



**Samuel Billin, P.E., P. Eng.**  
*President/Senior Process Engineer*

Mr. Billin has 26 years of experience consulting the mineral industry in environmental investigation, remediation, civil engineering, and water resources. He is experienced in subsurface flow and contaminant transport and couples that specialty with hydrogeology and civil engineering for design of water supply, water treatment systems, and wastewater treatment facilities. Mr. Billin leads Linkan Engineering focusing on mine water treatment plant scoping, design, construction, and operations. His broad range of mine water treatment plant design affords any project unique insights in both conventional treatment plant design and innovative, cost-saving alternatives. His design project history includes essentially every mine water process technology common in the industry as well as numerous innovative approaches. He has conceived and designed mine water treatment processes across North America, South America, Asia and Africa.

## Project Experience:

### **Underground Dewatering Water Treatment Plant, Elko, Nevada**

Mr. Billin served as a lead designer for the installation of a 1,400 gpm water treatment plant to address elevated arsenic and antimony in dewatering flows from the Smith underground mine. The facility was designed to be installed in an existing building to speed up the permitting and construction. The facility includes iron salt injection for arsenic removal and filtration by multimedia sand filters. The water is further polished for antimony removal with a series of iron hydroxide media adsorption beds. Chemical storage for the process was incorporated into the reagent tank farm of the adjacent tailings supernatant treatment plant.

### **Tailings Supernatant Water Treatment Plant, Elko, Nevada**

Mr. Billin served as Project Manager for the scoping, design and construction of a 1,000 gpm water treatment plant at the Jerritt Canyon Gold site north of Elko, Nevada. The project was executed as a Design/Build due to the urgent project schedule. Mr. Billin led the Linkan Construction division in formulating a rapid response for this project. The facility includes a 14,000 square foot treatment building housing equipment for pretreatment, Inclined Plate Settlers, Ultrafiltration, Sea Water Reverse Osmosis and Ion Exchange polishers. An exterior reagent tank farm was provided with approved secondary containment. The feed water presented significant challenges and an optimized system was determined through onsite pilot testing. The feed water consisted of highly saline water (i.e., 19,000 mg/L TDS) and very high levels of mercury, thallium, arsenic, and antimony. The rapid response to the problem is estimated to have saved the client over \$4M in temporary treatment costs.

### **Preliminary Design of UF/RO Water Treatment Plant, MPW, Freeport Texas**

Mr. Billin served as Project Manager for the design of a preliminary treatment system for an Ultrafiltration and Reverse Osmosis water treatment facility to provide cooling system and boiler makeup water at an industrial plant. The source water is from the Brazos River, so is high in suspended solids. Equipment was evaluated and sized including reaction tank, inclined plate settlers, gravity thickeners, plate and frame solids presses, transfer pumps and piping, coagulant and flocculent mixing, storage and delivery systems, chlorine dioxide disinfection system, collection sumps, and general arrangement of all equipment. A mass balance calculation, a full set of P&IDs, and GA drawings were provided, as well as a conceptual cost estimate. Linkan was able to optimize design and construction of the plant resulting in an estimated 30 percent reduction of the anticipated capital costs.

#### **Professional Registration:**

- Arizona, Idaho, Nevada, Montana, Utah, Alaska, Texas, Yukon, British Columbia
- Nevada T-3/D-2 Certified Operator, ABC Class II, Colorado Class B Operator

#### **Education:**

- M.S., Civil Engineering, Utah State University, 1992
- B.S., Civil Engineering, Brigham Young University, 1991

#### **Relevant Qualifications**

- Water Treatment Plant Design
- Project Management
- Water Balance
- Hydrogeology
- Civil Engineering
- Remediation
- Pipeline Design
- Permitting
- Process Engineering
- Contract Operation
- Operator Training

#### **Certifications:**

- Water Rights Surveyor
- MSHA Surface Mining
- Certified Water Operator

#### **Years of Experience:**

- 26

#### **Microfiltration Pre-Treatment Plant, Carlin, Nevada**

Mr. Billin served as the Project Manager and lead designer for a temporary 4,800 gpm mobile microfiltration plant. This project was completed to provide pretreatment for an existing failed UF/RO plant designed by others. Mr. Billin identified the existing plant fatal flaws, pilot tested the proposed solution, designed the facility, permitted the change and supervised construction and commissioning. The entire process was completed in less than 45 days. The microfilter pretreatment provided sufficient solids removal to allow the existing UF/RO plant to operate at design conditions.

#### **Tailings Reclaim Reverse Osmosis Water Treatment Plant, Carlin, Nevada**

Mr. Billin served as the Project Manager for 24/7/365 operation of a 4,000 gpm ultrafiltration/reverse osmosis water treatment plant for one of the world's largest gold mining companies. He led a team of 11 full-time operators in operating this aggressive membrane plant for challenging tailings reclaim water with 30,000 mg/L total dissolved solids. He led the team responsible for training the entire operations staff in proper plant operations and modification of plant parameters to achieve high quality effluent and recover the concentrate for reagent reuse.

#### **Mine Tailings Water Treatment Plant, Masbate Island, Philippines**

Mr. Billin served as Project Manager for the design of a 3,000 gpm cyanide and molybdenum removal plant at a remote mine site in the Philippines. He conducted the on-site bench testing to confirm optimal process design and led the design, procurement, and construction of the permanent facility within a total period of 7 months. The novel process utilized the INCO cyanide removal process followed by molybdenum removal by adsorption onto ferric hydroxide. Mr. Billin conducted innovative development of this Mo removal process. Once adsorbed to ferric floc, the solids are removed by microfiltration.

#### **Diamond Mine Dewatering Water Treatment Plant, Northwest Territory, Canada**

Mr. Billin served as Project Manager for the scoping, pilot testing and design of a 8,500 m<sup>3</sup>/day water treatment plant to treat elevated TDS from an underground diamond mine. Ultra-pure discharge standards required the use of high efficiency, multi-stage membrane treatment to achieve discharge standards. Pilot testing was conducted to compare lower cost options with 90 percent water recovery with 95 percent recovery options with more complex equipment. Brine concentrate is collected and processed through a brine crystallizer to achieve a solid waste stream capable of being trucked for disposal from the remote mine site.

#### **Turquoise Ridge Mine Water Treatment Plant, Golconda, NV**

Mr. Billin served as Project Manager and lead designer for pilot testing and design of a 2,000 gpm mine water treatment plant for the reduction of arsenic, antimony, manganese, iron, sulfate, and TDS. The project involved a four week pilot trial of the microfiltration/nanofiltration (MF/NF) process. The process successfully removed arsenic from 12,000 ppb to the discharge standard of 10 ppb (99.96% removal). A 30% slip stream of nanofiltration is utilized for the removal of sulfate. Pilot testing confirmed the conceptual design and Mr. Billin lead the detailed design, permitting and procurement of this new treatment facility.

#### **Cortez Hills Water Treatment, Barrick Gold, Crescent Valley, NV**

Mr. Billin served as the project manager on the design and construction of a 2,500 gpm water treatment plant for Barrick's Cortez Hills Underground Mine. He led the team conducting detailed bench testing, Scoping Study, and on-site pilot testing. The pilot testing was conducted using Linkan's mobile pilot laboratory designed and constructed by Mr. Billin. The team was successful at pinpointing a process for simultaneous removal of arsenic and antimony to discharge standards. Linkan prepared a Preliminary Design (30%) for permit submittal. This process uses pretreatment with oxidant and ferric salts to create a suspended ferric hydroxide floc used to adsorb arsenic and antimony. The suspended floc is then removed by microfiltration and solids are thickened, pressed and disposed of in mine waste.

#### **Demineralization Water Treatment, Newmont TS Power Plant, Dunphy, NV**

Mr. Billin was the project manager and lead designer assisting Newmont's TS Power Plant with modification/upgrade options for their existing demineralization Water Treatment Plant. Linkan evaluated the existing water treatment plant used to treat and generate boiler feed water for use in power generation and provide recommendations for improvements. After a thorough system evaluation, research, modeling, bench scale testing, and investigation of available technologies on the market, Linkan recommended double pass reverse osmosis and replacement of the mixed bed ion exchange with electrodeionization (EDI) as an alternate technology. In addition, a bottled mixed bed ion exchange is recommended for additional assurance of water production and quality.



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**Fire Creek Mine Dewatering, Klondex Gold and Silver Company, Crescent Valley, NV**

Mr. Billin was called in to assist Klondex with an urgent water management project. After struggling with reverse osmosis plants provided by global equipment providers, Klondex struggled with continual fouling of the membranes. Mr. Billin led the Linkan team to evaluate the system, bench test the process and design a microfiltration/reverse osmosis plant that greatly simplified operations, increased performance, and was reliable. The key to the project was the use of microfiltration to maintain an absolutely solids-free feed to the reverse osmosis. Sub 5 micron particles had been passing the sand filter of the previous system and fouling the membranes. This required membrane replacement every 24 hours. Mr. Billin led the design, procurement, commissioning, and operation of the plant within a 45 day period to restore mine operations underground. The project saved Klondex more than \$1.6M over a four month period.

**Big Ledge Pit Dewatering, Wells, NV**

Mr. Billin served as the Project Manager for a fast-paced dewatering of the Big Ledge Pit. His client required the urgent removal, treatment, and discharge of 40 million gallons of acid pit water laden with metals. He developed and executed detailed bench testing which developed and confirmed the proposed process of oxidation, lime addition, ferric chloride addition, and microfiltration. The project is presently being decommissioned and Mr. Billin has been a key member of the Linkan team in constructing the facility, commissioning the processes and operations throughout the summer of 2012.

**Eagle Project Feasibility Study and Preliminary Design, Victoria Gold, Yukon Territory**

Mr. Billin served as the Project Manager for the NI43-101 Feasibility Study for the Eagle Gold Project in the Yukon Territory. His responsibilities involved the coordination of water management planning as well as the specific development of water treatment alternatives and costing. He served as the Qualified Person for the water treatment sections of the study. By questioning the prefeasibility study water balance, Mr. Billin was able to rework the water management to eliminate the costly requirement for removal of sulfate and total dissolved solids from the water treatment plant significantly reducing the proposed cost. Mr. Billin led the development of a metals precipitation plant that segregated caustic and ferrous sludge precipitation phases to allow for long-term solids management and disposal on the mine site. Mr. Billin led the design team preparing the preliminary engineering for inclusion in the Water Use License application.

**\*Sulfate Removal Plant, US Steel Corporation, Virginia, MN**

Mr. Billin led the team conducting the scoping, bench testing, piloting and Preliminary Design of a 10 MGD integrated membrane plant for removal of sulfate from tailings water at this taconite mine in northern Minnesota. Innovations in sulfate removal processes reduced the capital cost by 40%. Mr. Billin led the detailed Stage-Gate development of a Preliminary Design and Feasibility Study for this \$40M facility. The process involved lime softening, microfiltration and reverse osmosis with a gypsum precipitator and crystallizer for managing the residual brine.

**\*Cavern Leaching Membrane Filtration Plant, Jackson, Mississippi**

Mr. Billin served as the Project Manager, design, pilot testing, construction and operation of a 12 million gallon per day (MGD) water filtration plant at a natural gas cavern leaching operations. He led the design effort to construct a large filtration plant removing solids down to 0.1 microns using microfiltration membranes. Significant research and testing were required to confirm the membrane cleaning procedures required for filtering this salt-saturated brine. Mr. Billin developed an innovative application of microfiltration that resulted in a total cost savings of over \$360 million over 7 years compared to the previous filtration system. Mr. Billin led the design and operation of a 4 MGD pilot plant followed by a 12 MGD full build-out.

**\*Pit Dewatering/Tailings Decant Treatment, Barrick Gold Africa, Tanzania**

Mr. Billin served as the Project Manager for two individual water treatment plants for this gold mine in northern Tanzania. He led the conceptual development of the proposed process trains and is presently leading the design and commissioning. One process train will treat pit dewatering from the Gokona pit utilizing pH adjustment, oxidation and coagulation-assisted microfiltration for the removal of TSS, arsenic, and ammonia. A second process train uses lime and soda ash softening as a pretreatment for tailings decant water through an integrated membrane plant. The treatment plant was constructed and commissioned in Tanzania and meets all design standards for discharge.

\* Denotes work performed while working for a prior employer