VEOLIA

Mining
Case Studies

WATER TECHNOLOGIES

CONTENTS

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Mine Water Treatment Capabilities

Specialized expertise

We provide specialized water systems, thanks to our understanding of the unique requirements of mine operations and our worldwide expertise in mine water issues.

Focusing on system performance, compliance with process and environmental requirements and long-term cost-effectiveness, we are able to meet the demanding reliability, safety and quality standards of the mining industry.

Meeting Your Needs

- To **improve productivity** by treating water for production process requirements
- To **manage environmental risks** by treating contaminated water to achieve water quality suitable for reuse or for safe discharge into the environment
- To **add value** to the bottom line by treating sludge streams to recover suspended and dissolved constituents
- To have **robust and reliable equipment** requiring minimal unplanned maintenance
- To cope with production peaks while **complying with stringent regulations**
- To guarantee long-term efficiency and cost control through **operations services**

Applications

- Tailings pond water treatment for reuse or discharge
- Gold / Silver cyanide solution treatment
- Merrill-Crowe clarification filters
- Treatment of contaminated pit and underground mine water
- Reuse of mine water for irrigation
- Heavy metals removal / metal recovery
- Ammonia / Nitrate removal
- Effluent treatment
- Sulfate reduction
- Potable water and sanitary systems (mining camps)
- Resource recovery

Pretium Resources Brucejack Mine

Location: British Columbia, Canada

Challenge

Veolia was approached by Pretium in 2014 to assist for the permit request with all government instances, to supply a temporary plant used for the exploration and construction phases and ultimately, a permanent wastewater treatment plant to be used once the mine was in operation.

The project brought its own set of challenges, mainly due to the location of the mine. With the mine situated near a glacier, the treated water criteria was very stringent, and, with no road or air access, the site was only accessible by using a Husky tracked vehicle to cross the glacier.

The available space at the site being very limited, Pretium was unable to find space to build a pond for primary decantation, which meant that the TSS in wastewater was correspondingly potentially very high. Space constraints also meant that the treatment chain needed to be as compact as possible.

Key Project Drivers

- Compact and efficient wastewater treatment plant
- Metals removal and high solid sludge content
- Ensure regulatory compliance

Solution

The permanent effluent treatment system, started-up in 2017, consisted of several Veolia proprietary technologies which were selected for their robustness and compactness, starting with the Actiflo® high-rate ballasted clarification process for primary metals removal. The water was further polished by a highly-efficient Hydrotech™ Discfilter, which gave added insurance in meeting very stringent discharge criteria. A centrifuge was installed to dewater the sludge. The inlet flow was between 3,200 and 6,000 m^3/d.

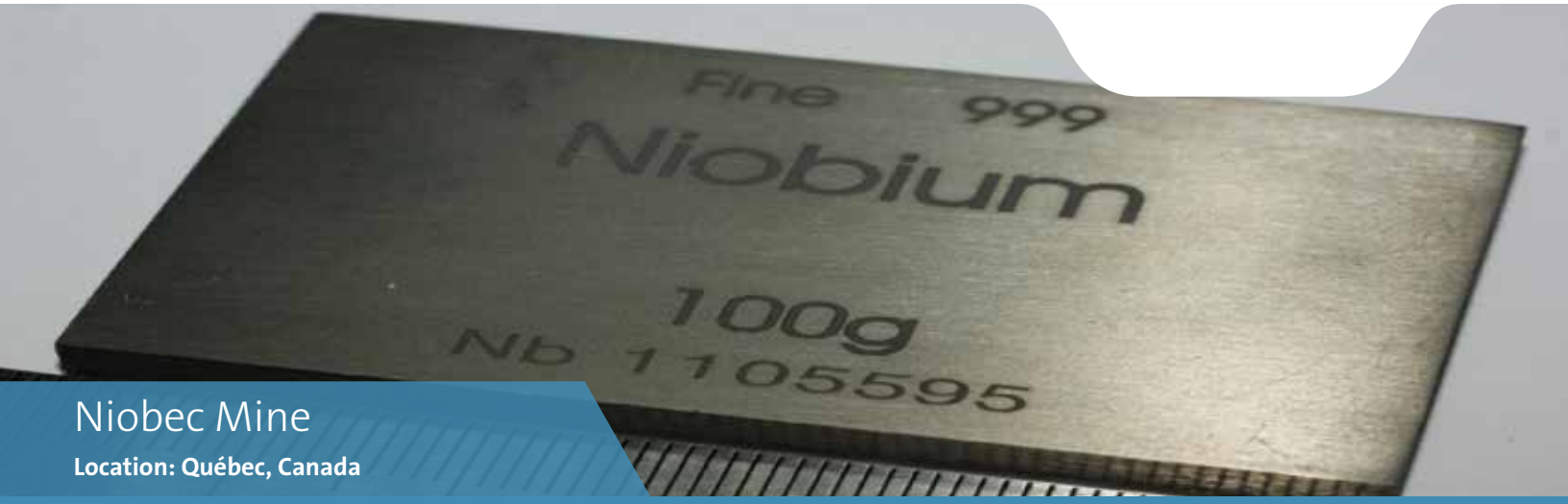
Results

The TSS concentration at the treatment inlet was much higher than expected during design. As the construction activities increased, the TSS increased gradually to eventually exceed 10,000 mg/L. Even given this, the Actiflo® effluent quality was better than required with an average TSS at the Actiflo® outlet around 8 mg/L.

The Hydrotech™ Discfilter, acting as polishing after the Actiflo®, was able to decrease the TSS even further, with an average of less than 2 mg/L. This mining application demonstrated that the Actiflo® can operate with a very high TSS and operated with no degradation of performance with TSS at more than 10,000 mg/L.

Pretium requested that Veolia produce a sludge that could be dry stacked with over 30% solid. To achieve the sludge requirements, Veolia provided a centrifuge to dewater the sludge.

Veolia was able to meet Pretium's expectation by building a compact and efficient plant. The treatment chain used on the project was able to handle more than 10,000 mg/L TSS and to deliver clarified water at less than 10 mg/L while producing sludge at well over 40% solid.



Niobec Mine

Location: Québec, Canada

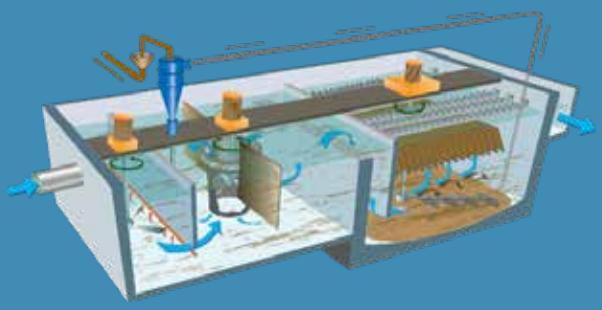
Challenge

Faced with standards that were more demanding in terms of discharge to the environment, Niobec was experiencing difficulty in meeting the standards during the summer months when the phosphorus in the water of their lakes encouraged the proliferation of microscopic algae.

The addition of suspended solids as well as those from the operation of the concentrator and decaying organic matter, caused a slight overshoot of very strict concentrations permitted under the Effluent Regulations Metal Mining (MMER) to the environment.

Key Project Drivers

- Regulatory compliance
- Ability to handle fluctuations in lake levels



Solution

Following a test laboratory and pilot testing of the effluent from the mine, Veolia Water Technologies submitted a rental unit for testing large-scale effectiveness Actiflo® for removal of suspended solids during the summer. The selected water treatment system includes an Actiflo® ballasted floc unit, and chemical dosing systems, calibration systems, instrumentation and controls specific to the process. Chemicals as well as installation, startup and operation of the unit by a qualified employee of Veolia are also provided with the rental of the system, requiring no maintenance from Niobec.

Results

The Actiflo® unit, in addition to enabling compliance with environmental standards in the summer, helps exercise control over lake levels settling at all times, even during heavy rains.

The weighted settling handles a larger volume of water over a wide range of water qualities, despite its low borrows to the ground. The system allows production to 14,000 m³/day of treated water that is then released into the environment.

Ambatovy Nickel Mine

Location: Madagascar

Challenge

The Ambatovy mining and refinery site, located in Toamasina, Madagascar, is one of the largest lateritic nickel mines in the world with an annual estimated production of 60,000 tons of refined nickel and 5,600 tons of refined cobalt.

Ambatovy has entrusted Veolia Water Technologies to design and build a wastewater treatment plant that incorporates the largest evaporation and crystallization project within Southern Africa, not to mention one of the largest in the world. Through a state-of-the-art evaporation and crystallization process, the wastewater plant enables Ambatovy to recover ammonium sulfate as a valuable by-product in the refining process.

This also allows Ambatovy to produce an additional 210,000 tons of ammonium sulfate to be sold as agricultural fertilizer thus increasing the site's profitability.

Key Project Drivers

- Remote location of the site required all equipment to be transported in a modular construction and assembled on-site.
- HPD crystallization technology allows for by-product recovery of ammonium sulfate in the refining process

Solution

Veolia provided a solution that enables Ambatovy to not only meet its production objectives by recovering valuable by-products, but also its environmental objectives by reducing effluent volume thus limiting the impact of its activity on Madagascar's rich and varied natural environment. The solution includes unique HPD® evaporation and crystallization technology developed by Veolia. The process selected is comprised of a purge crystallizer that removes high chlorides from the main crystallizer section, thereby enabling the use of more traditional, and less expensive, 316L stainless steel materials in the construction of the process vessels and equipment without the risk of chloride corrosion.

Results

The crystallization process, utilizing evaporation, occurs over three stages and is very energy efficient. First, the initial energy input of low pressure steam (43 tons per hour) results in a vapor that provides the energy input, as heat, to the subsequent stages. Then vapor is condensed and recovered as process condensate and returned to the condensate system. Ultimately, the plant is capable of recovering 36 tons per hour of dry ammonium sulfate from an initial liquid inlet feed of 160 tons per hour.

The performance of the plant is also enhanced by its robust structure and systems design. The structures, 10m x 10m and 17m high in size, are designed to withstand 280 km/h hurricane winds, as well as mild earthquakes caused by nearby fault lines. Additionally, in order to avoid shutdowns and ensure optimization during the cyclone season, redundant systems have been included for the pumps and vessels.

PA DEP Abandoned Mine

Location: Pennsylvania, USA

Challenge

The water quality in Bennett Branch of Sinnemahoning Creek was impacted by Acid Mine Drainage (AMD) to the point that the stream could no longer support aquatic life. The Bureau of Abandoned Mine Reclamation's (BAMR) goal was to restore water quality to the main stem of Bennett Branch to a level that would sustain sport fishing between Hollywood and Caledonia, Pennsylvania. The AMD entered the stream from 20 discharge points, requiring an extensive collection and treatment solution.

Results

- Recreational fishing has been restored.
- Sludge generation is reduced by 90%.
- The DenseSludge process incorporates sludge recirculation, which reduces lime usage and the associated cost. The sludge disposed in the mine contains less water, reducing the volume of water that returns to the mine pool for re-treatment.

DenseSludge vs. Conventional Sludge

Solution

Veolia conducted treatability studies and developed a treatment process and system design utilizing DenseSludge technology to effectively treat the AMD. DenseSludge technology reduces sludge management costs and improves treatment plant operating efficiency. The process utilizes standard equipment combined with Veolia's process expertise in sludge recycling techniques to form a heavier, denser sludge, reducing sludge generation by nearly 90%. Sludge from this process contains up to 25% solids as compared to 4% solids or less typically achieved by conventional processes, facilitating sludge disposal.

Veolia designed a centralized treatment facility near Hollywood, Pennsylvania, with provisions for sludge disposal in an abandoned mine. The facility treats up to 10 million gallons per day (MGD) of AMD and meets the requirements of Pennsylvania Code, Title 25 PA DEP Chapter 87 Subpart 102 - Hydrologic balance: effluent limits, Group A criteria plus aluminum, as required by BAMR. Due to a PA DEP reorganization, the plant is now operated by DEP's Bureau of Conservation and Restoration.

For this project, Veolia partnered with Civil & Environmental Consultants, Inc. (CEC) for the design of the civil work, including design of the collection system, sludge disposal system, a polishing basin for the effluent, and building architecture. Veolia's work scope included the treatability studies, process design, equipment specifications, general plant layout, the basic mechanical design for the treatment plant, and electrical and instrumentation/controls for the entire project.

Auto-Jet® Pressure Leaf Filters

Location: Various

Auto-Jet Filters

Veolia's precoat filtration technology help gold producers achieve maximum efficiency in their gold recovery operations. By filtering the cyanide leach solution before zinc precipitation, precipitated impurities that could be carried over from the decantation steps are removed. No more than a trace of oxygen is left, minimizing zinc and cyanide consumption.

Key Benefits

> Deep-cleaning of leaves yields longer filtration cycles, thicker cake and better filtrate quality
> Effective pre-coating procedures with uniform cake distribution on both side of leaves
> Higher flux rates and smaller footprint requirements compared to fixed-leaf designs
> Low inspection and maintenance requirements thanks to easy access and full automation capabilities
> Flexibility. Wet of dry cake discharge option using sluice jets or air-dried cake cleaning
> Lower capital and operating costs compared to membranes systems likely to foul and fail

Enhanced Filtration for La Herradura Mine, Mexico

La Herradura Mine, Mexico, needed a compact and easy-to-maintain technology for filtering the pregnant leach solution treated by the Merrill-Crowe process. An Auto-Jet system was installed at the ore processing plant, to remove particles and impurities from liquid streams.

Auto-Jet Filter Helps Expand Gosowong Gold Processing Plant, Indonesia

The Gosowong Gold Processing Plant, in Indonesia, uses a single process plant for all of its mining operations. The plant consists of 3 Auto-Jet systems that treat the pregnant leach solutions from the Merrill-Crowe process. The operator, PT Nusa Halmahera Minerals, purchased an additional Auto-Jet system in order to expand the capacity of the plant.

Auto-Jet Filters Boost Productivity in Hidden Valley Gold Project, Papua New Guinea

The Hidden Valley Gold Project, Papua New Guinea, likewise employs 2 Auto-Jet systems to maximize productivity in the Merrill-Crowe process. The filters treat up to 136 m^3 /hr of high-purity filtered gold liquor, by separating solid impurities from the pregnant cyanide solution.

Teck Resources

Location: British Columbia, Canada

Challenge

The client urgently needed to remove 200,000 m^3 – 300,000 m^3 of water from tailings pit in three months. The mine operations were in an environmentally sensitive and remote area.

The client needed to dewater the mine pit in order to meet blasting target date. The production schedule was critical. Therefore, the rapid mobilization of a mobile water treatment system and Hydrex water treatment chemical program was imperative.

Key Project Drivers

- Needed emergency solution to ensure pit was dewatered in time to meet blasting date
- Regulatory compliance to ensure the stringent environmental discharge requirements met the Federal Water Quality standards

Solution

Veolia Water Technologies supplied a bundled package of a customized mobile Actiflo® clarifier, reactor mix tanks together with a comprehensive range of Hydrex chemicals.

The mobile water treatment process consists of metal precipitation in reactors followed by Actiflo clarification in order to meet Federal Water Quality Objectives. The Hydrex program included commodity precipitation chemicals (Hydrex 3253 - ferric sulphate in combination with Hydrex 3515 (anionic polymer) at 10 mg/L. The mobile Actiflo unit was designed to treat a capacity of 10,000 cubic metres per day. A mobile Hydrotech™ Discfilter was additionally used for tertiary polishing.

Results

The Actiflo-Hydrex combination produced a treated water with the following characteristics:

Parameters	Units	Treated Water Limits	Water Quality Results
pH	-	6.5 - 9.0	7.2
Total Aluminum (Al)	mg/L	0.1	0.0264
Total Beryllium (Be)	mg/L	0.0053	0.00215
Total Cadmium (Cd)	mg/L	0.00018	0.00015
Total Cobalt (Co)	mg/L	0.004	0.00011
Total Copper (Cu)	mg/L	0.011	0.00075
Total Iron (Fe)	mg/L	1	0.345
Total Nickel (Ni)	mg/L	0.15	0.0064
Total Zinc (Zn)	mg/L	0.14	0.0106

All discharge permit requirements and the mine pit was dewatered in advance of the deadline such that blasting could be completed as scheduled.

Nunavik Nickel Mine

Location: Québec, Canada

Challenge

The client needed to remove thiosalts from its wastewater at its Nunavik Nickel mine site in the north of Quebec, in order to ensure the site could meet their permit limits for discharging wastewater back into the environment.

Additionally, due to the remote location of the mine site, the client needed an expedited water treatment solution.

Key Project Drivers

- Ability to offer multi-year mobile rental option to lower CAPEX
- Expedited treatment option due to the severe remoteness of the mine site in order to get equipment in before winter
- Ease of integration into existing wastewater treatment process

Solution

The client contracted Veolia Water Technologies to provide two 100 m^3/h nano-filtration units through its Mobile Water Services rental fleet for the required thiosalts removal from the wastewater.

Veolia was able to expedite the supply of the mobile units in order to meet the client's limited delivery timeframe due to the remote site location and very harsh climate. The compact and efficient design of the units were able to easily integrate into the facility's existing wastewater treatment process at the site. The two nano-filtration units were commissioned in June of 2018 and have been providing consistent performance results at the mine site.

Results

The nano-filtration units allowed for over 99.9% removal of thiosalts from the wastewater. Additionally, with ability to rent the units in a multi-year contract, the mine was able to lower its capital budget by utilizing operating expenditures instead.

Bacanora Lithium

Location: Mexico

Challenge

Lithium, a key component for fast-growing rechargeable battery markets, powers everything from consumer electronics to electric cars and energy storage systems.

Although lithium is a relatively abundant metal, high-purity lithium chemicals used by battery makers are rarer because lithium extraction, either from brines or hard-rock, consists of a series of complex operations that make design production rates hard to achieve. While these issues are also common in other mining sectors, the problems with lithium are compounded because of the reduced number of lithium plants in operation which means that the industry know-how is limited.

Key Project Drivers

> Ability to achieve >99.5% battery-grade lithium carbonate

> By-product recovery of waste stream to create value-added SOP

> Technology partner with deep lithium production expertise

> Testing and process design expertise

Solution

To mitigate the risks of the project and confirm that the proposed technical and commercial process is both feasible and scalable, Bacanora, a lithium exploration and development company, relied on Veolia's deep lithium production expertise to test the process flow sheet developed during the feasibility study and simulate the unit operations planned for the Sonora Lithium Project, an integrated mine in northern Mexico designed to reach a capacity of 17,500 tons per annum battery-grade Li_2CO_3 (lithium carbonate) operation in its first phase.

Integrated to this innovative plant, Veolia designed an evaporation circuit with a double crystallization sequence featuring HPD® thermal separation technologies to maximize the recovery of potassium sulfate, a specialty fertilizer also known as sulfate of potash (SOP), and sodium sulfate, a valuable salt that is recycled upstream as the reagent in the clay roasting process. The production line is completed by ion-exchange purification, solid-liquid centrifugal separation and drying systems to achieve >99.5% battery-grade lithium carbonate.

Veolia's exhaustive testing program and process design expertise with HPD® evaporation and crystallization technologies, validated Bacanora's product purity requirements while removing potassium and converting a waste stream into a high-value-added fertilizer. Because lithium mining is inherently risky, Veolia partners with developers and producers to improve their environmental performance and optimize their operations to help them extract the most economic value out of the production of high-purity lithium chemicals.

Resourcing the world

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