10 OPERATIONS: ORE PROCESSING

10.1 PROCESS OVERVIEW

Ore processing for the Stibnite Gold Project is the separation of gold, silver and antimony from its host rock. The processing will result in production of an antimony concentrate and a gold- and silver-rich doré and barren tailings. The Project is expected to produce for sale approximately 4-5 million ounces of gold, 2-3 million oz of silver and 100-200 million pounds of antimony over a 12- to 15-year Project life. See the simplified ore processing flow sheet on Figure 10-1.

In general, ore processing involves the physical reduction of the size of rock fragments, and resulting increase in surface area, followed by chemical processes acting on the enlarged surface area to separate metal-bearing minerals from surrounding rock.

Stockpiling and crushing activities, and large process tanks will be outside, while the remaining activities associated with ore processing will occur inside a series of buildings, which collectively comprise the ore processing facility. The plan-view arrangement of the proposed ore processing facility and associated support infrastructure is shown on Figure 10-2. This facility will include an administration office with meeting and training rooms, laboratory, workshop, warehouse, reagent storage areas, control rooms, and construction and operational laydown area.

At full production, a team of employees will process an estimated 20-25,000 tons of ore per day. Oxide ore will be fed direct to vat leach and bypass flotation (see Figure 10-1). Employees working in the ore processing facility will operate the following components:

- Run-of-mine ore stockpile area;
- Crushing;
- Grinding;
- Antimony flotation, dewatering and concentrator;
- Gold and silver flotation;
- Oxidation and neutralization of gold/silver concentrate;
- Gold and silver leaching and carbon adsorption;
- Carbon stripping and regeneration;
- Gold and silver recovery; and,
- Tailings neutralization.

Materials and process reagents mentioned throughout this section are discussed in greater detail in Section 12.3.

10.1.1 Run-of-Mine Stockpile Area

Midas Gold has designated a run-of-mine ore stockpile area adjacent to the crusher. In order to optimize mill feed and metal recovery, materials with different characteristics (including grade) will be stockpiled separately to allow for precise blending of materials. The stockpile site will have the capacity for approximately 250,000 tons of material, with sufficient area available for separate stockpiles. A front end loader will be used to retrieve material from the stockpiles.

RESTORE THE SITE

Figure 10-1, Ore Processing Flow Sheet

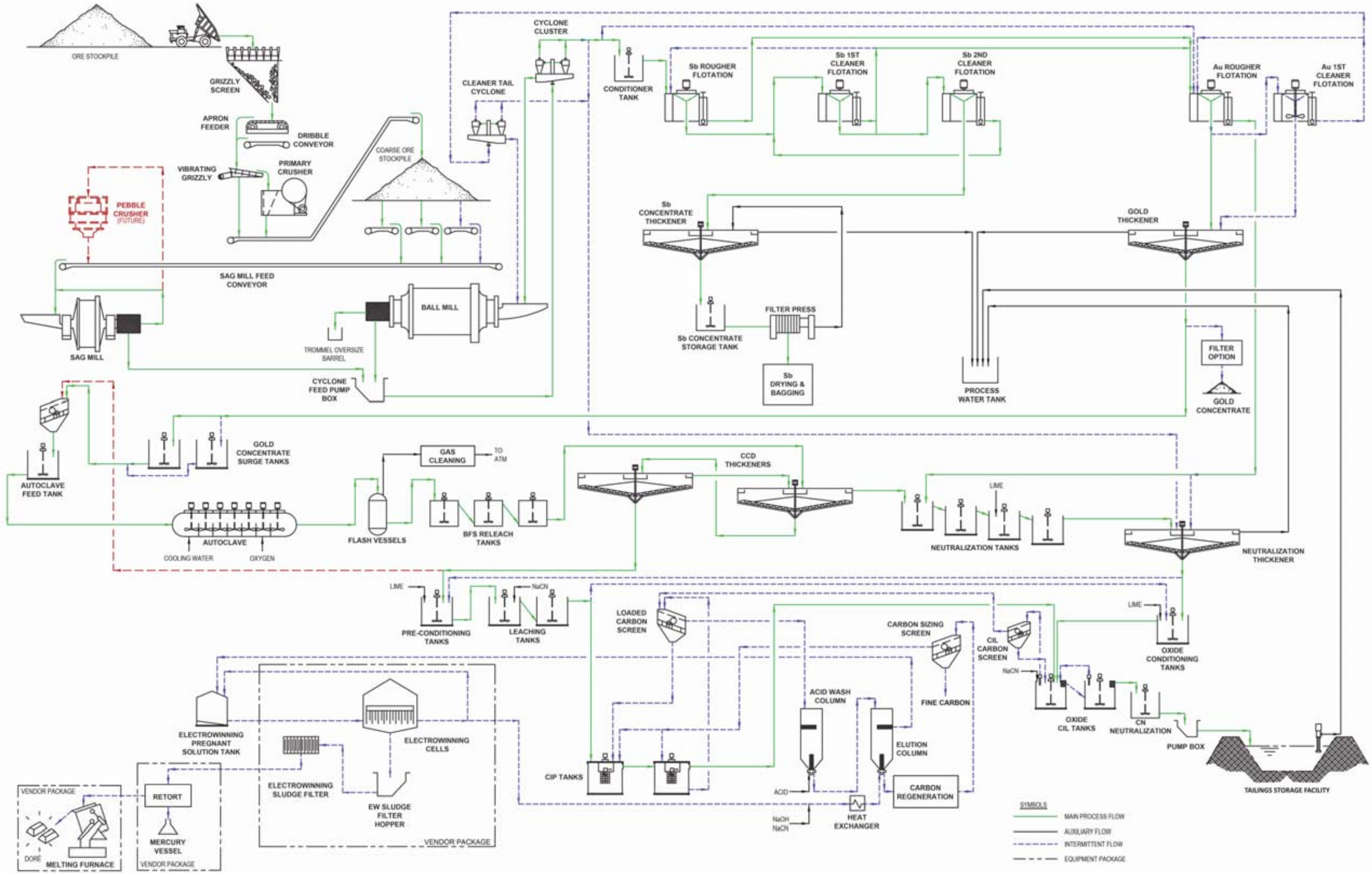
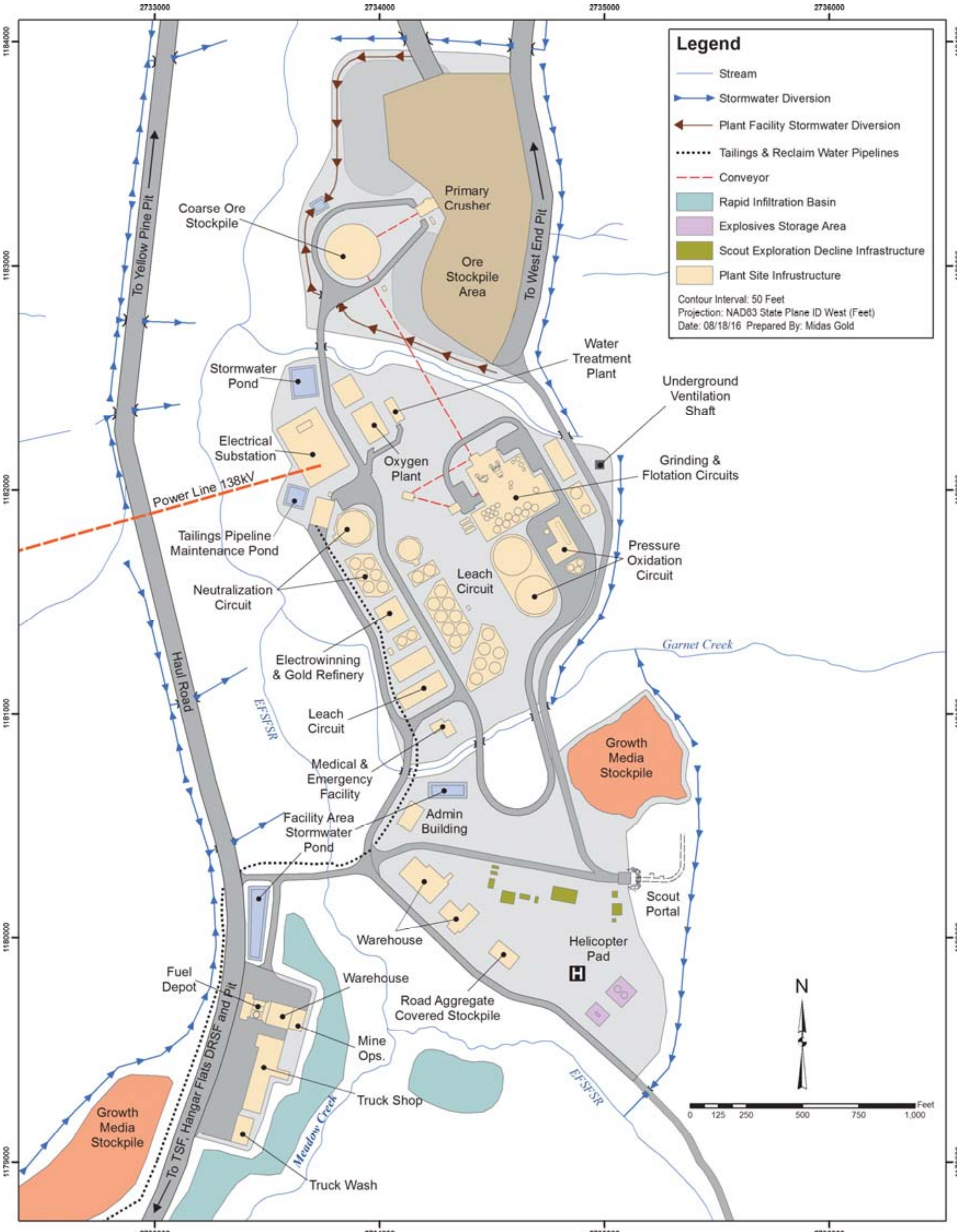


Figure 10-2, Ore Processing and Other Surface Support Facilities



10.1.2 Crushing

The crusher will break the ore into smaller pieces to a consistent diameter of approximately seven inches or less (Section 17.2 includes a photo of a typical jaw crusher). The run-of-mine ore will be hauled from the surface or underground mines and will either be dumped directly into a crusher pocket, where the ore will be fed into the crusher via an apron feeder, or will be stockpiled adjacent to the crusher.

Crushing will produce dust. In order to protect air quality, the crushing unit will be equipped with water sprays and a dust collection system to control dust at the crusher unit. Crushing operations will be scheduled for 24 hours per day, 365 days per year. The crushed ore will be conveyed to the covered crushed ore stockpile and then to the grinding circuit.

Crushed ore material that is stockpiled in the covered facility will be recovered via draw points under the stockpile from which ore material can be reclaimed and fed via a conveyor belt into the grinding circuit (see Figure 10-2). The crushed ore stockpile area will have capacity to store approximately 50,000 tons.

10.1.3 Grinding

Once crushed, the ore will be conveyed to the grinding circuit, where ore will be ground in two stages (initial and secondary) to a size similar to fine sand (80% passing 75 microns). Grinding is required to liberate mineral species from one another and prepare for the subsequent flotation stage of the processing. During the grinding stage, lime may be added to the feed conveyor to control circuit alkalinity. Dry lime will be supplied from a silo adjacent to the feed conveyor (see Figure 10-2). Grinding will be restricted to an enclosed steel frame building to reduce outside noise levels and to eliminate weather impacts, such as freezing and wind, on the process.

Initial grinding will be conducted in a semi-autogenous grinding (**SAG**) mill. Ore, water, and steel grinding balls will be tumbled in this large-diameter, rotating cylindrical ore processing facility to reduce the ore to a finer size. The term semi-autogenous means that larger ore material fed into the ore processing facility assists the grinding media (steel balls) in reducing the particle size. Section 17.2 includes a photo of a typical SAG mill.

The SAG mill will discharge to a vibratory screen. Smaller fragments which pass through the screen will report to a sump; larger fragments which do not pass through the screen will be returned to the SAG mill via a belt conveyor. A pebble crusher may be added to this circuit to crush particularly hard oversize material that is not being adequately crushed by the SAG mill, should the need arise.

Secondary grinding will be performed in a ball mill that also uses water and steel balls in a rotating cylindrical mill (Section 17.2 includes a photo of a typical ball mill). Hydro-cyclones are used to classify the ground ore, with coarser material from the hydro-cyclones returned to the ball mill for further grinding. The ore that is ground fine enough for subsequent flotation or leaching will be routed from the hydro-cyclones to a conditioner tank, where solids will settle to the bottom of the thickener tank to be pumped as slurry with approximately 45-65% solids by weight to the flotation circuit for the antimony recovery process or, in the case of low antimony feed or oxide ore, direct to gold recovery circuits. Decanted water from the conditioner tank will be pumped to a reclaim water tank for reuse in the ore processing facility. Legacy tailings that are excavated from below the SODA area will be mixed with water recycled from the TSF and pumped to the secondary grinding circuit, bypassing the crusher and SAG mill.

Once crushing and grinding has reduced the ore to small particles with a large surface area, the next step is flotation: the first flotation circuit is designed to produce antimony-rich concentrate; the second flotation circuit is designed to produce gold-rich concentrate. Silver will be present in both of these flotation concentrates at approximately equal ratios.

10.1.4 Antimony Flotation, Dewatering & Concentrate Transport

Flotation is a process whereby air is bubbled through agitated tanks of finely ground rock mixed with water and reagents; some reagents cause certain minerals to stick to the bubbles and float to the surface (where the foam spills over into collector troughs and sent for subsequent treatment), while some reagents depress other minerals so that they report to the tailings and are sent for further treatment or disposal; generally, non-sulfide minerals do not adhere to the bubbles and so also report to the tailings.

The antimony flotation process will separate antimony from the mineralized material feed where grades are sufficient to warrant this step. During grinding, the ore processing facility feed will be mixed with milk of lime (water and pulverized lime) and sodium cyanide or equivalent to depress flotation of gold-bearing minerals pyrite and arsenopyrite for subsequent collection. Before antimony flotation an activator reagent (lead nitrate or equivalent) is added to prepare the antimony minerals for flotation, then a promoter reagent (a sulfur and phosphate-bearing organic chemical marketed as Aerophine 3418A or equivalent) is added to render the antimony-bearing particles hydrophobic. During flotation a frother reagent (methyl isobutyl carbinol or equivalent) is added to strengthen the bubbles.

In addition to the reagents, air is blown into the flotation tanks/cells and the slurry is agitated like a giant blender producing a foamy froth. The antimony-bearing mineral particles are treated with the chemicals described in the previous paragraph, which make these particles hydrophobic. The coated antimony-bearing particles attach to the air bubbles, which rise to the surface creating a froth that flows over the edge of the tank into a collection trough. Section 17.2 includes a schematic of a typical froth flotation cell and a photo of typical froth.

The antimony-bearing froth/slurry (the overflow) will be routed through cleaners and recleaner flotation cells to further enhance concentrate grades and then to a thickener, where a flocculent reagent will be added to facilitate the thickening of the antimony slurry. The underflow from the thickener (containing the antimony minerals) will be pumped to a storage tank and then to a filter, where approximately 85-90% of the water will be removed to produce the final antimony concentrate with a 10-15% moisture content. The water removed by the filter will be recycled within the ore processing facility.

The antimony concentrate will contain approximately 60% antimony by weight; the balance of the concentrate includes non-mineralized rock with trace amounts of gold, silver and mercury. The concentrate will be transported by truck in one- or two-ton containers from the Project site for offsite smelting and refining. An estimated one to two truckloads of concentrate will be hauled off-site each day to a commercial barge or truck loading facility depending upon the refinery location.

The rock and mineral particles that do not adhere to the bubbles in the flotation tanks will drop to the bottom of the flotation tanks, become the antimony flotation “tailings” and will be routed to a gold flotation circuit for further processing.

10.1.5 Gold & Silver Mineral Flotation

Following recovery of antimony, the remaining antimony flotation tailings will be processed in a gold/silver flotation circuit in a process similar to that described in Section 10.1.4, only using different reagents (copper sulfate or equivalent is used as an activator to improve performance of the frother, methyl isobutyl carbinol or equivalent is used as the frother, and potassium amyl xanthate or equivalent is used as the collector) with an affinity for floating sulfide minerals (pyrite and arsenopyrite) that contain the gold and silver. The gold/silver-bearing grains that are "floated" in this circuit become the concentrates that will be pumped to the oxidation circuit. The rock particles that do not contain sulfide minerals will not adhere to the bubbles in the flotation tanks and therefore will drop to the bottom of the tanks and become tailings. The gold and silver concentrations of the tailings will be regularly monitored, and if the concentrations are high enough to warrant further processing, they will be sent to the vat leaching circuit (see Section 10.1.7); otherwise, the tailings will be thickened and neutralized (see Section 10.1.10) then routed to the onsite TSF (see Section 11).

10.1.6 Oxidation & Neutralization of the Gold Concentrate

Gold may occur in nature as "free", meaning the gold occurs alone, or "refractory" meaning the gold is trapped within the crystal structure of another mineral, such as the sulfide mineral pyrite. Silver may also occur in a similar fashion. At the Stibnite Gold Project, both gold and silver mineralization generally occurs within sulfide mineral grains and therefore is classified as a refractory ore. In nature, sulfide ores near the earth's surface eventually weather and oxidize the sulfide minerals that contain gold and silver particles, creating oxide deposits that are free milling. To efficiently liberate the gold and silver from the refractory ore, Midas Gold plans to use an autoclave system to artificially accelerate the mineral oxidation process that occurs through natural weathering. Section 17.2 includes a photo of a typical gold autoclave.

An autoclave is, in essence, a pressure-cooker for minerals, in which increased pressure and temperature artificially accelerates the natural process of oxidation. The gold and silver concentrate generated through the mineral flotation process will be fed into the autoclave, where high-pressure steam, water and oxygen are applied to oxidize the sulfide minerals, thereby liberating the gold and silver from their encasing sulfide minerals for subsequent recovery. Upon exiting the autoclave, the slurry will be cooled in flash vessels, neutralized using slurry lime and caustic soda prior to being sent to the vat leaching circuit for gold and silver recovery. The slurried lime and caustic soda will be fed from bulk tanks located adjacent to the mill.

The entire autoclave facility will be housed in a steel frame building set on concrete foundations, with interior walls high enough to contain 110% of the volume of the tanks, thereby eliminating the risk of excursions of solutions from the building in the event of a spill or tank failure.

10.1.7 Gold & Silver Leaching & Carbon Adsorption

The gold and silver leeching component of the recovery process will be designed and operated under the International Cyanide Management Institute Code (**ICMI Code**). The ICMI Code provides best engineering practices for the manufacture, transport, and use of cyanide in the production of these important metals. The Code was developed in an industry program for gold mining companies. It focuses exclusively on the safe management of cyanide and cyanidation of mill tailings and bleed solutions. Companies that adopt the Code must have their mining operations audited by an accredited independent third party to determine compliance with the Code. If the audit is approved, the facility can be certified. Audit results are made public to inform stakeholders of the status of cyanide management practices and procedures at the operation.

The vat leaching operation will be conducted in closed circuit, fully contained facilities to capture, retain and return all solutions within the circuit. A dilute sodium cyanide solution will be added to the leach tanks to dissolve the gold and silver from the ore. The leach tanks will be agitated and compressed air will be injected to assist in the leaching reaction. Slurried lime will be added to the leach circuit, as required, to maintain alkalinity at a pH of approximately 11 in the circuit.

Several tanks at the end of the series will contain granular activated carbon. As gold and silver is dissolved from the ore, the gold and silver will be attracted to the activated carbon and adsorbed. In-tank screens will allow the slurry to pass from tank to tank, but the carbon will remain in each tank. The carbon will be periodically transferred from tank to tank, counter-current to the slurry flow. As the carbon particles are moved through the tanks, they become progressively "loaded" with gold and silver.

Moving the carbon counter-current to the slurry flow will allow carbon with the lowest gold/silver loading capacity to contact slurry with the lowest gold/silver capacity concentration, and conversely, carbon with the highest gold/silver loading capacity to contact slurry with the highest gold concentration. This counter-current arrangement maximizes carbon adsorption efficiency. Fresh or regenerated carbon will be added to the final (or down-gradient) tank while the carbon from the first (up-gradient) tank, loaded with gold and silver, will be removed from the circuit by screening and advanced for gold/silver recovery.

The entire leach facility will be housed in a steel frame building set on concrete foundations, with interior walls high enough to contain 110% of the volume of the tanks, thereby eliminating the risk of excursions of solutions from the building in the event of a spill or tank failure.

Reuse, reactivation and recycling of carbon reduces consumption and transportation requirements.

10.1.8 Carbon Stripping & Regeneration

In the stripping process, the loaded carbon will be washed with acid inside sealed tanks to remove impurities, rinsed with fresh water, and stripped under controlled temperature (approximately 190^{o}F) and pressure conditions using a hot alkaline caustic stripping solution within a sealed vessel. The resulting gold-bearing solution, or electrolyte, will be transferred to the gold/silver recovery process area. Boilers provide temperature control for the carbon stripping process, and the acid used in the process will be contained in tanks and recycled, thereby reducing consumption and transportation requirements. The whole setup will be contained in buildings with concrete floors and aprons that would prevent any escape from the facilities in the event of a spill.

Stripped carbon will be regenerated by heating it to approximately 1,300 ^{o}F in a rotating kiln. Emissions (primarily particulate matter and carbon monoxide) volatized from the process will be controlled by a wet scrubber and carbon filter pack. The regenerated carbon will be reused in the carbon adsorption and leaching circuit. Section 17.2 includes a photo of a typical carbon regeneration kiln.

10.1.9 Gold & Silver Recovery

The gold and silver recovery facility will have a closed circuit system so no process solution can or will be lost or discharged from the circuit to the environment.

The electrolyte, or gold/silver-bearing solution, obtained from the carbon stripping process will be passed through the electrowinning cells where the gold/silver is precipitated onto steel wool. The gold/silver-plated steel wool will be digested with acid and filtered, then dried into a precious-metal laden precipitate. The precipitate will then be retorted[10] in a furnace to volatize any remaining

[10] A retort is a vessel into which materials are placed for the purpose of purifying them using heat.

impurities, such as mercury, which is collected in the retort condensers. Emissions from the retort furnaces will be controlled by carbon canisters and a carbon filter pack.

The retorted precipitate will be mixed with flux and reheated to higher temperatures in an induction furnace. Emissions from the induction furnaces will be controlled by a bag house and a carbon filter pack. The molten material (principally gold and silver) from the induction furnace will be cast (poured) into doré bars. Section 17.2 includes a photo of typical induction furnace.

The used carbon canisters and filter packs will be placed in containers and managed in accordance with the Project's comprehensive materials management plan (see Section 12.3 for details).

10.1.10 Tailings Neutralization

Cyanide-bearing solutions used in ore processing will be neutralized within the ore processing plant before the material is safely transported to the TSF. Cyanide neutralization occurs by first routing tailings from the leaching circuit to one or more tailings thickeners, where the overflow solution will be recycled within the ore processing facility. Thickened tailings will then report to the cyanide neutralization facility, where the residual cyanide will be treated using a sulfur dioxide (**SO_2**) and air system (or equivalent). This treatment process was developed by INCO Limited in the 1980s and is currently in operation at over 100 sites worldwide. The process utilizes SO_2 and air in the presence of a soluble copper catalyst to breakdown and oxidize cyanide to the much less toxic compound cyanate (**OCN-**).

Remnant cyanide levels will be monitored in the TSF supernatant pond to ensure they remain in compliance with issued approvals and permits throughout operations, which will be at levels protective of wildlife. Cyanide solutions contained within the ore processing facilities will have appropriate containment in the event of spills, and the cyanide-bearing solutions will not be sent to the TSF until safe levels of cyanide concentration can be achieved. At no time will unsafe levels of cyanide-bearing solutions leave the building or be discharged into the environment. Once neutralized, the neutralized, thickened tailings slurry will be pumped to the lined TSF (see Section 11).

The ICMI Code identifies a residual cyanide concentration limit of 50 mg/L as sufficiently protective of terrestrial life. EPA and IDEQ require a limit of three orders of magnitude lower for a discharge to the aquatic environment. The Project will be subject to both of these requirements, as it will be designed and operated to meet the ICMI Code as well as State and Federal regulatory requirements.

10.2 ORE PROCESSING FACILITY MOBILE EQUIPMENT

The mobile equipment to be used at the Project ore processing facility is set forth in Table 10-1. This equipment list may be modified during the Project depending on site-specific conditions and needs.

Table 10-1, Projected Ore Processing Facility Mobile Equipment List

Ore Processing Facility Mobile Equipment Type	Estimated Number of Units
Front end loader (Cat 992 or equivalent)	1-2
Small wheel loader with integrated tool attachments (Cat 930 or equivalent)	1-2
Off-road extended boom forklift	2-3
Standard forklifts	2-3
Skid steer loader (S160 Bobcat or equivalent)	2-3
Boom truck	1-2
Mobile crane	1-2
Flatbed supply and stake trucks	2-3
Service trucks with compressors and welders	2-4
Trash truck	1-2
Crew vans	3-5
Pickup trucks	10-15

Notes:
(1) Midas Gold will utilize miscellaneous contractors and their equipment on an as-needed basis to handle small or short (time duration) projects.
(2) Table 7-1 and Table 9-2 provide additional mobile equipment required for the Project.
(3) The range in the number of units is due to equipment service requirements. The lower number represents the typical number of active units whereas the higher number represents the additional units that may be required while the primary unit is undergoing service.

10.3 WATER USE & MANAGEMENT FOR ORE PROCESSING FACILITY

Water will be required to operate the ore processing facility and to pump the tailings slurry to the tailings storage facility (see Sections 11 and 8.11). Midas Gold intends to maximize recycling and reuse of water as much as reasonably possible, thereby reducing the overall net water usage; further, water that has come into contact with Project activities (contact water) will be collected and either utilized in the processing or treated to discharge standards and released. Water used for ore processing, including precipitation falling on the tailings impoundment, is known as "process water".

The ore processing facility will be operated as a closed-circuit facility. Process water will be recycled within the facility and not discharged into the environment.

Recycled and makeup water will be initially added to the ore in the grinding process. Following grinding, the ore will be pumped as slurry throughout the rest of the facility, from flotation cells to leaching tanks. As explained in Section 10.1.10, tailings will be thickened to recover process water and will be pumped as slurry (approximately 55% solids) to the tailings storage facility, where the tailings solids will separate from the slurry and settle and the resulting decanted water will be returned to the ore processing facility. Some process water will naturally evaporate or remain as residual water entrapped in the tailings materials.

Typically, with regard to water use and management, an ore processing facility has three stages:

1. Start-up (charging the system);
2. Normal operation; and,
3. Closure.

When the ore processing facility is first commissioned, fresh water will be used for the ore processing facility, until such time as recyclable water becomes available. During this initial operation, water will accumulate in the supernatant pool of the tailings impoundment and will be recycled to the ore processing facility as sufficient quantities become available. Snowmelt and rainfall will add water to the supernatant pond, especially in the spring.

Generally, after the first year of ore processing, the facility will attain an operational status, where fresh water makeup needs stabilize. At this time, about two-thirds of the total water used in the process will be recycled from uses within the ore processing facility and from the tailings impoundment. However, due to the evaporation and retention of residual water within the tailings, fresh water makeup will continue to be required for ore processing throughout the life of the Project. A portion of this makeup water will come from annual spring meltwater collected within the tailings impoundment, and this water will be further supplemented by water from pit dewatering and contact water collected from runoff within the footprint of the ore processing facility and surrounding infrastructure that is collected, diverted and pumped to the TSF.

When sufficient operational water volume is attained in the TSF, water will be returned from the TSF back to the ore processing facility. The amount will depend on water losses in the system, such as residual water retention within the tailings themselves and evaporation; however, fresh water makeup demand for the ore processing facility should stabilize to an annually consistent cycle that decreases over the life of the Project. Seasonal precipitation and temperature will play a role in determining the amount of water recycled to the ore processing facility from the tailings impoundment.

In the final years of the Project, dewatering requirements for the open pits will decrease, which will allow the operations team to reduce the inventory of supernatant water in the TSF, and minimize fresh water added to the ore processing system, to gradually reduce the size of the supernatant pool at the TSF before operations cease.

At the conclusion of ore processing facility operations, remaining water in the TSF will be evaporated naturally and through the use of evaporative sprayers, or the water will be treated to appropriate discharge standards and reintroduced into the EFSFSR, prior to final closure and reclamation of the TSF (see Section 14.2.3).