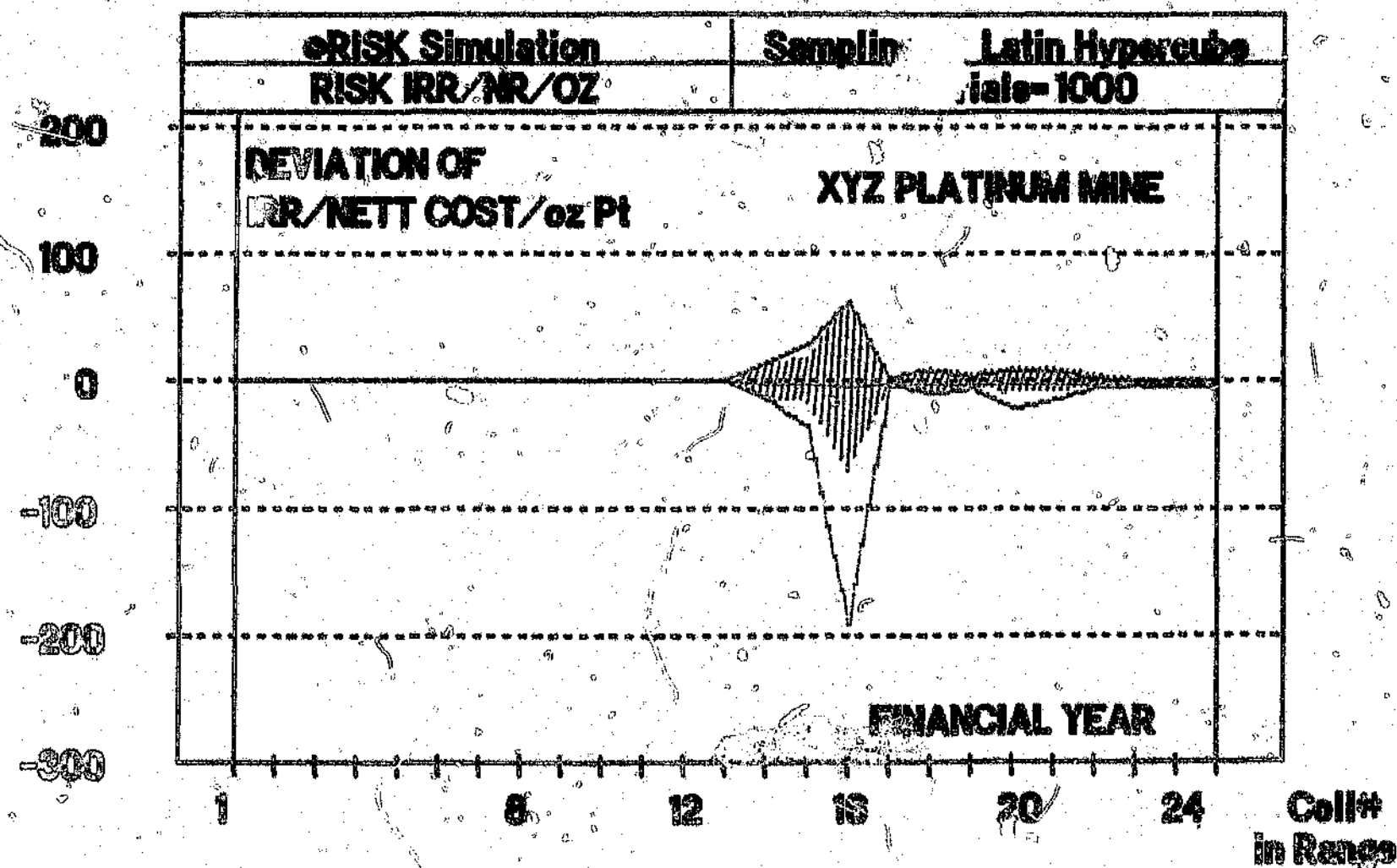
Expected
Result-
11.251



Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Trend in Mean,
1 Std Dev.,
5/95 Perc.



5.4 ROBUSTNESS CRITERIA

As mentioned in section 3.4, the objective is to find the variable, V , with an expected result closest to zero and with the smallest standard deviation.

The following results were produced (see pages 108 to 119 for graphical representations of these results), where E is the expected result and SD is the standard deviation for V for that year :-

RESULTS FOR x/y = REAL IRR DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criteria	1		2		3		4		5		6	
	Net Cost (RM)		Net Cost (RM/yr)		Pay-Off (RM)		Pay-Off (RM/yr)		Cost-Off Net Pay-Off (RM/yr)		Cost-Off Net Pay-Off (RM/yr)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
14	(0.759)	12.563	(0.743)	12.276	(0.093)	0.055	(0.093)	0.035	(0.140)	0.035	(0.022)	0.542
15	(0.714)	17.036	(0.723)	17.694	0.102	1.435	0.163	1.429	(0.040)	1.075	0.065	1.202
16	(1.093)	64.831	(3.934)	65.223	0.015	6.341	(1.010)	6.318	(0.975)	5.243	(0.035)	5.819
17	(0.025)	2.558	(0.221)	2.414	(0.277)	1.040	0.018	1.050	0.045	0.909	0.017	0.952
18	(1.060)	2.557	(1.000)	7.563	0.075	0.367	0.073	0.564	0.041	0.510	0.035	0.624
19	(0.373)	3.380	(0.870)	1.200	0.080	0.462	0.079	0.462	0.050	0.131	0.053	0.373
20	(1.143)	9.375	(1.031)	9.137	0.090	0.445	0.082	0.453	0.024	0.312	0.057	0.327
21	(0.998)	9.777	(0.998)	3.734	0.083	0.401	0.072	0.397	0.027	0.271	0.052	0.284
22	(0.925)	2.639	(0.959)	3.054	0.002	0.391	0.021	0.324	0.011	0.221	0.002	0.272
23	(1.021)	1.653	(1.019)	1.660	0.077	0.356	0.076	0.350	0.017	0.222	0.043	0.241
24	(1.075)	1.503	(1.077)	1.551	0.083	0.325	0.082	0.323	0.016	0.217	0.051	0.245
25	(0.504)	2.609	(0.913)	1.652	0.142	0.322	0.152	0.301	0.025	0.197	0.053	0.479
OVERALL	(1.106)	11.309	(1.107)	11.299	(0.015)	1.103	(0.010)	1.100	(0.040)	0.035	(0.010)	0.941

5.4 ROBUSTNESS CRITERIA

As mentioned in section 3.4, the objective is to find the variable, V, with an expected result closest to zero and with the smallest standard deviation.

The following results were produced (see pages 108 to 119 for graphical representations of these results), where E is the expected result and SD is the standard deviation for V for that year :-

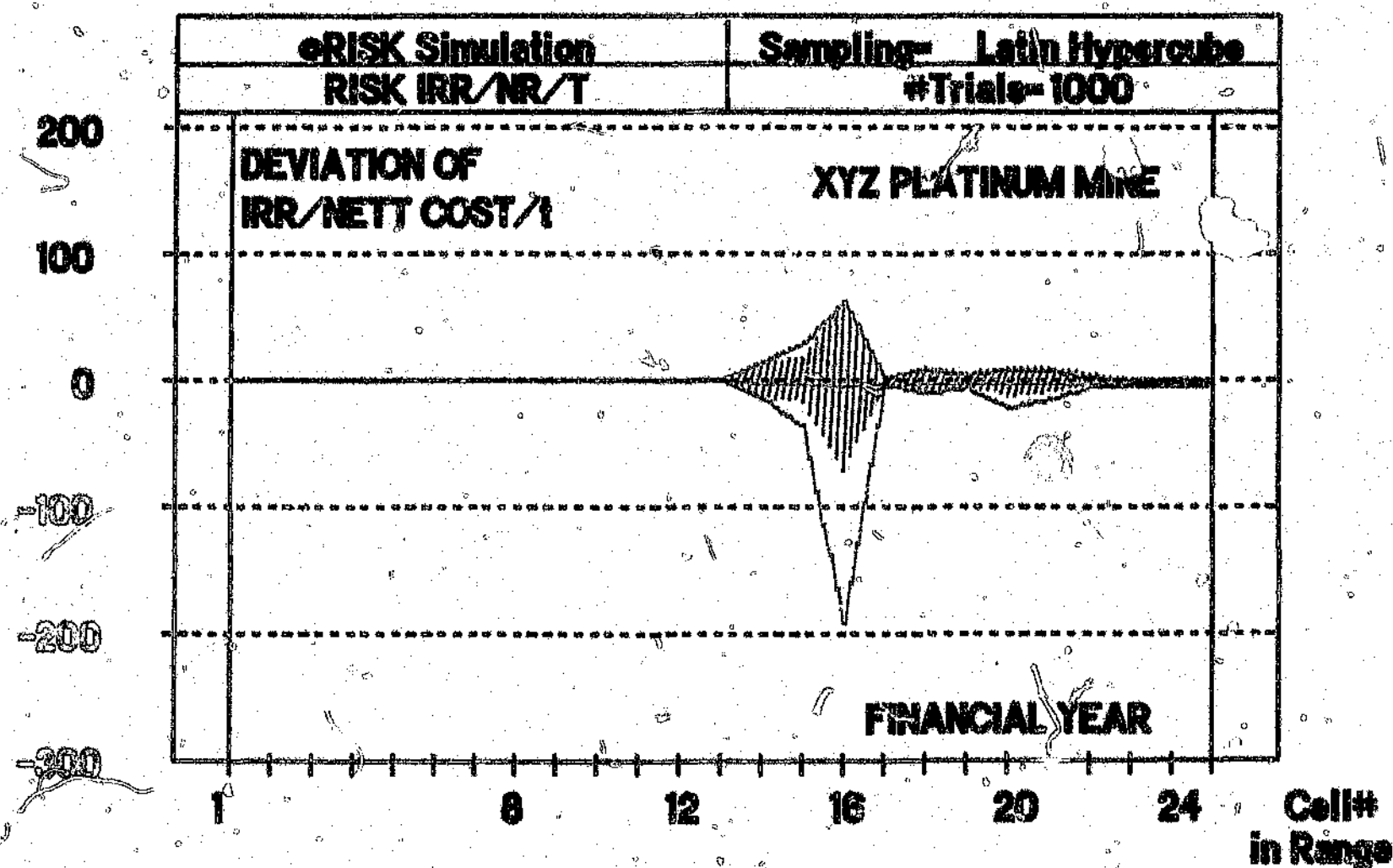
RESULTS FOR x/y = REAL IRR DIVIDED BY ROBUSTNESS CRITERIA 1 TO 6

Robustness Criteria	1 Net Cost (R)		2 Net Cost (R/ea P)		3 Profit (R)		4 Profit (R/ea P)		5 Cut-off Headgrade (g PGD/P)		6 Cash Margin (%)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
14	(8,739)	12,563	(0,748)	12,276	(0,053)	0,656	(0,053)	0,655	(0,147)	0,435	(0,092)	0,542
15	(6,714)	17,836	(0,721)	17,694	0,162	1,436	0,161	1,430	(0,046)	1,075	0,046	1,262
16	(5,090)	64,821	(3,131)	65,243	(1,015)	6,341	(1,013)	6,318	(0,575)	3,243	(0,833)	5,019
17	(0,835)	2,398	(0,321)	2,414	0,017	1,040	0,018	1,036	0,046	0,909	0,010	0,952
18	(1,777)	7,517	(1,000)	7,563	0,075	0,567	0,075	0,564	0,041	0,310	0,033	0,494
19	(0,875)	3,280	(0,076)	3,240	0,050	0,462	0,079	0,458	0,030	0,381	0,033	0,370
20	(1,033)	9,365	(1,031)	9,137	0,090	0,445	0,089	0,438	0,024	0,315	0,037	0,327
21	(0,994)	0,779	(0,999)	8,754	0,033	0,401	0,032	0,397	0,020	0,271	0,052	0,284
22	(0,035)	3,039	(0,505)	3,055	0,032	0,391	0,001	0,384	0,017	0,241	0,052	0,272
23	(1,020)	1,658	(1,019)	1,650	0,077	0,356	0,076	0,350	0,017	0,225	0,043	0,241
24	(1,075)	1,001	(1,077)	1,551	0,033	0,375	0,022	0,362	0,016	0,217	0,031	0,243
25	(0,704)	2,809	(0,903)	2,432	0,142	0,822	0,132	0,801	0,005	0,197	0,036	0,475
OVERALL	(1,100)	11,309	(1,109)	11,273	(0,015)	1,100	(0,016)	1,100	(0,040)	0,935	(0,019)	0,941

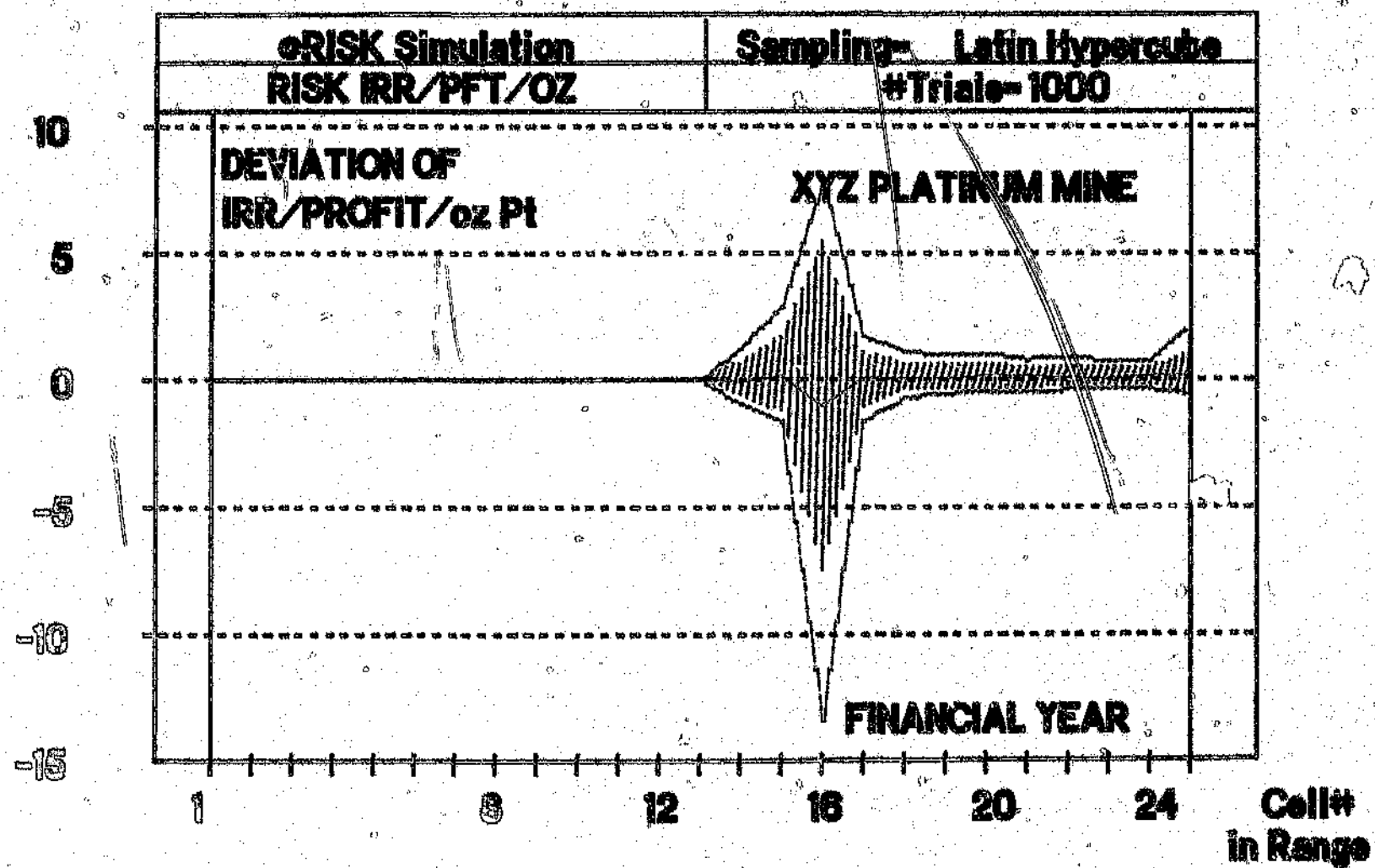
**RESULTS FOR x/y = NPV @ 0% DISCOUNT DIVIDED BY ROBUSTNESS
CRITERIA 1 TO 6**

Robustness Criterion	1 Net Cost (\$M)		2 Net Cost (\$/cc Py)		3 Profit (\$M)		4 Profit (\$/cc Py)		5 Default Expenditure (\$ PGMA)		6 Cash Margin (\$)	
Financial Year	E	SD	E	SD	E	SD	E	SD	E	SD	E	SD
6	0,031	0,284	0,031	0,207	0,929	22,669	0,011	26,370	0,021	0,116	0,078	11,913
7	(0,231)	66,036	(0,231)	59,794	0,131	0,343	0,131	0,342	0,019	0,108	0,079	0,363
8	(0,535)	14,397	(0,533)	14,433	0,113	0,401	0,111	0,403	0,019	0,102	0,081	0,326
9	(0,806)	2,722	(0,809)	2,689	0,091	0,446	0,090	0,448	0,018	0,114	0,083	0,298
10	(0,892)	3,143	(0,892)	3,132	0,037	0,413	0,035	0,407	0,033	0,128	0,014	0,271
11	(0,970)	2,571	(0,932)	2,569	0,053	0,423	0,051	0,418	0,048	0,139	0,017	0,289
12	(0,973)	6,510	(0,966)	6,606	0,039	0,482	0,032	0,476	0,054	0,201	0,003	0,339
13	(0,921)	5,845	(0,920)	5,811	0,040	0,503	0,044	0,538	0,066	0,283	0,000	0,414
14	(0,906)	3,933	(0,903)	3,939	0,023	0,723	0,031	0,719	0,091	0,483	0,010	0,604
15	(0,663)	15,629	(0,670)	15,514	0,015	1,439	0,013	1,438	0,193	1,243	0,037	1,346
16	(2,375)	83,187	(2,293)	82,210	0,106	4,290	-0,111	4,273	0,497	3,936	0,214	4,043
17	(4,347)	83,453	(4,341)	83,296	0,073	0,807	0,072	0,889	0,091	0,806	0,005	0,832
18	(1,025)	4,560	(1,026)	4,531	0,031	0,613	0,079	0,606	0,038	0,516	0,056	0,519
19	(1,356)	10,366	(1,369)	10,705	0,071	0,463	0,070	0,463	0,025	0,399	0,044	0,373
20	(1,134)	4,023	(1,151)	4,042	0,068	0,424	0,087	0,418	0,014	0,321	0,040	0,312
21	(1,003)	1,420	(1,004)	1,414	0,082	0,390	0,062	0,3	0,012	0,293	0,034	0,279
22	(0,933)	3,267	(0,953)	3,245	0,060	0,256	0,039	0,351	0,004	0,264	0,032	0,249
23	(1,212)	6,516	(1,204)	6,344	0,064	0,369	0,053	0,362	0,003	0,244	0,034	0,247
24	(1,005)	2,039	(1,004)	2,035	0,061	0,354	0,061	0,350	0,004	0,235	0,032	0,231
25	(1,330)	10,344	(1,330)	10,313	0,068	0,353	0,079	0,33	0,002	0,220	0,047	0,226
OVERALL	(1,113)	16,359	(1,110)	16,190	0,113	1,835	0,111	2,015	0,009	0,514	0,071	1,674

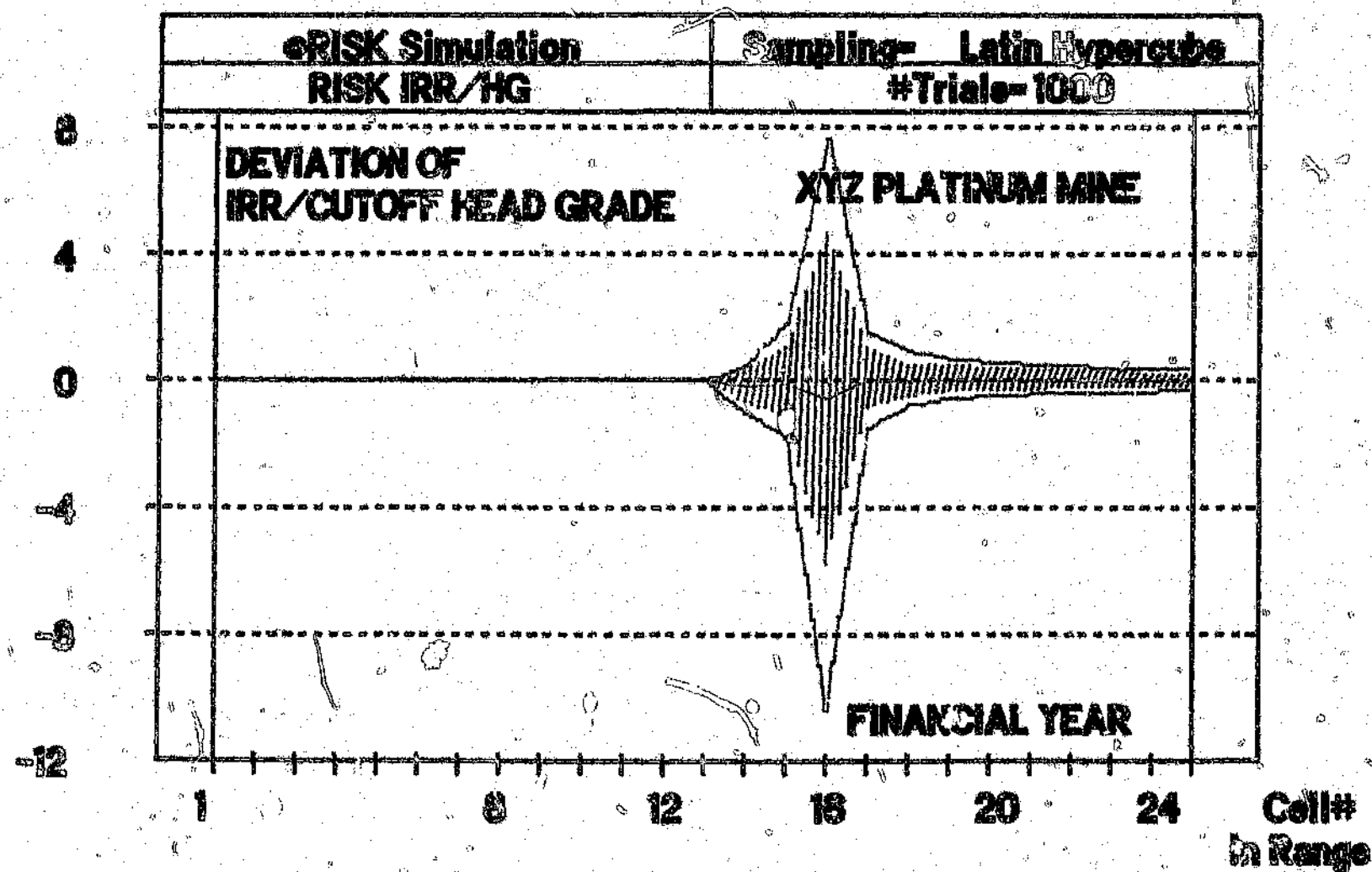
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



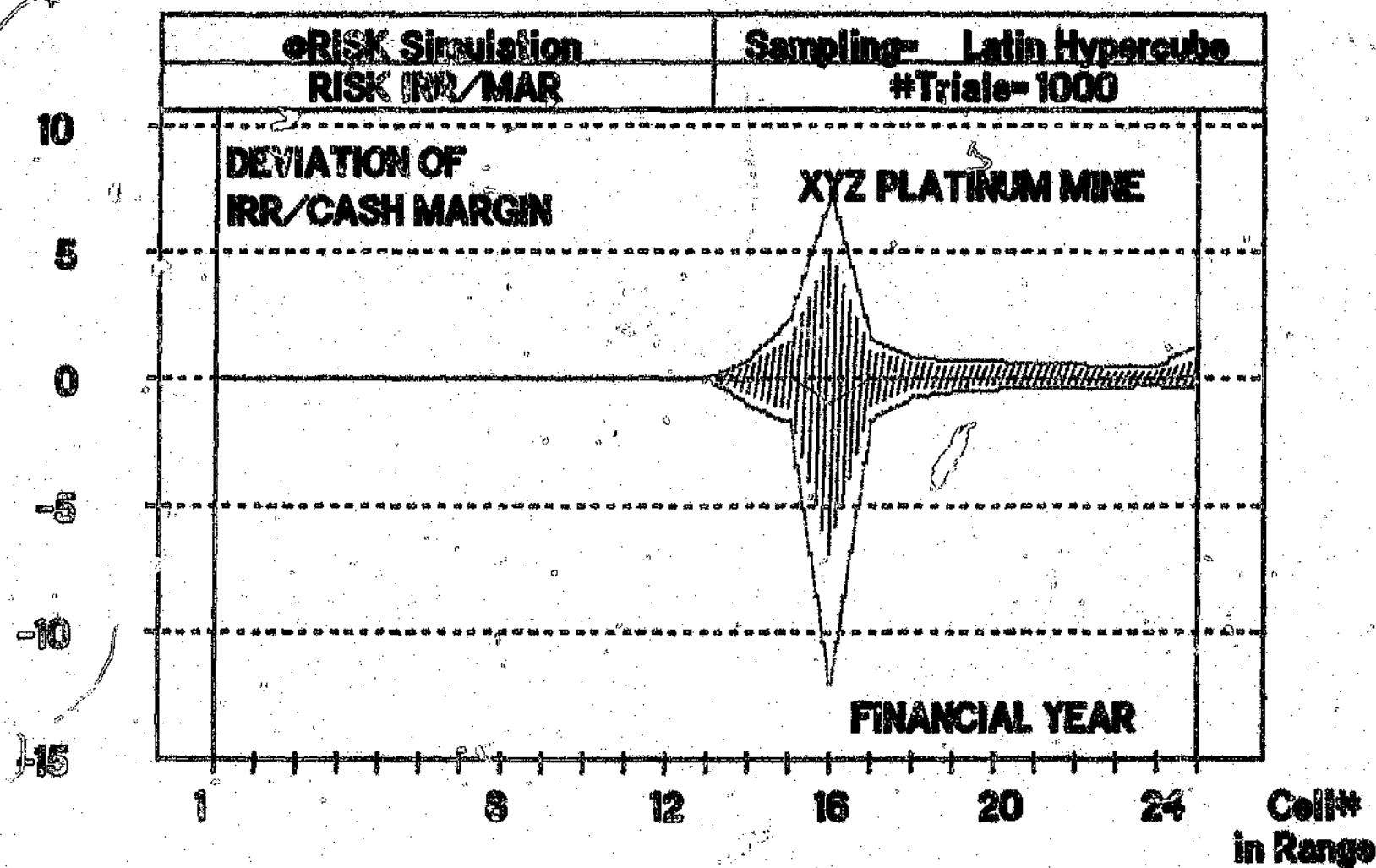
Trend in Mean.
1 Std Dev.
5/55 Perc.



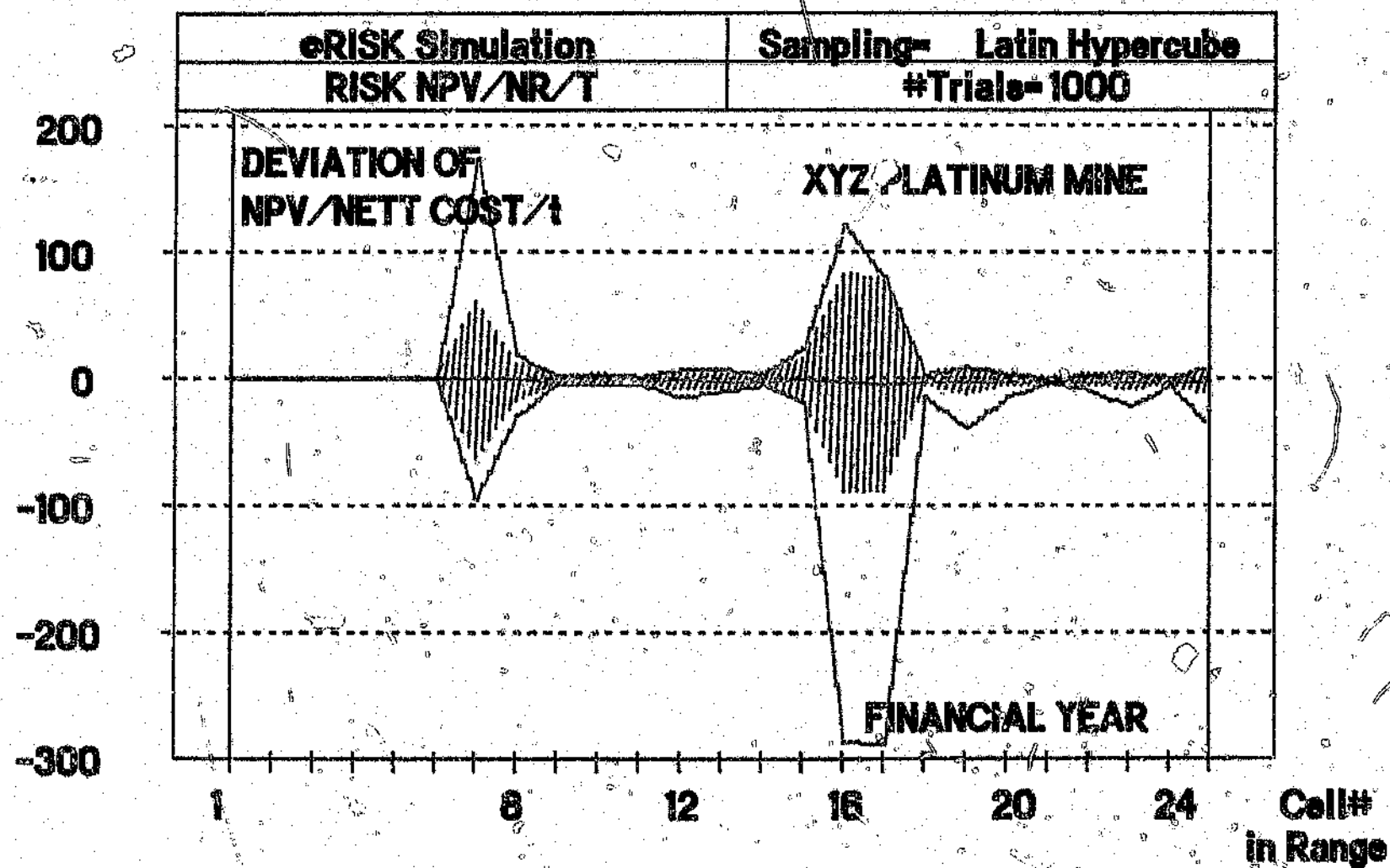
Trend in Mean,
1 StdDev.,
5/95 Perc.



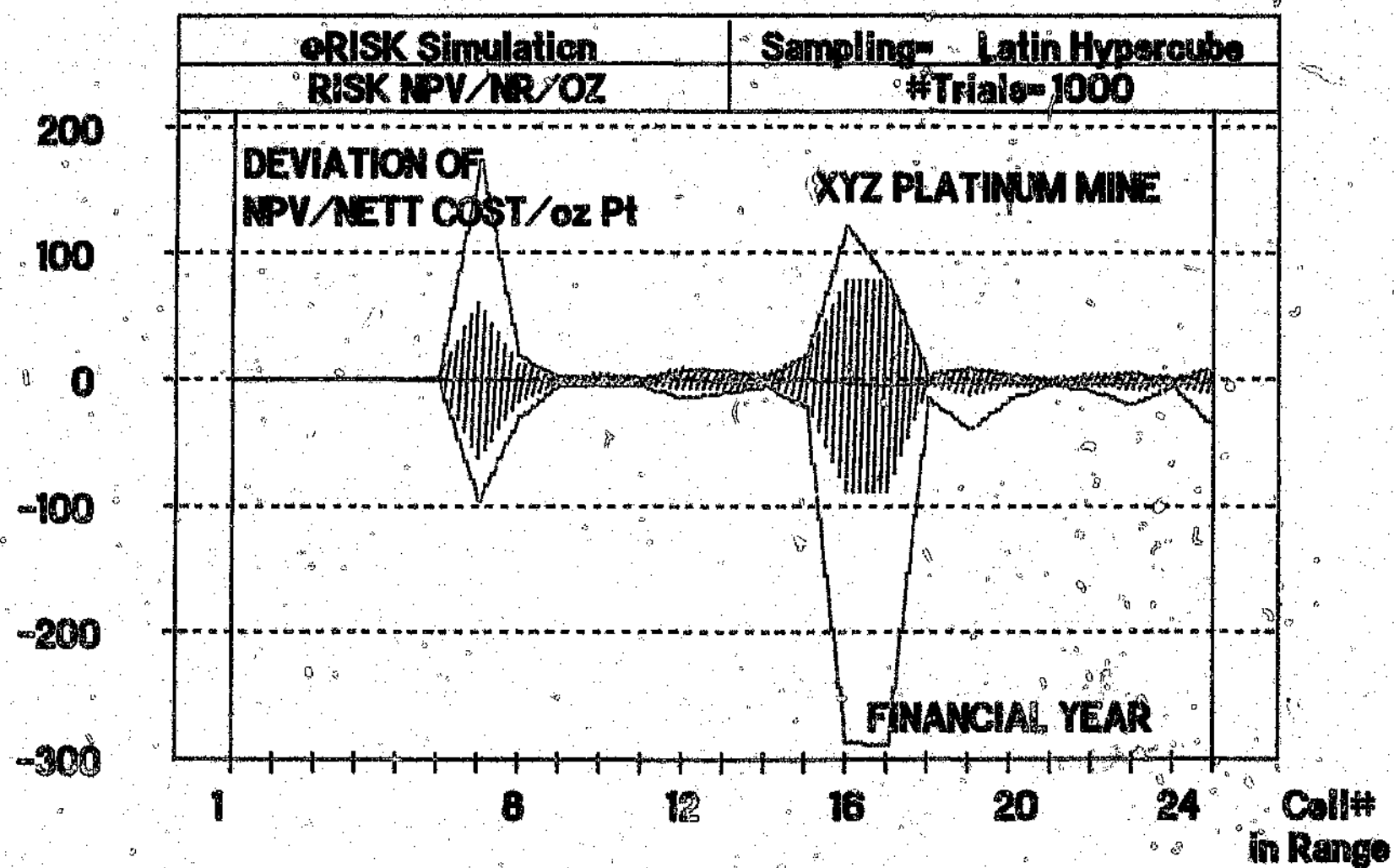
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



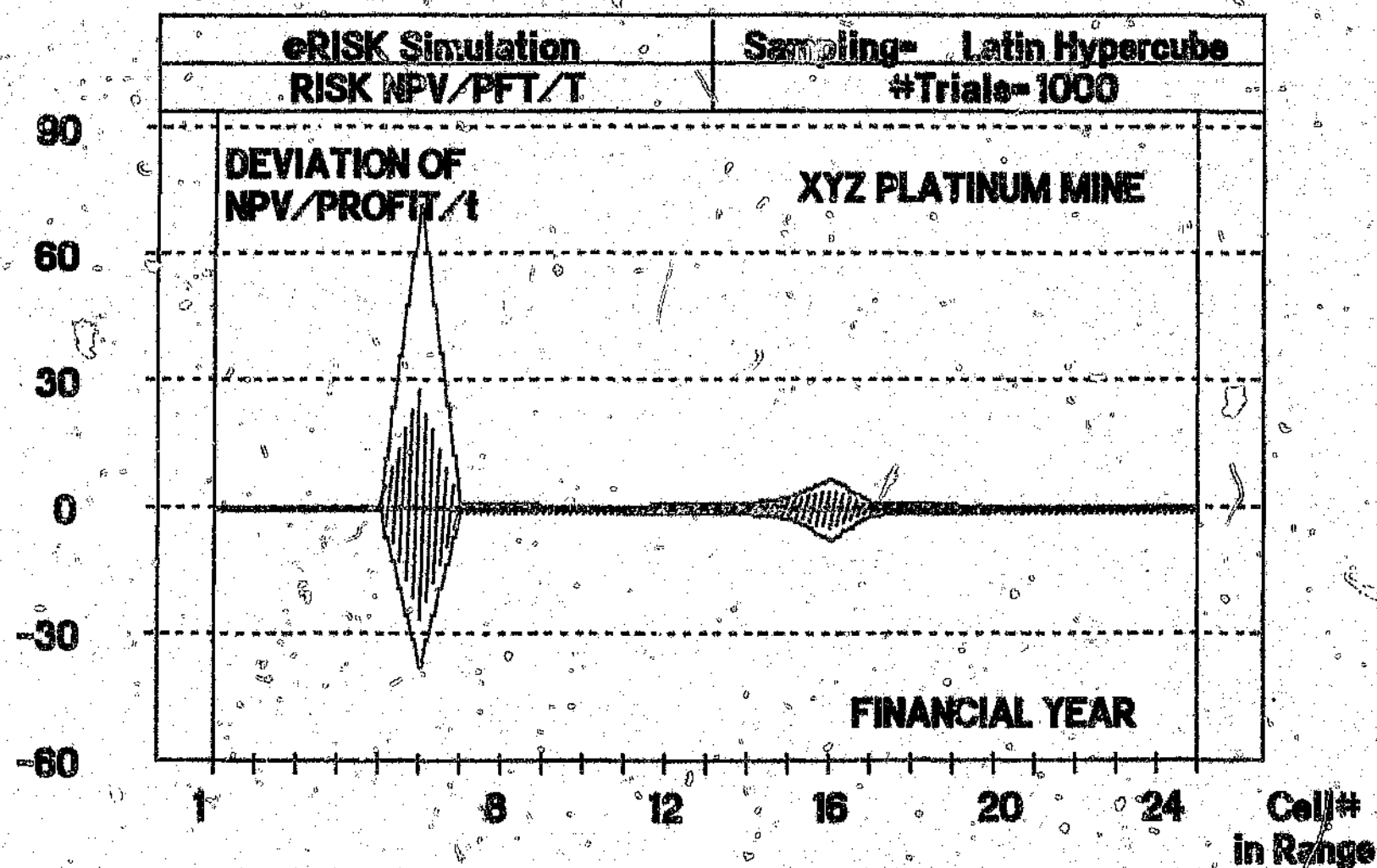
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Trend in Mean,
1 Std.Dev.,
5/95 Perc.

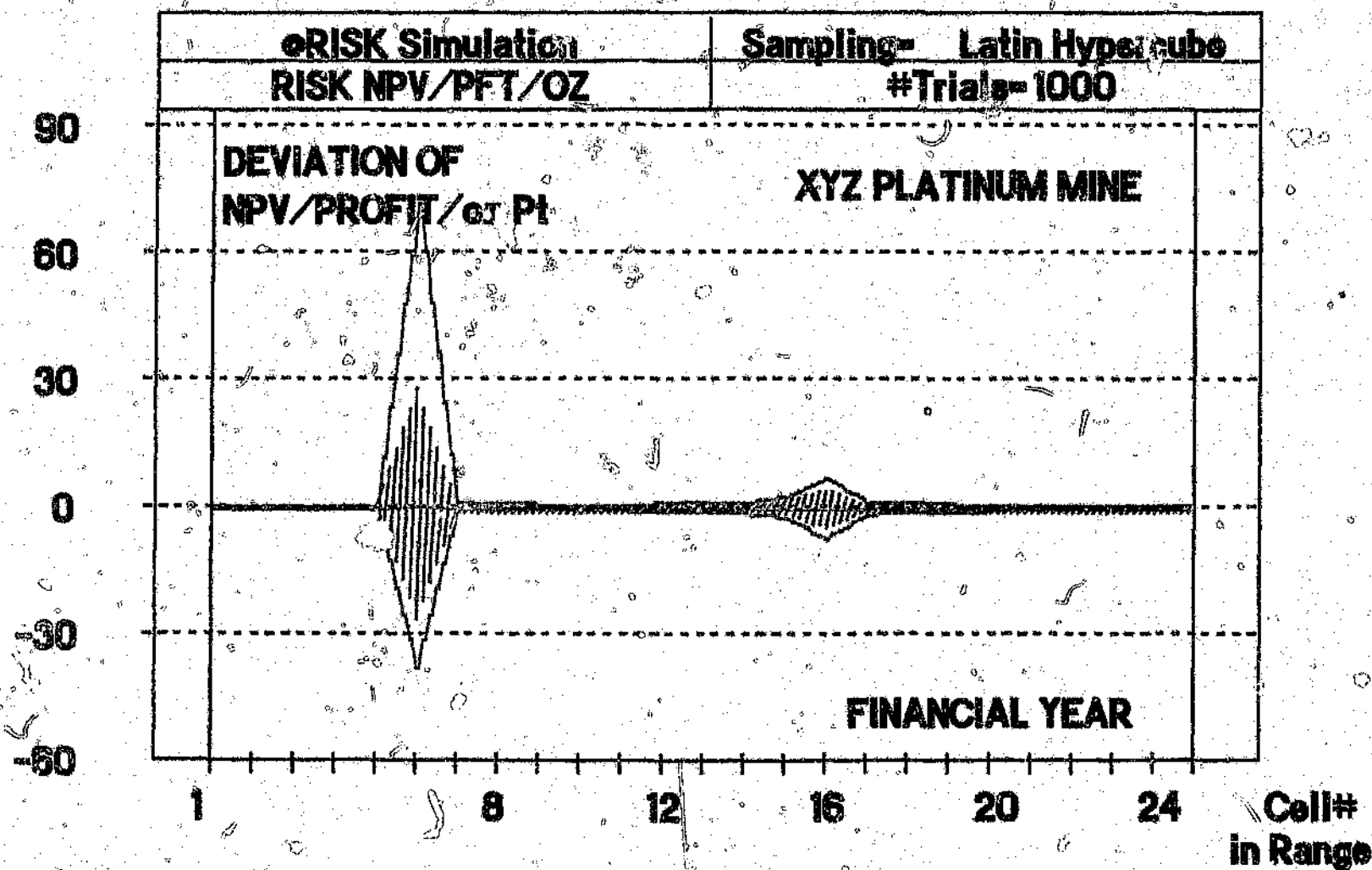


Trend in Mean,
1 Std.Dev.,
5/95 Perc.

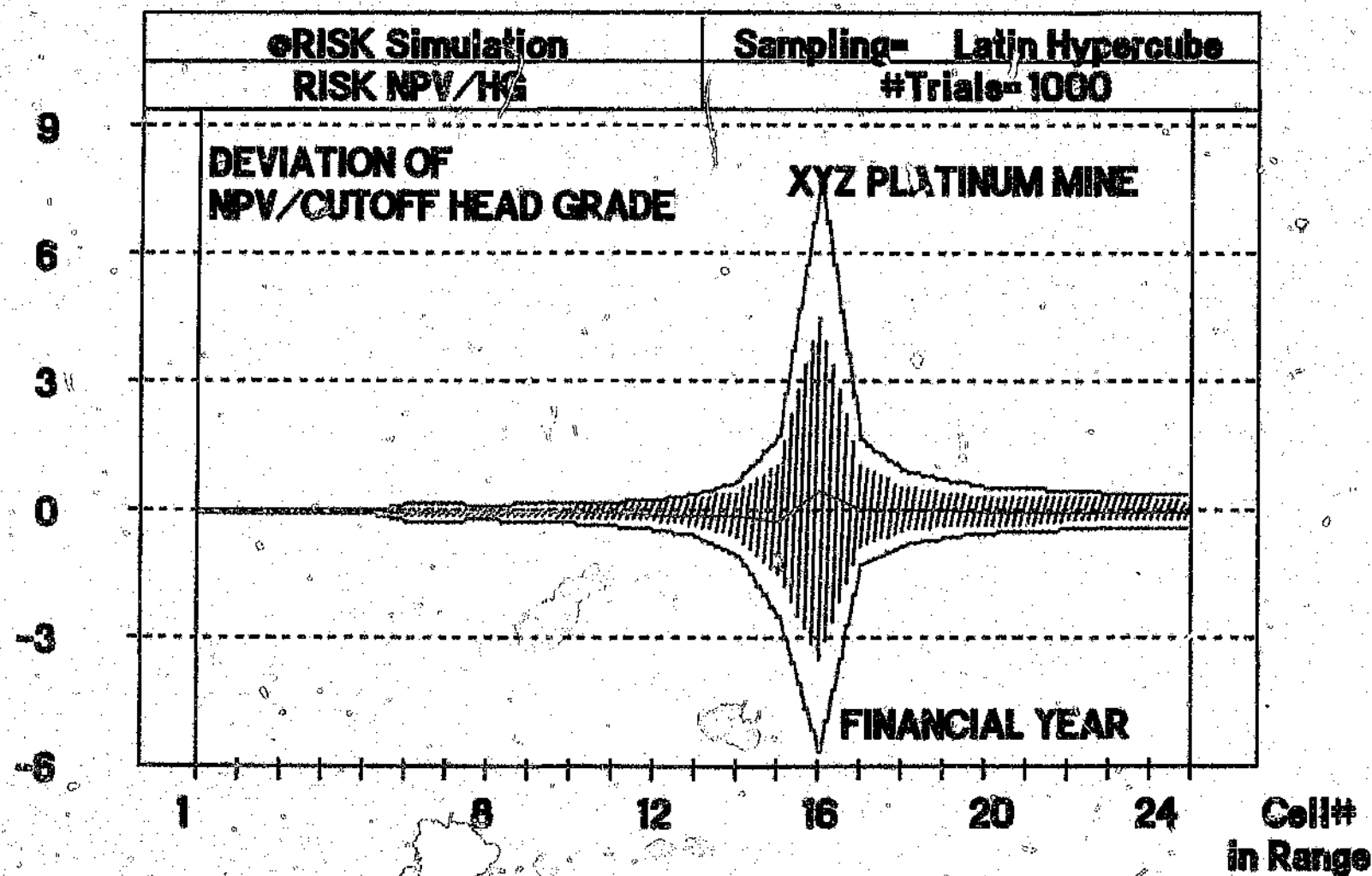


- 911 -

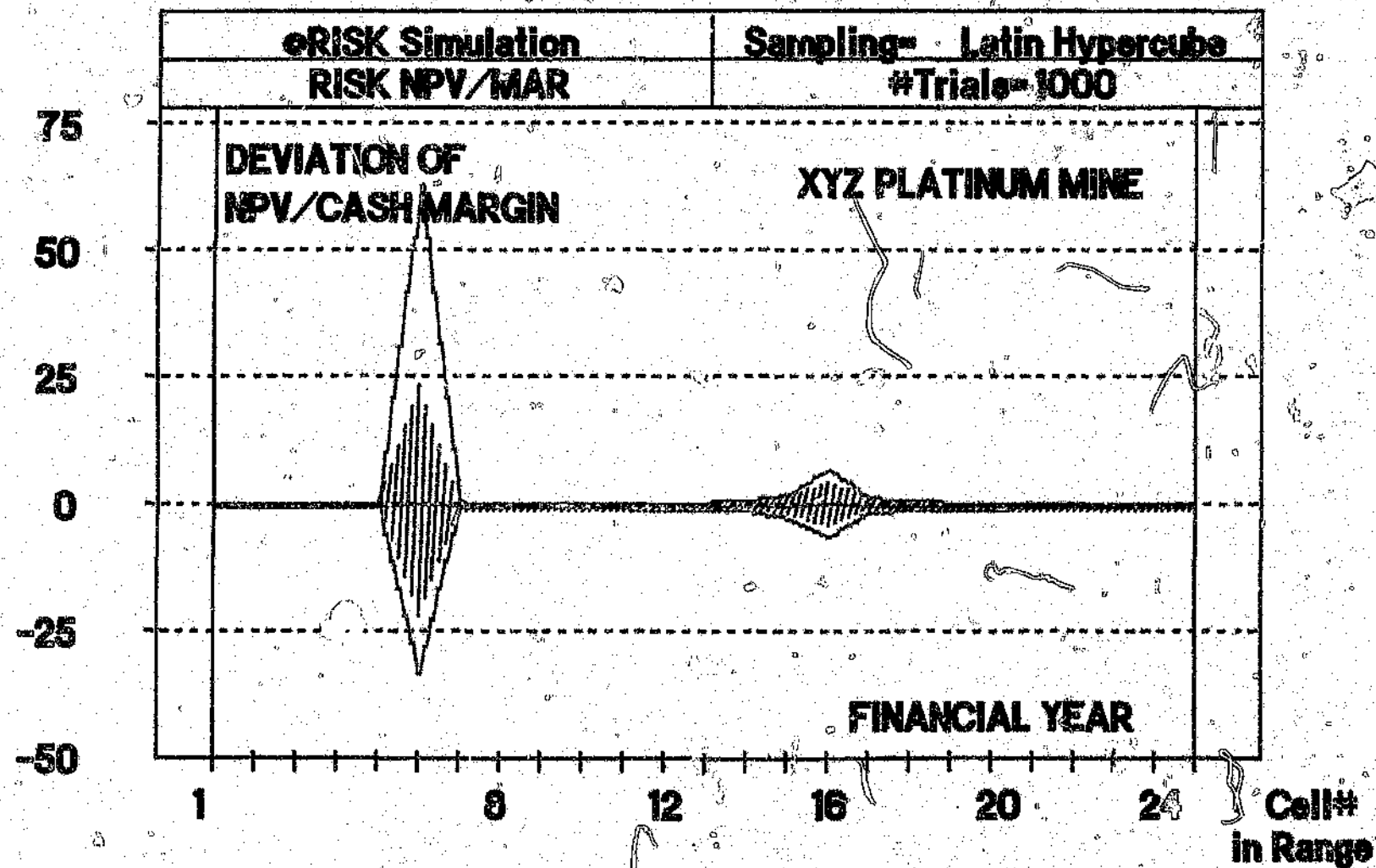
Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Trend in Mean,
1 Std.Dev.,
5/95 Perc.



Trend in Mean,
1 Std.Dev.,
5/95 Perc.



The underlined numbers on pages 106 and 107 are the lowest SD figures or the E figures closest to zero for each particular year and overall. The following notes can be made :-

- (i) the Net R/t and Net R/oz Pt criteria produce the worst SD and E results of the ones considered. Net R/oz Pt is slightly worse than Net R/t.
- (ii) Although the actual numbers are different, criteria 3 to 6 show similar patterns over time for SD and E. This is probably to be expected since all of these are related to profit.
- (iii) Cut-off head grade, however, stands out as producing the lowest SD for V, especially in years 6 and 15 - 17.
- (iv) The Profit/t, Cash Margin and Cut-Off Head Grade criteria stand out as producing values for E closest to zero.
- (v) Years 6 and 15 - 17 are the periods when (1) production starts and (2) Real IRR and NPV @ 0% discount first become positive, respectively.

6. COMPARISON OF RESULTS

If one were to compare the conventional results for Hartley and XYZ, from a potential investor's point of view, the following would emerge :-

	Hartley	XYZ
Real IRR, %, 25 years :	11,36	6,85
NPV, R million, 25 years, @ 0% discount :	993	928
@ 3% discount :	530	363
@ 5% discount :	333	139
Maximum Exposure, escalated, R million :	595	1 305
Maximum Exposure, base date, R million :	518	851
Payback Period, years, escalated money :	6	11
Payback Period, years, base date money :	9	15

Clearly, without taking strategy or risk analysis into account, the Hartley project stands out as having better financial results in all cases than XYZ. The difference in production between the two projects is not great enough for this to make them uncomparable.

Risk analysis helps to add quantitative results for the perceived uncertainties for both projects. The following results comparison is thus produced :-

	HARTLEY		XYZ	
	E	SD	E	SD
Real IRR, %, 25 years	3,825	1,010	6,301	0,873
NPV, R million, 25 years, @ 0% discount	723,9	84,5	794,0	118,4
@ 3% discount	351,8	58,0	290,8	77,5
@ 5% discount	191,6	48,0	91,9	61,1
Maximum Exposure, escalated, R million	639,8	38,8	1 287,3	83,2
Maximum Exposure, base date, R million	553,8	31,3	832,2	46,6
Payback Period, years, escalated money	7,0	0,8	11,3	0,6
Payback Period, years, base date money	10,4	1,1	15,2	1,0

This comparison is now different from the one that the conventional results presents. Hartley is shown to suffer more as a result of the risk quantification than XYZ does. In fact, XYZ's expected NPV @ 0% discount is now higher than Hartley's and XYZ's maximum exposure has decreased whilst that for Hartley has increased. In effect, the conventional results have now been discounted for risk for both projects. For example, the risk discount rate for Hartley is 2,55%, compared to XYZ's 0,55%.

However, this exercise is not meant to reflect a diligent analysis of either Hartley or any South African PGM operation, but the above results do illustrate the usefulness of risk analysis in looking beyond conventional results, especially when two potential projects are situated within different uncertainty and risk environments.

What is important is that the following are common to both projects with regard to the robustness criteria studied :-

- (i) Net cost/t and net cost/oz Pt are both inefficient and inaccurate measurements of robustness when conducting sensitivity and risk analyses, compared to other available criteria which produce lower values of SD and values of E closer to

zero in the foregoing analysis. The reason that these are inefficient robustness criteria is that variations in metal prices both for platinum and for other PGMs and base metals can affect these criteria without necessarily affecting profitability. For example, a reduction in net cost/oz Pt could also be accompanied by a reduction in revenue/oz Pt.

- (ii) Cut-off head grade is the most efficient of the robustness criteria, producing an average standard deviation of between 0,545 and 0,835 for the V-factor $(z + \Delta z)/z - 1$ when Real IRR is divided by it and of between 0,430 and 0,514 for V when NPV @ 0% discount is divided by it.
- (iii) Cut-off head grade has an expected result for V of between (0,140) and (0,046) when Real IRR is divided by it and of between (0,049) and 0,009 when NPV @ 0% discount is divided by it.
- (iv) Cash margin has a slightly better expected result for V when Real IRR is divided by it ((0,066) - (0,035)) and also is relatively accurate when NPV @ 0% discount is divided by it ((0,035) - 0,071).
- (v) Cut-off head grade is a better robustness criterion during the critical periods of (1) start of production, (2) when a positive Real IRR and NPV @ 0% discount are first made and (3) when a fresh capital programme is embarked on, producing lower deviations and expected results closer to zero for V than the other criteria in the foregoing analysis.

Cash margin is equal to profit divided by revenue expressed as a percentage. Cut-off head grade is equal to 100% less this cash margin multiplied by the actual mined head grade. It can be concluded, therefore, that cut-off head grade is a more accurate reflection of a project's robustness when sensitivity and risk analyses are run because it relates both the financial and technical soundness of the project in one parameter.

If this is the case, then presumably one could take it a step further by calculating the cut-off recovered grade and thus covering all the possible technical variations. To do this, one would have to let individual metal recoveries have an input variability, but this is not done in the model. This variability would probably be very difficult to define.

A problem lies in trying to determine why the cut-off head grade criterion should vary less than the cash margin criterion when the two are so closely related. One can normally determine the one if one knows the other.

The answer lies in the effect that changes in head grade have over time. Because of the pipeline effect, which is built into the model, a change in head grade will be manifest by a change in production not only in the year in which the head grade changes but also in the subsequent year. This, in turn, spreads the changed revenue over those two years and thus dilutes the effect on cash margin for the first year. The cut-off head grade, however, is determined by multiplying the full head grade by a factor related to cash margin.

As an example, assume that, in one particular year, head grade changes by x%. Furthermore, the pipeline effect is only y% for that year and (1 - y) % for the subsequent year. The original cash margin is :-

$$M = \frac{(R - C)}{R}, \text{ where } R = \text{revenue and } C = \text{costs}$$

The new cash margin for that year will thus be :-

$$M^1 = \frac{(R(1+xy) - C)}{R(1+xy)}$$

$$\therefore \frac{M^1}{M} = \frac{(R(1+xy) - C)R}{R(1+xy)(R-C)} = \frac{R(1+xy) - C}{R(1+xy) - C(1+xy)}$$

Similarly, the original cut-off head grade is :-

$$CO = \frac{C}{R} \cdot HG, \text{ where } HG \text{ is head grade}$$

The new cut-off head grade will thus be :-

$$CO^1 = \frac{C}{R(1+xy)} \cdot HG(1+x)$$

$$\therefore \frac{CO^1}{CO} = \frac{C \cdot HG(1+x)R}{R(1+xy) C \cdot HG}$$

$$= \frac{(1+x)}{(1+xy)}$$

Let us assume that :-

$$\frac{CO^1}{CO} > \frac{M^1}{M}$$

Therefore :-

$$\frac{(1+x)}{(1+xy)} > \frac{R(1+xy) - C}{R(1+xy) - C(1+xy)}$$

$$\therefore (1+x) (R(1+xy) - C(1+xy)) > (1+xy) (R(1+xy) - C)$$

$$\therefore (1+x) R(1+xy) - C(1+x)(1+xy) > C(1+xy)^2 R - C(1+xy)$$

$$\therefore R(1+x) - C(1+x) > R(1+xy) - C$$

$$\therefore R(1+x-1-xy) > C(1+x-1)$$

$$\therefore R(x-xy) > Cx$$

$$\therefore Rx(1-y) > Cx$$

$$\therefore R(1-y) > C$$

$$\therefore R(1-y) - C > 0$$

which means that revenue must be greater than costs by a factor of $(1-y)$, or 100% less the pipeline percentage applicable for each year, for the effect of a variation in head grade to be greater on cut-off head grade than on cash margin.

The important point here is that cut-off head grade does vary differently than cash margin and that it varies less when used as a robustness criterion for Real IRR or NPV @ 0% discount. During production build-up, when this difference is marked, $(R-C)$ is not large, and may even be negative, and thus $R(1-y) - C$ will probably be less than zero, which, from the calculation above, means that the effect of a change in head grade is greater on cash margin than on cut-off head grade, resulting in the distortions in SD for V produced by the cash margin criterion during the relevant periods shown by this study.

Costs are relevant as a major barometer of robustness. It is a simple fact that low cost producers will survive longer than high cost producers. However, high revenue producers will also survive longer than low revenue producers. The net cost criteria do not take both sides of this equation into account. The other criteria (profit and margin-related) do take both sides into account, but this study shows that margin-related criteria are more efficient indicators of robustness than profit criteria.

In practical applications, however, it may be easier to refer to cash margin as a robustness criterion rather than to calculate the cash margin from the cut-off head grade. This choice needs to be made by the person conducting the evaluation.

7. CONCLUSIONS

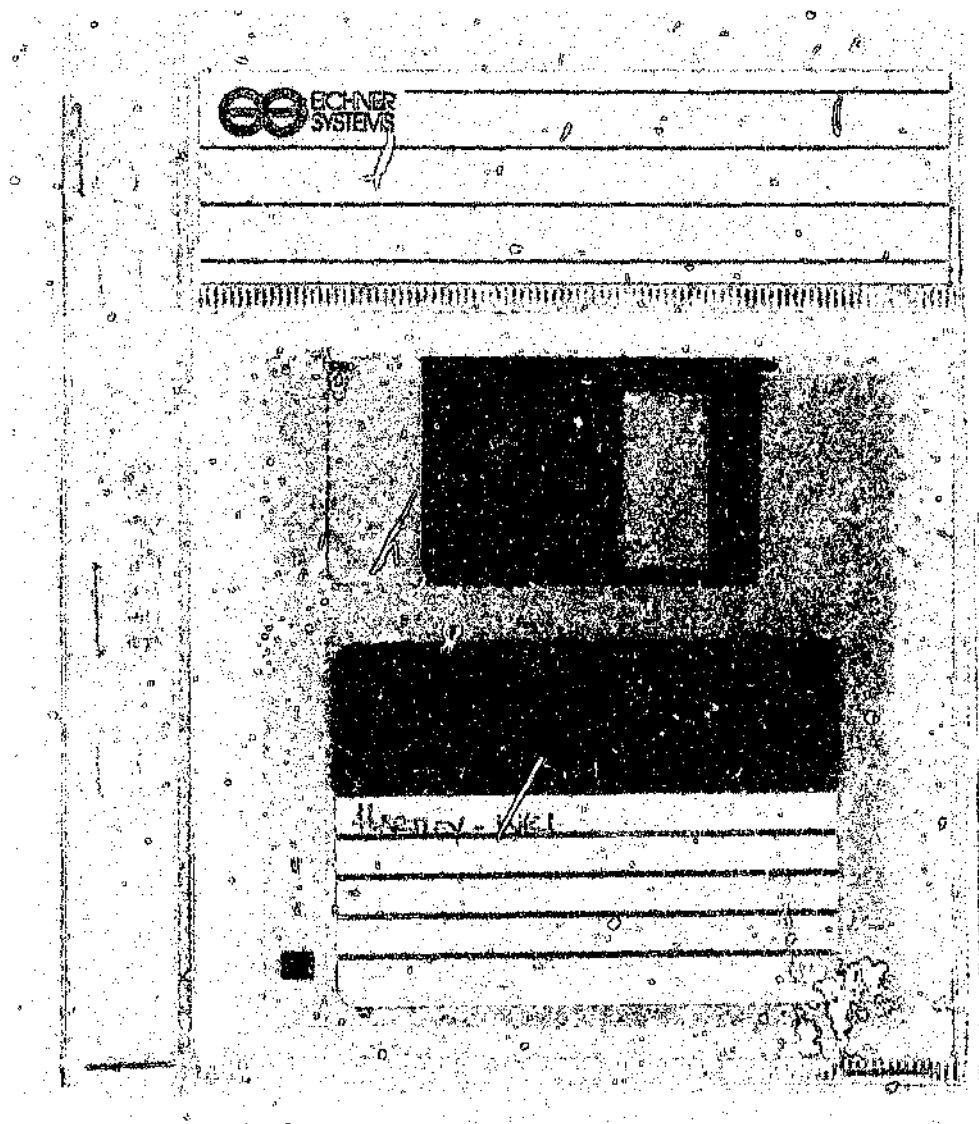
It is concluded that, since the cash margin criterion produces a value of E closest to zero, it is expected to be a more accurate measure of project robustness than the other criteria considered. However, when running sensitivity or risk analyses, cut-off head grade will be a better indicator of project robustness because its SD is lower in the foregoing analysis.

The following steps are thus suggested when evaluating a potential PGM project :-

- a) Run the PGM project results conventionally, predicting Real IRR, NPVs and other financial indicators.
- b) If these results are acceptable and could possibly fit into corporate strategic aims, compare them against alternatives available to the corporation.
- c) Run similar conventional analyses for all competitors or potential competitors.
- d) Rank these results in descending order on the basis of cash margin.
- e) Run sensitivity/risk analyses for all the above PGM producers.
- f) Rank them again, but this time on the basis of the expected difference between head grade and cut-off head grade, expressed as a percentage of head grade.
- g) The position of the project in the above rankings will determine the project's robustness and thus provide decision-makers with the necessary information to assess the riskiness involved.

The assessment of the potential upward and downward potential of each input parameter for each producer is essential to this kind of evaluation and requires in-depth knowledge and information. This kind of competitiveness analysis should form an essential part of any executive summary of a PGM project evaluation. A brief outline of a potential PGM project's robustness would probably be of greater value to executive decision-makers than a myriad of financial data with no reference to competitiveness.

8. COMPUTER DISK WITH MODEL



9. REFERENCES

1. Johnson Matthey Platinum Review, May 1991.
2. Lotus Development Corporation, 1989.
3. The Economist, 8 June 1991, p. 87.
4. D.G. Krige, Journal of the South African Institute of Mining and Metallurgy, September 1978, pp. 42 - 49.
5. @Risk, Version 1.5 Users Guide, March 31 1989.
6. Metal Bulletin, 11 June 1990, p. 25.
7. Mining Magazine, June 1991, pp. 370 - 377.

Author: Brogan Paul Louis.

Name of thesis: The measurement of the viability of PGM-mining projects in a competitive market.

PUBLISHER:

University of the Witwatersrand, Johannesburg

©2015

LEGALNOTICES:

Copyright Notice: All materials on the University of the Witwatersrand, Johannesburg Library website are protected by South African copyright law and may not be distributed, transmitted, displayed or otherwise published in any format, without the prior written permission of the copyright owner.

Disclaimer and Terms of Use: Provided that you maintain all copyright and other notices contained therein, you may download material (one machine readable copy and one print copy per page) for your personal and/or educational non-commercial use only.

The University of the Witwatersrand, Johannesburg, is not responsible for any errors or omissions and excludes any and all liability for any errors in or omissions from the information on the Library website.