SKEENA'S ESKAY CREEK REVITILIZATION PROJECT UPDATE: SIMPLIFICATION OF THE PROCESS FLOWSHEET

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Abstract

The Eskay Creek mine located in the golden triangle of British Columbia previously operated from 1994 to 2008 and was at one time the highest grade gold producer in the world, and fifth largest silver producer. Grades were so rich it began as a direct shipping ore (DSO) before adding a processing plant that recovered gold by gravity and flotation. In 2017 Skeena Gold + Silver (Skeena) optioned the property from Barrick Gold and began conceptualizing the project as an open pit operation with a processing facility producing a flotation concentrate. In 2022 a feasibility study presented a processing flowsheet consisting of multiple stages of grinding and flotation to produce a saleable concentrate. Following a strategic review, Skeena Gold + Silver sought to simplify and de-risk the project and this case study outlines the design changes that were made and presented in a 2023 Updated Feasibility Study. The simplified and more robust grinding circuit directs ground product into a single flotation stream with highly efficient cleaning cells. This reduced the number of mills, flotation cells, classification stages and resulted in improved concentrate grades with better payables and like-for-like gold recovery.

Keywords

Gold, Flotation, Fine Grinding, Concentrate

Introduction

The Eskay Creek mine is renowned as a high-grade gold and silver deposit primarily associated with volcanic massive sulphide (VMS) mineralization. Initially prospected by Tom Mackay in 1932, high grade gold at Eskay Creek was discovered in 1988-89, and the mine began production in 1994. Eskay Creek operated for 14 years producing approximately 3.3 million ounces of gold and 160 million ounces of silver with average grades of 45 g/t gold and 2200 g/t silver. At the time gold was between $250-$400 per ounce and an underground mine was established with ore direct shipped (DSO) to smelters. As the highest grade zones were mined, the high costs of DSO meant that lower grade ores would become uneconomical and in 1996 International Metallurgical and Environmental studied the potential for a gravity/flotation process to produce marketable concentrates. In 1997 a 150 tonne per day (TPD) mill was constructed which reduced the cut-off grade to 15 g/t. The mill was later expanded to 350 TPD until production ended in 2008.

A decade after Eskay Creek was placed on care and maintenance, Skeena Gold + Silver signed an option with Barrick to allow them to investigate historic data and see if, in a world of improved infrastructure in the golden triangle and higher gold prices, a revitalized Eskay Creek could be a viable operation again. Skeena acquired 100% ownership of Eskay Creek in 2020 and recent feasibility studies conducted by Skeena in 2022 and 2023 considered different flotation concentrators for the project.

2022 Feasibility Study

In 2022 Skeena released a feasibility study (FS) as an open-pit averaging 3.87 g/t gold equivalent (AuEq) (2.99 g/t gold, 79 g/t silver) containing Proven and Probable open-pit mineral Reserves of 29.9 million tonnes containing 2.87 million ounces gold and 75.5 million ounces silver (combined 3.85 million AuEq oz). Total production over a 9 year mine life was 3.2 million AuEq ounces from 2.4 million ounces of gold and 66.7 million ounces of silver. It outlined a project with an after-tax net present value (NPV) of C$1.41B and an internal rate of return (IRR) of 50.2% at a base case of US$1,700 Au and US$19 Ag at a discount rate of 5%.

Testwork completed leading into the feasibility study considered several options of process routes and ultimately lead to the selection of a Mill-Float-Mill-Float, or MF2, flowsheet which can be utilized when trying to avoid overgrinding and sliming of gangue minerals.

Initial operation of 3.0 MTPA for years 1-5 would see primary crushing through a jaw crusher to a 4.4MW 7.3m diameter by 4.3m effective grinding length (EGL) semi-autogenous (SAG) mill and a 5.8MW 6.1m diameter by 8.53m EGL ball mill in closed loop with hydrocyclones to achieve a primary grind P80 of 100μm to rougher flotation. Initially pebbles would be recycled with a pebble crusher added during year 4 as ore hardness increased. As ore grades begin to decline year 6 saw a throughput increase to 3.7 MTPA and a transition to harder ore which required the installation of a secondary crusher and a second primary ball mill of 2.6MW with a 4.88m diameter and 6.72m EGL with hydrocyclones operating in parallel with the existing primary ball mill.

Rougher flotation was accomplished by 4 conventional tank cells. Concentrate from rougher flotation circuit was pumped to a regrind circuit to bring the particle size to P80 of 15μm and pumped to the cleaner flotation circuit for 2 stages of cleaning. Tails from the rougher flotation circuit reported to a slimes classification circuit where 2 stages of cyclones would produce an overflow product with a P80 of 20µm that was sent to a fines rougher/cleaner flotation circuit.

The underflow product from both stages of the slimes classification circuit reported to a 2 stage coarse rougher tails regrind circuit with a 3.4MW 5.2m diameter by 8.4m EGL ball mill in closed loop with hydrocyclones and overflow reporting to a 3.8MW IsaMill as the second stage to produce a final product P80 of 30µm for the scavenger circuit. To support the expansion in year 6 a 1.1MW IsaMill is added to the coarse rougher tail regrind circuit in parallel with the existing IsaMill. With the addition of equipment as part of the year 6 throughput expansion a new pre-engineered building was required to house the additional primary ball mill and IsaMill. No additional equipment for the flotation circuit was expected as part of the expansion as there was not a significant change in the concentrate production and values remained within the design criteria limits.

Concentrates from the cleaner circuit and the fines cleaner circuit were combined and thickened in a 13m diameter high rate thickener then dewatered with a filter press. As the filter cake still contained approximately 15% w/w moisture the concentrate was to be dried to achieve <13.5% moisture w/w and stored in a bunker prior to transportation to smelters. The final concentrate represented 5-10% of the plant feed and produce a concentrate grade of 25-50 g/t Au. At those grades the expected payable for gold in concentrate ranged from 80.1% to 88.2%. The concentrate also had elevated levels of arsenic, mercury and antimony during the first 3 years of operation that would incur penalty before the deleterious elements dropped to values that fell within typical industry expectations.

The flowsheets are provided in Figure 1 (initial) and Figure 2 (expansion).

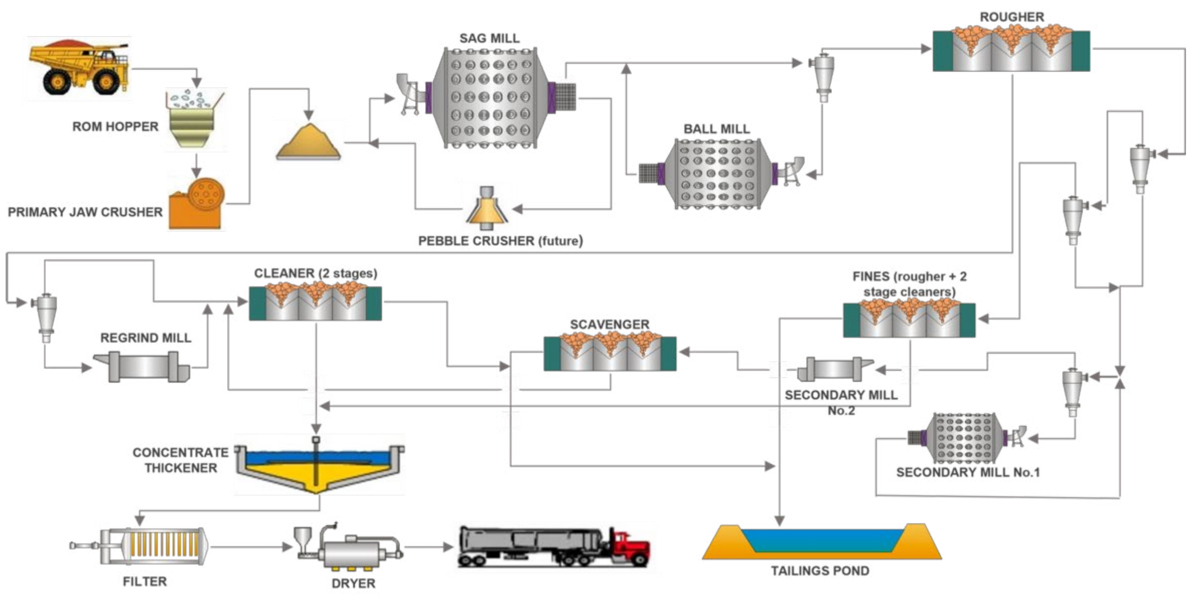

Figure 1 2022 FS Flowsheet Years 1-5

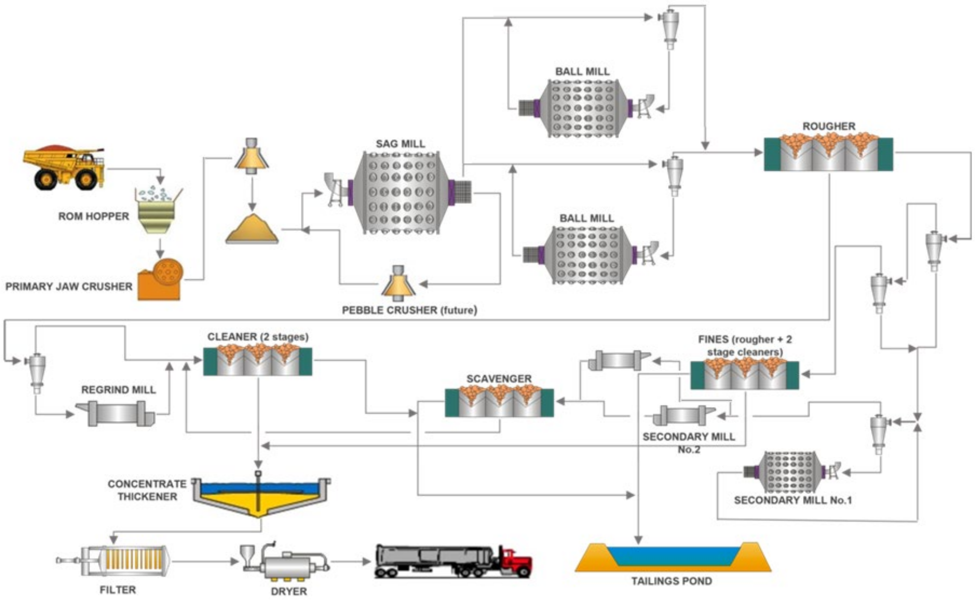

Figure 2 2022 FS Flowsheet – Year 6 Expansion

Strategic Review and a Simplified Flowsheet

Following the 2022 Eskay Creek feasibility study Skeena conducted a strategic review of the metallurgical test work and operational plans for the Eskay Creek Project. The objective of the review was to address risks identified with the FS, to simplify the process flowsheet, to improve the flotation concentrate quality without compromising gold and silver recoveries and to minimize the requirements for the expansion as this would be very disruptive to the operation.

Key risks identified in the 2022 FS included:

- Disruption to operations during the expansion construction phase
- Complexity of multiple integrated milling and flotation circuits – including multiple regrinding stages
- Operational challenges of multiple ball and regrind mills of different sizes
- Flotation of low gold bearing slimes
- Impact of slimes on concentrate dewatering

Laboratory testing continued focusing on grind and flotation which sought to address complex metallurgical issues caused in part by reactive sulphide minerals and organic carbon within the ore. Historical testing had also observed slow flotation kinetics that were not fully understood. As was found during the 2022 FS a fine primary grind was required but this test program sought to achieve this without regrinding of the rougher flotation tails. Also determined during testing for the 2022 FS was that flotation performance was sensitive to the release of iron (Fe) ions from the grinding media.

Three bulk samples were prepared that presented differing ratios of the two dominant lithologies (mudstone and rhyolite) corresponding to expected phases of mine life as well as capturing the suspected worst case scenarios occurring when organic carbon would be in greatest relative quantity. All three composites were tested using a common flowsheet.

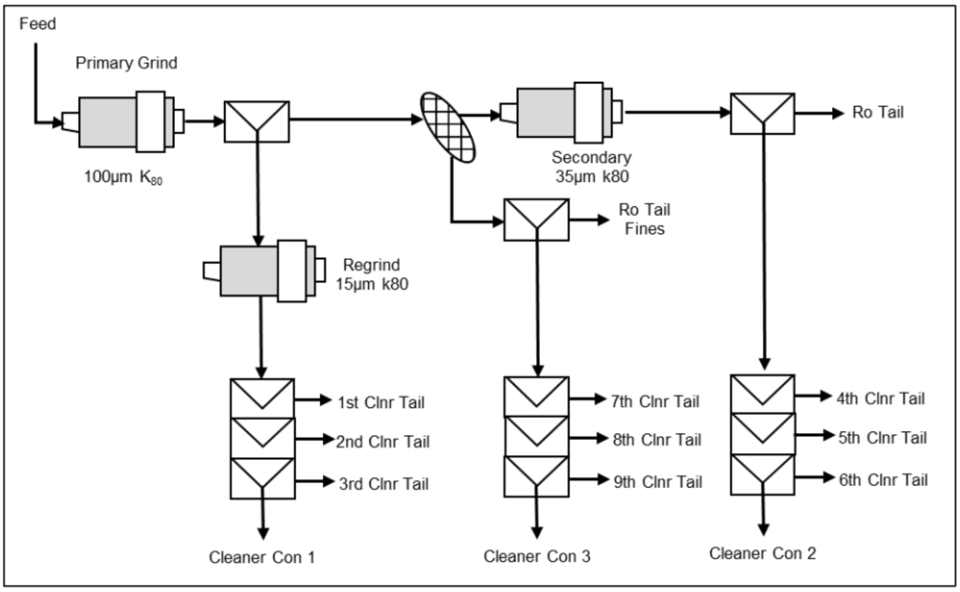

Figure 3 2022 FS Laboratory Flowsheet

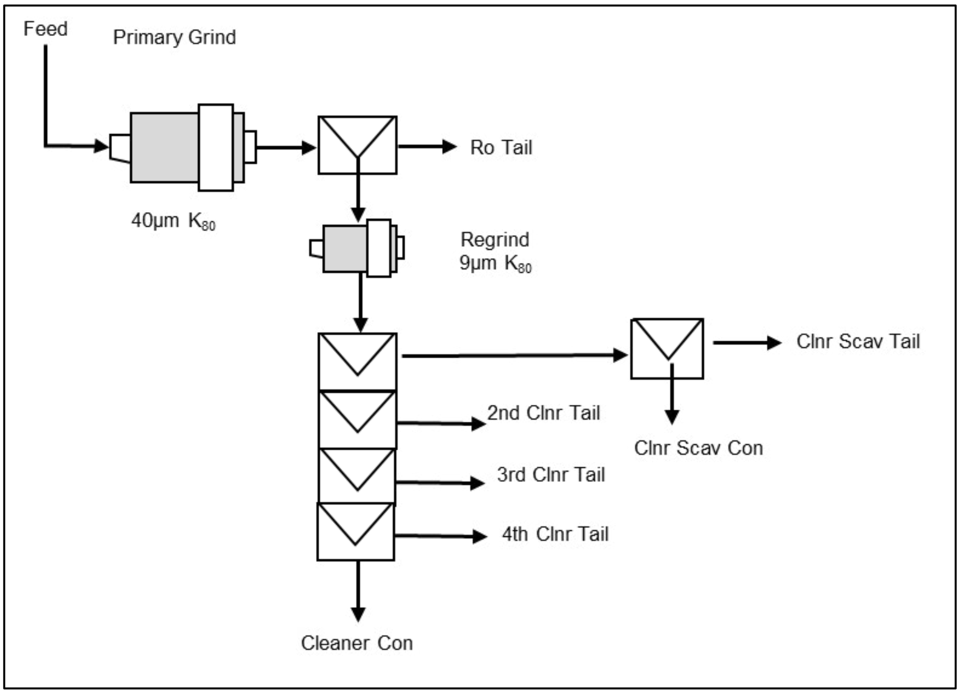

Figure 4 2023 FS Laboratory Flowsheet

It was found that a primary grind of P80 30 µm and dosage rates of potassium amyl xanthate (PAX) as high as 800 g/t in the rougher stage achieved satisfactory recovery. It was also observed that PAX performed better when added into the mill during grinding allowing for more contact time. It is believed that organic carbon in the mudstone is competing for PAX and once sufficient PAX is available sulphide mineral kinetics were observed to be normal. The new reagent scheme also removed the use of copper sulphate as a chemical on site. The high dosage rate of PAX resulted in poor froth quality and optimization work was able to reduce the PAX dosage to 600 g/t in the rougher stage and a coarser primary grind of P80 40 µm as this provided equivalent results. Additional testing considering stronger frothers indicated that improved froth stability could improve recovery but insufficient sample meant that this could not be conclusively determined.

Signature plot testing was completed on rougher feed and rougher concentrate ores to characterize the energy input required for both stages of grinding. Signature plot for the rougher feed samples ranged from 8.5 kWh/t to 11.5 kWh/t across the samples to go from a F80 of 100µm to the target P80 40µm. Rougher concentrates had specific grinding energies of 23.0 kWh/t to 33.7 kWh/t. The regrind of rougher concentrate was adjusted slightly finer compared to the 2022 FS to P80 10 µm.

Cleaner flotation also examined standard flotation testing as well as dilution tests to consider conventional and Jameson or equivalent flotation cells. The dilution tests provided equivalent results to the standard flotation tests. Test results were then piloted to confirm performance and produce sample for dynamic thickening and pressure filtration testing. Pressure filtration testing provided similar results to the 2022 FS and indicated that the final product moisture would be similar to the transportable moisture limit (TML) and as such drying would still be required.

The outcome from the test program found gold recovery to be in the range of 80.8 – 84.0% and silver recovery of 89.0 – 94.2% for the different composites. Compared to the 2022 FS gold recovery was not compromised and silver recovery saw a small improvement. However, the most significant change was an improvement of grade and reduction in concentrate mass.

2023 Definitive Feasibility Study

In early 2023 Skeena initiated a definitive feasibility study (DFS) featuring an updated mineral resource estimate and utilizing the simplified processing flowsheet incorporating the metallurgical improvements. The changes of the flowsheet resulted in a consolidation of the comminution circuit and flotation circuit and the DFS looked to address risks associated with the execution of the expansion phase. A variation in the base case between the 2022 FS and 2023 DFS was that the year 7 expansion was reduced to 3.5 MTPA rather than 3.7 MTPA.

A new approach to the comminution circuit was required to achieve the finer grind prior to rougher flotation. It was decided to continue with a SAG-Ball mill combination and that an IsaMill would further grind the ball mill product to achieve a final rougher flotation feed P80 of 40µm. An IsaMill was selected as the preferred technology in part due to the internal classification which would aid in preventing the overgrinding of gangue minerals as the previous MF2 flowsheet sought to do, but primarily because it's footprint better fit the plant layout whereas other technologies would increase in the overall building size.

With an eye towards reducing the potential impacts during the expansion phase it was decided that the comminution circuit would be designed to be oversized for years 1-5 at 3.0 MTPA and softer ore but right sized for years 6+ at 3.5 MTPA with harder ore. In parallel it was determined that making a further small increase to the size of the SAG mill would be more economical than a secondary crusher and the associated conveyors, steel structure and earthworks.

The new comminution circuit design included an equivalent primary jaw crusher, a 6.1MW 8.5m diameter x 4.9m EGL SAG mill, a 7.9MW 6.5m diameter by 9.8m EGL ball mill and a 5.5MW M20,000 IsaMill. Initially pebble would be recycled via conveyors to the feed of the SAG mill with a pebble crusher added in year 4. Following rougher flotation a single 3.8MW M15,000 IsaMill would regrind the rougher concentrate to P80 10µm. By consolidating the comminution circuit and sizing equipment based on near term future requirements no additional equipment will be required for the grinding circuit. This consolidation of the grinding circuit reduces the circuit by two ball mills and an IsaMill according to Table 1 below which provided significant plant footprint reduction.

Table 1 Comminution Circuit Changes

Area	2022 Feasibility Study	2023 Definitive Feasibility Study
Primary Crushing	185kW Jaw Crusher (or equivalent)	220kW Jaw Crusher (or equivalent)
Secondary Crushing	315kW Cone Crusher (expansion)	n/a
Grinding		
SAG Mill	4.4MW – 7.3m Ø x 4.3m EGL	6.1MW – 8.5m Ø x 4.9m EGL
Pebble Crusher	200kW Cone	200kW Cone
Ball Mill	5.8MW – 6.1m Ø x 8.5m EGL 2.6MW – 4.9m Ø x 6.7m EGL (expansion)	7.9MW – 6.5m Ø x 9.8m EGL
Secondary Mill	3.4MW – 5.2m Ø x 8.4m EGL 3.8MW – M15,000 IsaMill 1.1MW – M5,000 IsaMill (expansion)	5.5MW – M20,000 IsaMill
Regrind Mill	2.2MW – M7500 IsaMill	3.8MW – M15,000 IsaMill

The new processing flowsheet consolidated the flotation circuit into a single rougher stage and removed the fines flotation circuit as this is no longer necessary with the finer primary grind. For the cleaner flotation circuit, the conventional tank cells were replaced with two stages of Jameson cells. Cleaner-scavenger tank cells were retained in the design to allow for capture of any slower floating particles. Replacing conventional tank cells with Jameson cells in the cleaner circuit allowed for additional plant footprint reduction. Combined all the changes to the flowsheet represented a significant total process plant footprint reduction of approximately 460m2. The DFS flowsheet is shown in Figure 5.

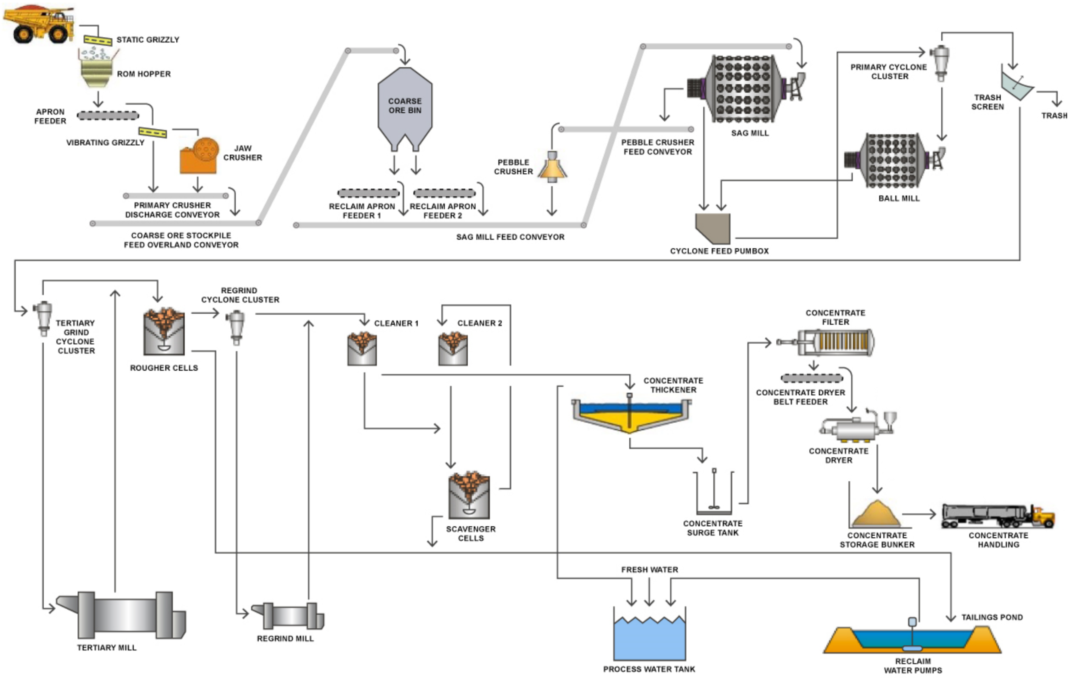

Figure 5 2023 DFS Flowsheet

The outcome for the DFS found gold recovery to be approximately equivalent to the 2022 FS and silver life of mine (LOM) recovery was improved from 88.0% to 90.5%. The concentrate quality also improved as the concentrate production was reduced from 5-10% of plant feed to <5% resulting in a gold in concentrate improving from 25-50 g/t Au to 20 – 94 g/t Au with a life of mine average of 55 g/t which would be payable at approximately 90.5% rather than ~88.0%. Mercury and arsenic were still present in penalty amounts for some years of operation.

The definitive feasibility study had a significant impact on the overall project economics with an after-tax NPV (5%) increasing to C$2.0B and IRR at 43.0%. This was aided by an increase to an open pit grade of 4.2 g/t AuEq and an additional 10 Mt of reserves which extends the mine life by a year. Eskay Creek now would operate for 10 years producing 3.9 M ounces AuEq at assumed metal prices of US$1800 Au and US$23 Ag. While the economic improvement can be largely attributed to the additional reserves and metal prices the concentrate grade improvement and concentrate volume reduction resulted in an average annual after-tax free cash flow increase of C$20M. Table 2 below highlights the differences in the feasibility studies.

Table 2 Feasibility Study Comparison

Measure	2022 Feasibility Study	2023 Definitive Feasibility Study
Open Pit Grade	3.87 g/t (Au Eq)	4.2 g/t (Au Eq)
P&P Reserves	29.9 Mt with 3.85M oz Au Eq	39.8 Mt with 4.6 M oz Au Eq
Production Life	9 years	10 years
Production	3.2 M oz Au Eq	3.9 M oz Au Eq
NPV	C$1.41B @ 5%	C$2.0B @ 5%
IRR	50.2%	43.0%
Gold Price	US$1,700 / oz	US$1,800 / oz
Silver Price	US$19 / oz	US$23 / oz
Au Recovery - LOM	84.2%	83.0%
Ag Recovery - LOM	88.3%	91.0%
Concentrate Grade - Au	25 – 50 g/t	20 – 94 g/t Au (Average 55.0 g/t)
Average Annual After-Tax Free Cash Flow	C$293M	C$313M

References

Skeena Eskay Creek NI 43-101 Feasibility Study 2022 – Filed September 2022

Skeena Eskay Creek NI 43-101 Technical Report on Updated Feasibility Study 2023 – Filed December 2023