SO YOU ARE INVESTING IN A MINING PROJECT—WHAT USUALLY GOES WRONG

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ABSTRACT

The geology report, feasibility study, and mine plan look great. Why do so many mining project start-ups fail to perform? Most mining companies put a great deal of emphasis on the nature of the reserve, the mine plan, the extraction process to be used, and the process plant design—obviously all very important. Even when large, highly regarded engineering, procurement, and construction firms develop the project, operating results are very often disappointing. In this paper, we explore the role of *Operations Readiness* on the financial impact of mining project start-ups. A relatively small investment in operations readiness produces a huge financial return. Many investment firms, as well as mining company senior executives, fail to consider this important factor in operating success.

INTRODUCTION

We define *Operations Readiness* as all of the operating activities associated with start-up—those activities other than the engineering, design, and construction of the mine and plant. Specifically, these include operations and maintenance training, development of preventive maintenance procedures, and procedures specific to the initial introduction of feed. In this paper we pay particular attention to start-up of the process plant. In the 1970s, Charles River Associates Inc.[1] completed a mining project start-up study for the World Bank. Although the study was completed some 40 years ago, the conclusions are still germane to current mine and plant metallurgical projects. The study conclusions include the following:

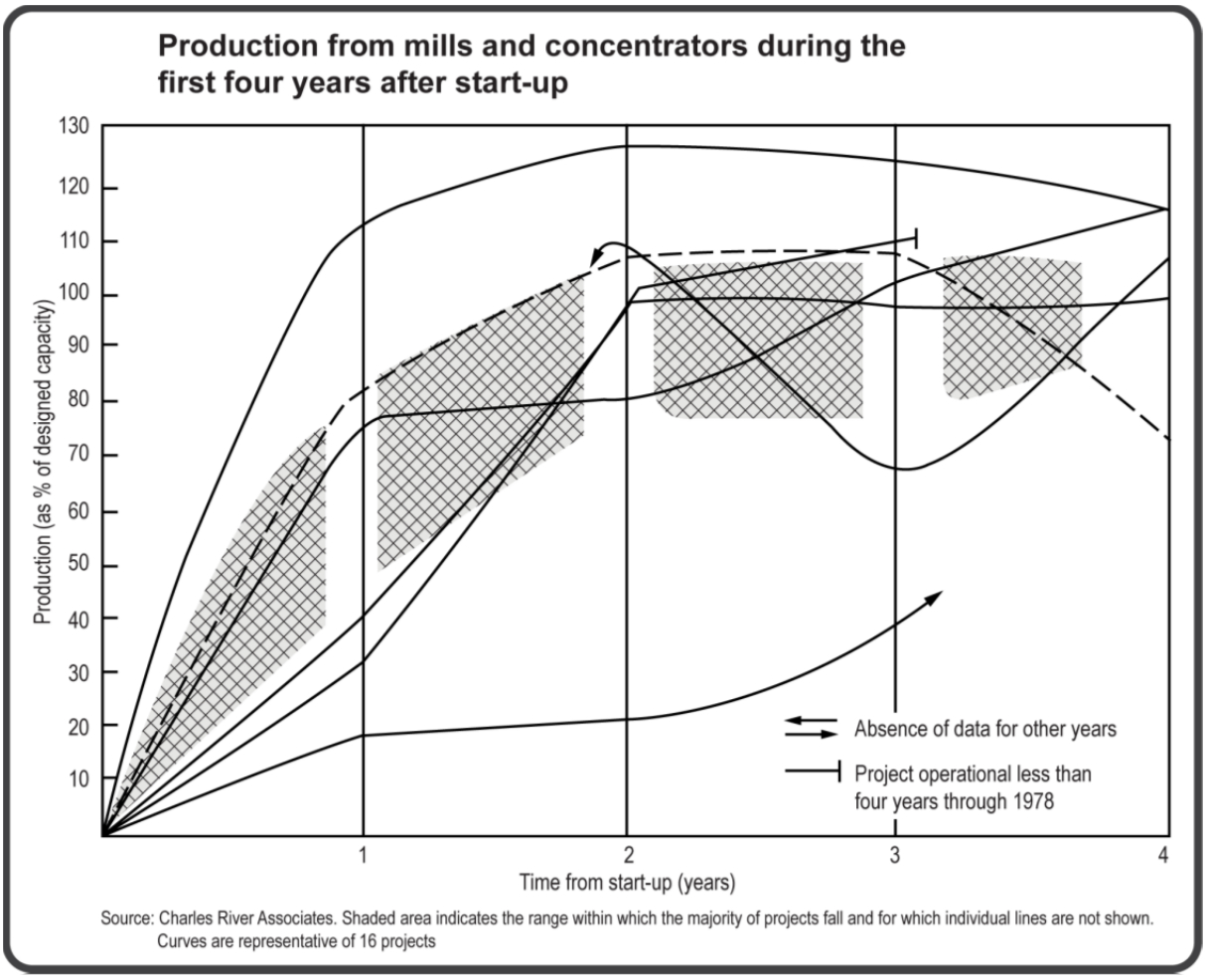
> Investors should be prepared for long delays, added capital to correct mistakes in scale-up, and loss of revenue. If delays are not properly factored into the project's financial feasibility analysis, the cash flow returns are grossly overstated and rarely achieved on schedule.

Figure 1 illustrates results of the study analyzing 16 mill and concentrator projects. We believe that these results are also typical of gold processing plants comprising relatively straight forward SAG mill-ball mill grinding plants followed by CIL/Leach-CIP and ADR plants or Merrill-Crowe recovery plants.

Figure 2 illustrates results of the study analyzing 11 metallurgical processing plants, more complex than the mills/concentrators shown in Figure 1. We believe that the projects shown in Figure 2 are also representative of more complex refractory ore gold processing plants such as pressure oxidation or fluid-bed reactor plants.

1. *Engineering and Mining Journal*, September 1984, "Taking the Sting Out of Start-Up Problems," J.C. Agarwal, et al.

Figure 1



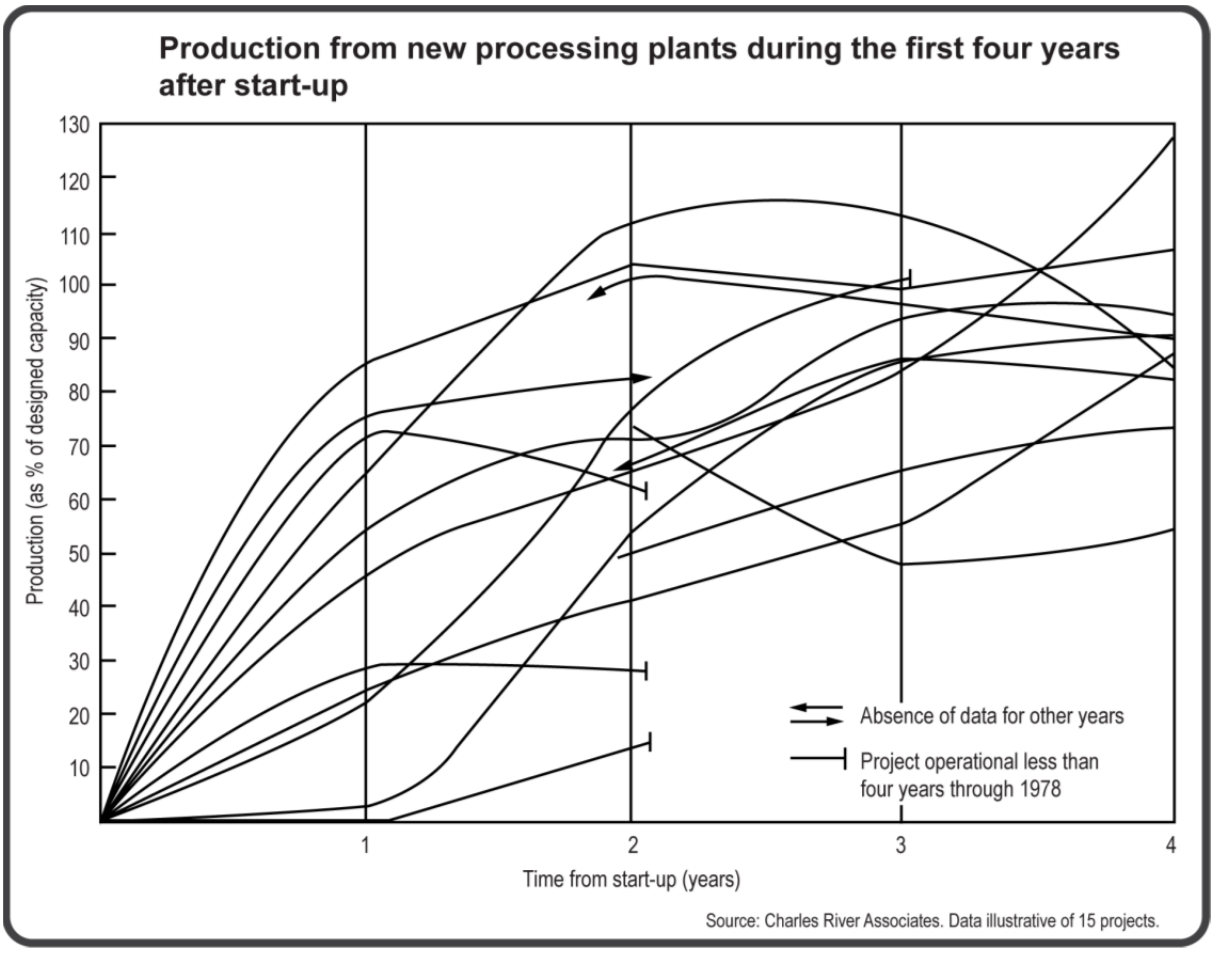
As evidenced by the Charles River Associates study, approximately 70 percent of the mills and concentrators had an average annual production of 70 percent of design capacity during their first year. However, most of these operations operated at between 80 percent and 100 percent of capacity by their third year.

The start-up performance of more complex metallurgical processing plants, as shown in Figure 2, is significantly poorer than for the average mill and concentrator. Even after four years, many of these processing plants failed to achieve design capacity. Several failed prior to the fourth year.

Although operating personnel normally blame poor design and equipment problems for the problems causing delays, these so-called problems usually mask a much more fundamental problem: *an inadequately prepared workforce.*

We note that the start-up delays identified in Figures 1 and 2 were in evidence for projects in developed countries, as well as in developing countries.

Figure 2



FINANCIAL IMPACT

Performance Associates has been involved with metallurgical plant start-ups for over 30 years on almost every continent. These projects include a continuum of complexity from simple heap leach gold projects to highly complex gold projects using pressure oxidation or fluid-bed reactors. Projects other than gold include complex nickel and copper hydrometallurgical processes, as well as straightforward flotation concentrators.

In our experience, the negative impact on project cash flow following initial start-up primarily occurs from the following:

- Extended production shortfalls during the early months, and sometimes years, of operation.
- Lower than design metal recovery owing to poor control of process variables.
- Substantial sums are spent making modifications to the plant. During the panic of a poor start-up, things quickly spiral out of control. Unnecessary modifications are made, some of which create new problems.

To illustrate the financial impact of a typical start-up, we have arbitrarily classified the start-up of a typical gold plant into four categories: excellent, good, fair, and poor, each with respect to tons produced as a percent of design and with respect to recovery.

Figure 3

Start-Up Performance Scenarios
Percent of Design Capacity Produced

Start-Up Performance	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total Year
Excellent													
Year 1	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	98%
Year2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Good													
Year 1	50%	60%	65%	70%	75%	80%	85%	90%	95%	100%	100%	100%	81%
Year 2	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Fair													
Year 1	50%	50%	60%	60%	60%	70%	70%	70%	80%	80%	80%	90%	68%
Year 2	90%	90%	95%	95%	95%	100%	100%	100%	100%	100%	100%	100%	97%
Poor													
Year 1	25%	25%	25%	30%	35%	40%	45%	45%	45%	50%	50%	60%	40%
Year 2	70%	75%	75%	80%	85%	85%	90%	90%	90%	90%	90%	90%	84%
Year 3	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%

Figure 4

Start-Up Performance Scenarios
Gold Recovery

Start-Up Performance	Month												
	1	2	3	4	5	6	7	8	9	10	11	12	Total Year
Excellent													
Year 1	80%	85%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	87%
Year2	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%
Good													
Year 1	65%	70%	75%	80%	85%	87%	88%	88%	88%	88%	88%	88%	83%
Year 2	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%
Fair													
Year 1	50%	50%	65%	70%	70%	70%	75%	80%	85%	88%	88%	88%	73%
Year 2	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%
Poor													
Year 1	40%	45%	50%	50%	55%	60%	60%	65%	65%	70%	75%	75%	59%
Year 2	75%	75%	75%	75%	75%	75%	80%	80%	80%	82%	82%	82%	78%
Year 3	82%	82%	82%	82%	82%	82%	82%	84%	84%	85%	85%	85%	83%

We have assumed that at nominal mine production the life of the mine is 15 years. However, even for the excellent start-up, there is some tonnage not mined in Years 1 through 15 and is shown mined in Year 16. Design production tonnage is assumed to be achieved by the fourth year in the case of the poor start-up and by the second year in the case of the excellent start-up. In the excellent start-up, design gold recovery of 88 percent is achieved in the second year, and in the poor start-up, recovery of 88 percent is achieved in the fourth year.

A financial model was constructed for each of the four cases.

The following factors are constant in each of the four scenarios.

- A total of $550,000,000 capital cost is spent during the first two years.
- A total of $18,000,000 is spent on pre-stripping over the first two years.
- The total reserve is 108,000,000 tons grading 0.12 oz/ton gold.
- The price of gold is $US 1,200 per oz.
- Following initial capital investment, an all-in-sustaining cost of $US 850 per oz. represented as 85 percent variable and 15 percent fixed is required to sustain operations for the life of the mine.
- The design production rate is 20,000 tons per day.
- An effective 25 percent income tax is assumed to be applied to net cash flow.
- Net present value was calculated based on a 12 percent discount rate.

Scenario 4—Poor Start-Up

We start with the poor start-up, Scenario 4. Refer to Figure 5 for the financial model representing the poor start-up. This scenario is all too typical of mine and plant start-ups with which we are familiar. Although a significant effort is made in managing the engineering company, the design, and construction, very little effort is expended on preparing the workforce for start-up. Note that in this scenario no money is spent on operations readiness. Project management often assumes that the operating management staff will organize development of standard procedures and training new operators and maintenance personnel. However, given the exigencies of recruiting, interviewing, and hiring, these other important activities never really materialize. There is also the assumption that equipment suppliers will take care of training on the equipment. However, this training is "hit and miss" and doesn't cover process variables and control loops, interlocks between equipment supplied by different suppliers, and the overall operating procedures for optimizing the entire process.

During start-up, many months of agonizing effort are spent trying to improve throughput and attain design recovery. Is it any wonder? A modern gold plant requires that literally thousands of elements operate correctly. These include operating procedures, control loops, interlocks, alarm responses, chemical reagent additions, flow rates, densities, concentrations, etc. How are the operators to be knowledgeable without a first-class training program based on written procedures and process documentation? The mining company has one chance to accomplish this documentation and subsequent training—during the approximately one year prior to start-up. Once start-up commences, it is too late. Everyone is buried in the efforts to get the operation going.

Scenario 3—Fair Start-Up

The financial model for Scenario 3, the fair start-up, is shown in Figure 6. This scenario results more from luck than managed effort. Note that as in Scenario 4, no money is spent on operations readiness. Design production is achieved in Year 3 and design recovery in Year 2. The results for this scenario may result from hiring more experienced personnel, but it is still well short of what is attainable given a significant effort in preparing the workforce.

Scenario 2—Good Start-Up

The financial model for Scenario 2, the good start-up, is shown in Figure 7. Note that production and recovery are much better in the first year for this scenario. Both design production and recovery are achieved in Year 2. Also note that a million dollars are spent on operations readiness. We can assume that this money was spent in preparing standard operating procedures for the specific plant and in developing preventive maintenance procedures for the plant equipment. Some pre-start-up training was probably also conducted.

Scenario 1—Excellent Start-Up

The financial model for Scenario 1, the excellent start-up, is shown in Figure 8. In this scenario, three and a half million dollars are spent on operations readiness. A significant computer-based training program for operations and maintenance will have been developed and training conducted before the start-up. Standard operating procedures and maintenance procedures will also have been completed and incorporated into the training program. Trained operators and maintenance personnel will have participated in preoperational and functional testing prior to introduction of feed. In short, operators and maintenance personnel know the plant "backward and forward" prior to introduction of feed. They know process variable targets and can effectively troubleshoot process and control problems. They can describe every control loop and how to respond to every alarm.

Design production and recovery are achieved very early—in the first few months of start-up and continue for the life of the project. As turnover occurs, there is no loss in effectiveness since the training program is electronic. New personnel can interact with the computer-based training at their own pace as they enter the workforce. This scenario is representative of the Voisey's Bay nickel concentrator start-up in Newfoundland and Labrador and the Lundin Eagle base metals concentrator in Michigan, U.S.A.

Figure 5--Open-Pit Mine and Conventional Gold Plant
Fifteen Year Mine - Scenario 4 - Poor Start-Up

Design ounces per year	760,320						Year												
Design production (tons of ore/day)	20,000	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Total reserve (tons)	108,000,000																			
Total recovered ounces	7,668,000																			
Gold price (USD per oz)	$1,200																			
Capital cost USD																				
Mine		($200,000,000)	($100,000,000)																	($300,000,000)
Plant		($100,000,000)	($150,000,000)																	($250,000,000)
Pre-stripping		($9,000,000)	($9,000,000)																	($18,000,000)
Operations readiness cost			**$0**																	
Operating parameters																				
Au oz/ton	0.12																			
Production factor (% of design)				40%	84%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
Tons ore mined				2,850,000	6,060,000	6,480,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	6,210,000	108,000,000
Au recovery	88%			59%	78%	83%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
Oz Au recovered				202,350	567,216	646,056	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	655,776	11,195,238
Financial data (USD)																				
Revenue				$242,820,000	$680,659,200	$775,267,200	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$786,931,200	
All-in sustaining cost/Au oz	$850																			
Variable operating cost (% total)[1]	85%			$146,197,875	$409,813,560	$466,775,460	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$473,798,160	
Fixed operating cost (% total)[2]	15%			$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$83,611,440	
Total operating cost				$243,138,675	$506,754,360	$563,716,260	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$557,409,600	
Net before tax cash flow		($309,000,000)	($259,000,000)	($318,675)	$173,904,840	$211,550,940	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$229,521,600	
Assume tax at	**25%**	$0	$0	($79,669)	$43,476,210	$52,887,735	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$57,380,400	
After-tax cash flow		($309,000,000)	($259,000,000)	($239,006)	$130,428,630	$158,663,205	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$172,141,200	

Internal rate of return (% IRR) **22%**
NPV at interest rate **12%** **$414,277,174**

Notes:
1 Variable cost based on actual ounces of production.
2 Fixed cost based on design ounces of production.

Figure 6--Open-Pit Mine and Conventional Gold Plant
Fifteen Year Mine - Scenario 3 - Fair Start-Up

Design ounces per year	760,320																			
Design production (tons of ore/day)	20,000	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
										Year										
Total reserve (tons)	108,000,000																			
Total recovered ounces	9,493,200																			
Gold price (USD per oz)	$1,200																			
Capital cost USD																				
Mine		($200,000,000)	($100,000,000)																	($300,000,000)
Plant		($100,000,000)	($150,000,000)																	($250,000,000)
Pre-stripping		($9,000,000)	($9,000,000)																	($18,000,000)
Operations readiness cost			**$0**																	
Operating parameters																				
Au oz/ton	0.12																			
Production factor (% of design)				68%	97%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
Tons ore mined				4,920,000	6,990,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	2,490,000	108,000,000
Au recovery	88%			73%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
Oz Au recovered				432,468	738,144	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	262,944	11,317,716
Financial data (USD)																				
Revenue				$518,961,600	$885,772,800	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$315,532,800	
All-in sustaining cost/Au oz	$850																			
Variable operating cost (% total)[1]	85%			$312,458,130	$533,309,040	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$189,977,040	
Fixed operating cost (% total)[2]	15%			$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$33,525,360	
Total operating cost				$409,398,930	$630,249,840	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$223,502,400	
Net before tax cash flow		($309,000,000)	($259,000,000)	$109,562,670	$255,522,960	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$92,030,400	
Assume tax at	**25%**	$0	$0	$27,390,668	$63,880,740	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$23,007,600	
After-tax cash flow		($309,000,000)	($259,000,000)	$82,172,003	$191,642,220	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$69,022,800	

Internal rate of return (% IRR)	**26%**
NPV at interest rate	**12%** **$521,648,129**

Notes:
1 Variable cost based on actual ounces of production.
2 Fixed cost based on design ounces of production.

Figure 7--Open-Pit Mine and Conventional Gold Plant
Fifteen Year Mine - Scenario 2 - Good Start-Up

				Year																
Design ounces per year	760,320																			
Design production (tons of ore/day)	20,000	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
		760320																		
Total reserve (tons)	108,000,000																			
Total recovered ounces	10,692,000																			
Gold price (USD per oz)	$1,200																			
Capital cost USD																				
Mine		($200,000,000)	($100,000,000)																	($300,000,000)
Plant		($100,000,000)	($150,000,000)																	($250,000,000)
Pre-stripping		($9,000,000)	($9,000,000)																	($18,000,000)
Operations readiness cost			**($1,000,000)**																	
Operating parameters																				
Au oz/ton	0.12																			
Production factor (% of design)				81%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
Tons ore mined				5,820,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	1,380,000	108,000,000
Au recovery	88%			83%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
Oz Au recovered				576,180	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	145,728	11,366,388
Financial data (USD)																				
Revenue				$691,416,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$174,873,600	
All-in sustaining cost/Au oz	$850																			
Variable operating cost (% total)[1]	85%			$416,290,050	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$105,288,480	
Fixed operating cost (% total)[2]	15%			$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$18,580,320	
Total operating cost				$513,230,850	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$123,868,800	
Net before tax cash flow		($309,000,000)	($260,000,000)	$178,185,150	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$51,004,800	
Assume tax at	**25%**	$0	$0	$44,546,288	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$12,751,200	
After-tax cash flow		($309,000,000)	($260,000,000)	$133,638,863	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$38,253,600	

Internal rate of return (% IRR)	**28%**
NPV at interest rate	**12%** **$558,529,960**

Notes:
1 Variable cost based on actual ounces of production.
2 Fixed cost based on design ounces of production.

Figure 8--Open-Pit Mine and Conventional Gold Plant
Fifteen Year Mine - Scenario 1 - Excellent Start-Up

Design ounces per year	760,320							Year											
Design production (tons of ore/day)	20,000	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Total reserve (tons)	108,000,000																			
Total recovered ounces	11,286,000																			
Gold price (USD per oz)	$1,200																			
Capital cost USD																				
Mine		($200,000,000)	($100,000,000)																	($300,000,000)
Plant		($100,000,000)	($150,000,000)																	($250,000,000)
Pre-stripping		($9,000,000)	($9,000,000)																	($18,000,000)
Operations readiness cost			**($3,500,000)**																	
Operating parameters																				
Au oz/ton	0.12																			
Production factor (% of design)				98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
Tons ore mined				7,020,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	7,200,000	180,000	108,000,000
Au recovery	88%			87%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	88%	
Oz Au recovered				733,590	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	760,320	19,008	11,397,078
Financial data (USD)																				
Revenue				$880,308,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$912,384,000	$22,809,600	
All-in sustaining cost/Au oz	$850																			
Variable operating cost (% total)[1]	85%			$530,018,775	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$549,331,200	$13,733,280	
Fixed operating cost (% total)[2]	15%			$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$96,940,800	$2,423,520	
Total operating cost				$626,959,575	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$646,272,000	$16,156,800	
Net before tax cash flow		($309,000,000)	($262,500,000)	$253,348,425	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$266,112,000	$6,652,800	
Assume tax at	**25%**	$0	$0	$63,337,106	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$66,528,000	$1,663,200	
After-tax cash flow		($309,000,000)	($262,500,000)	$190,011,319	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$199,584,000	$4,989,600	

Internal rate of return (% IRR)	**29%**	
NPV at interest rate	**12%**	**$592,336,139**

Notes:
1 Variable cost based on actual ounces of production.
2 Fixed cost based on design ounces of production.

Financial Comparisons

Figure 9 depicts the effect of start-up performance described in this paper on internal rate of return (IRR).

Figure 9
Effect of Start-Up Scenario on Internal Rate of Return (IRR)

Figure 10 depicts the effect of start-up performance described in this paper on the net present value (NPV) based on a 12 percent discount rate. This chart clearly demonstrates that an ounce of gold produced during the first year is of much greater value than an ounce produced during the 16th year. The chart is based on the results summarized in Table 1.

Figure 10
Effect of Start-Up Scenario on Net Present Value (NPV) Based on a 12 Percent Discount Rate

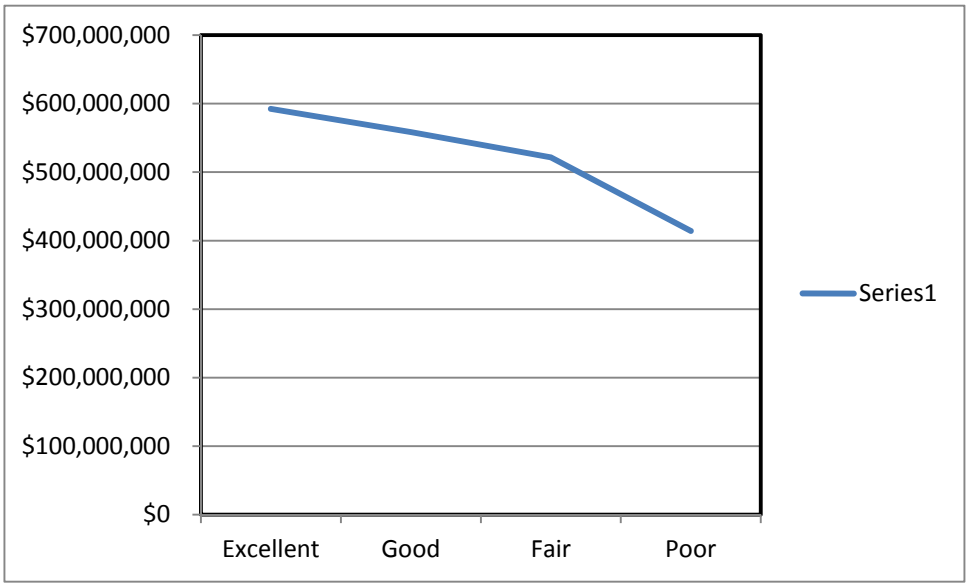


Table 1

	NPV at 12%
Excellent	$592,336,139
Good	$558,529,960
Fair	$521,648,129
Poor	$414,277,174

Even neglecting the $1,000,000 spent on operations readiness for the good start-up, the $3,500,000 spent on operations readiness for the excellent start-up (Scenario 1) pays back its investment over 16 times in after-tax cash flow in the first year, compared to the good start-up, and over 30 times in the first year compared to the fair start-up.

$3,500,000 Investment Payback Multiple
Excellent Start-Up After-Tax Net Cash Flow Compared to Good Start-Up Cash Flow

($190,011,319 - $133,638,863)/$3,500,000 = **16.11**

$3,500,000 Investment Payback Multiple
Excellent Start-Up After Tax Net Cash flow Compared to Fair Start-Up Cash flow

($190,011,319 - $82,172,003)/$3,500,000 = **30.81**

In the example cited for the excellent start-up, an operations readiness investment of 1.4 percent of the plant capital cost yields a return on after-tax cash flow of over 1600 percent during the first year of operation compared to the good start-up.

Without an operations readiness approach as described in this paper, these kinds of results are virtually impossible.