

BIOTEQ

BIOTEQ ENVIRONMENTAL TECHNOLOGIES INC

Biological Treatment of Acid Wastewater for Selective Metal Recovery and Site Remediation

Commercial Case Studies

David Kratochvil, Michael Bratty

BioteQ Environmental Technologies Inc, Canada

Johannes Boonstra

Paques BV, The Netherlands

Introduction

- n BioteQ and Paques have commercialized a high-rate H_2S generation biotechnology using sulphate and elemental sulphur
 - | treatment of acid drainage
 - | treatment of smelter and metal industry effluents
 - | recovery of metals as saleable concentrates

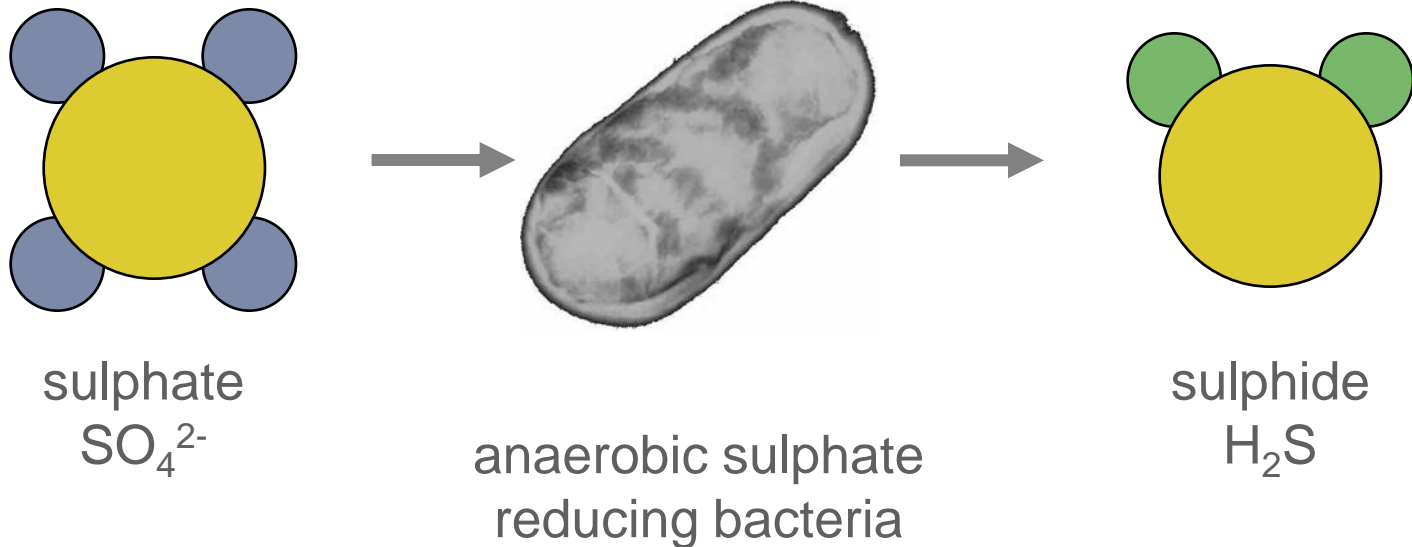
- n 4 Case studies:
 - | S^0 reduction upstream of an existing lime plant
 - | S^0 reduction to replace an existing lime plant
 - | S^0 reduction for metal recovery at a dump leach operation
 - | SO_4 reduction for groundwater remediation

Metal Sulphide Precipitation

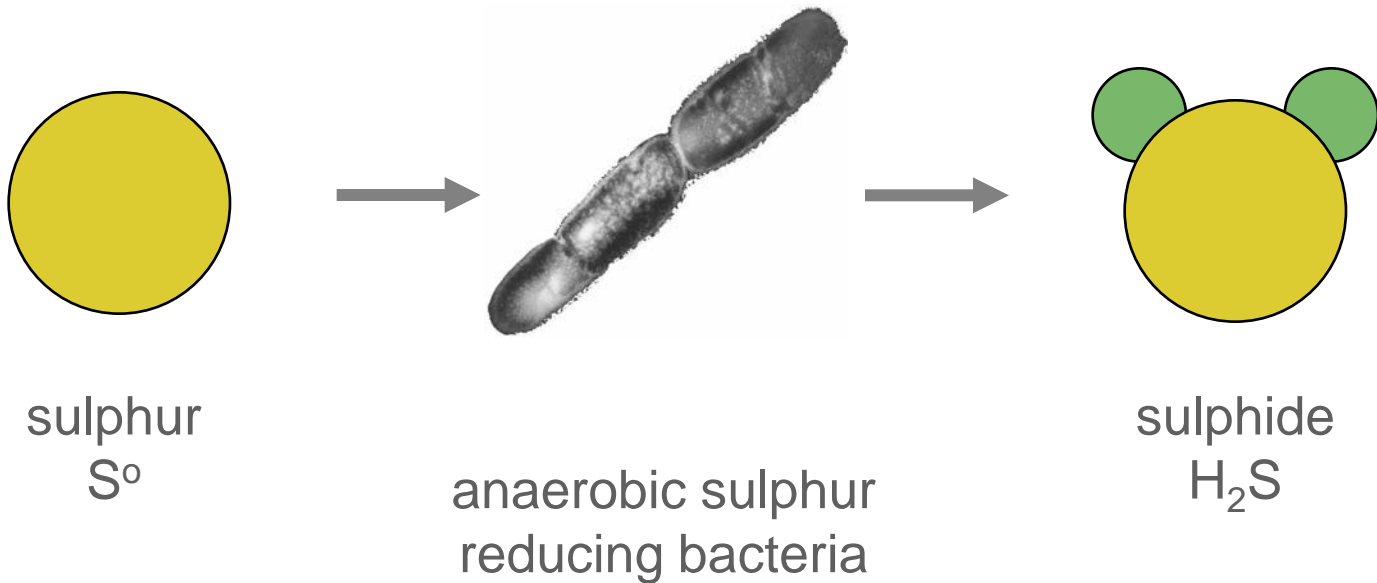
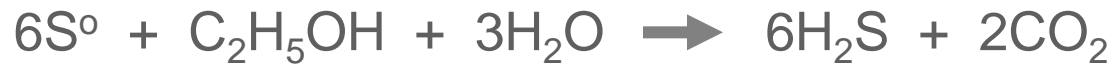
Metal-contaminated effluent + H₂S → Metal Sulphide

- n Metals can be removed selectively
- n High grade, saleable products

Biological Sulphate Reduction



Biological Sulphur Reduction



BioteQ and Paques

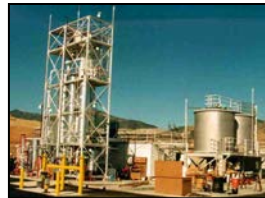
- n BioteQ and Paques have a Technology Cooperation Agreement and market the **BioSulphide - Thiopaq** technology for a number of industrial applications
- n 14 industrial plants for reduction of sulphur compounds marketed under trademark **Thiopaq**[®]
- n BioteQ owns the patented **BioSulphide Process**[™] concerned with the reduction of sulphur compounds and concurrent selective recovery of metals
- n First industrial BioSulphide-Thiopaq plant built in Canada

Why Sulphide for Water Treatment

- n Better effluent water quality - metal sulphides have lower solubility than hydroxides - lower overall TDS
- n Easier and less expensive solid-liquid separation - sulphide precipitates are crystalline and have higher density
- n Metals not stored on site as hydroxide sludge
- n Opportunities for revenue from recovered metals
- n Stand-alone application or integrated with lime plant
- n When integrated with lime plant:
 - | Reduced chemical consumption
 - | Reduced volumes and toxicity of sludge
 - | Environmentally better solution - better quality water, metals recycled and sludge is more stable

Biogenic Sulphide Generation

- n Sulphur reduction produces lowest cost sulphide
- n Sulphide is produced on demand - more efficient dosing of reagent
- n Increased safety - low inventory of sulphide

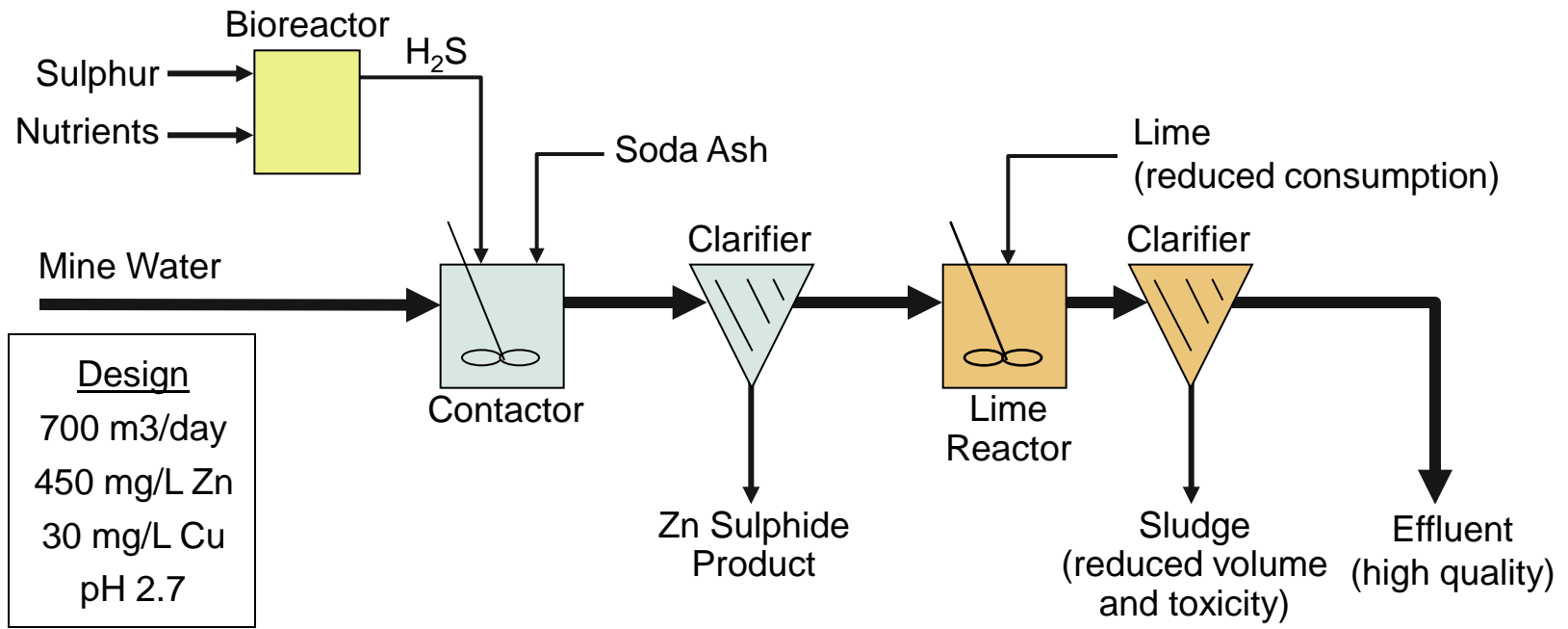


Case Study 1

S^o Reduction Upstream of Lime Plant Caribou Mine, New Brunswick



Caribou Flowsheet



Benefits of BioteQ Plant at Caribou

Incorporating high-rate biotechnology at Caribou has resulted in the following benefits (Stage 1):

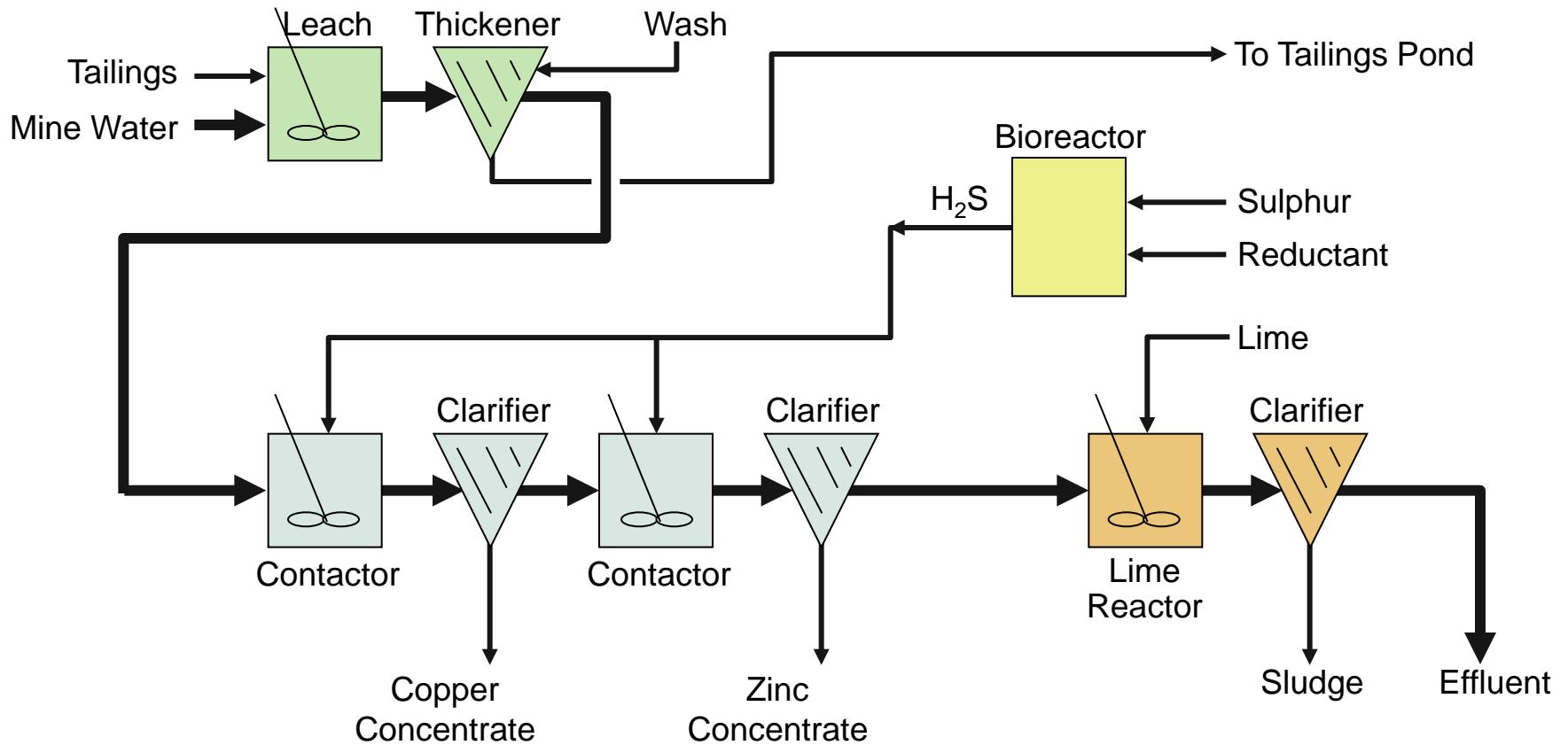
- n ~100% removal of zinc, copper, cadmium and lead from the mine water
- n Zinc product recovered for sale (est. 215 tonnes per year)
- n Projected lime savings of 24%
- n Volume of lime sludge production reduced by estimated 35%
- n Estimated reduction of heavy metal content of sludge from 125 tonnes/year to less than 0.1 tonnes/year

Caribou Project Facts

- n Started Engineering June 1, 2001
- n Start up / inoculation November 23, 2001
- n Commissioning complete February 2002
- n Budget CAPEX \$550,000
- n Actual CAPEX \$523,000

- n Metal concentrations in feed water exceeded design by 1.5 to 2 times
- n Sulphide generation rate 0.26 to 0.43 kg/m³ mine water - exceeded design expectations
- n Plant availability 98%
- n Zn concentrate (+ Cd, Cu, Pb) sold to Noranda Brunswick

Caribou Expansion Under Review

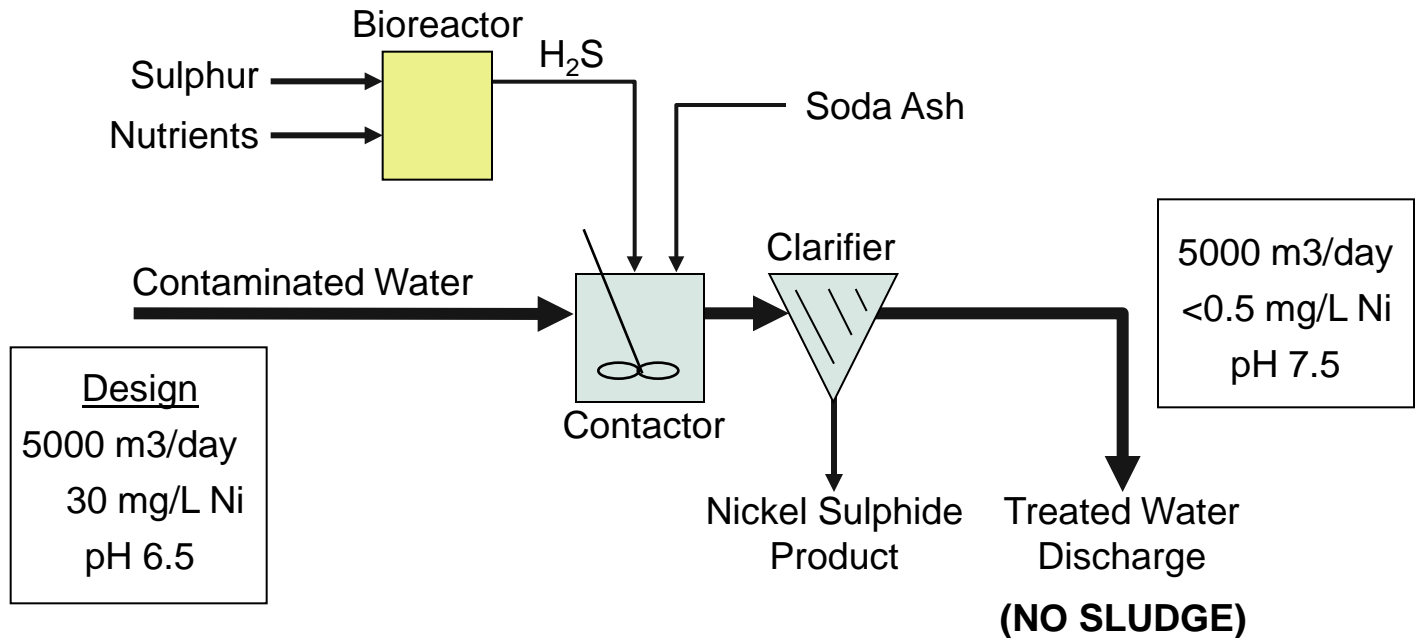


Case Study 2

S^o Reduction to Replace Lime Plant Raglan Mine, Quebec



Raglan Flowsheet



Advantage to SMRQ-Falconbridge

- n No sludge disposal and storage
- n Better quality treated water (TDS)
- n Nickel recovery from wastewater
- n More reliable treatment process for cold weather operation
- n Reduced water treatment costs



Raglan Facts

- n Piloting on site complete
- n Engineering in progress
- n Mine life +30 years

- n Projected capital cost CDN \$1.1 million
- n Net operating cost \$0.05 per m³
 (after nickel revenue)
- n Current operating cost \$0.45 per m³

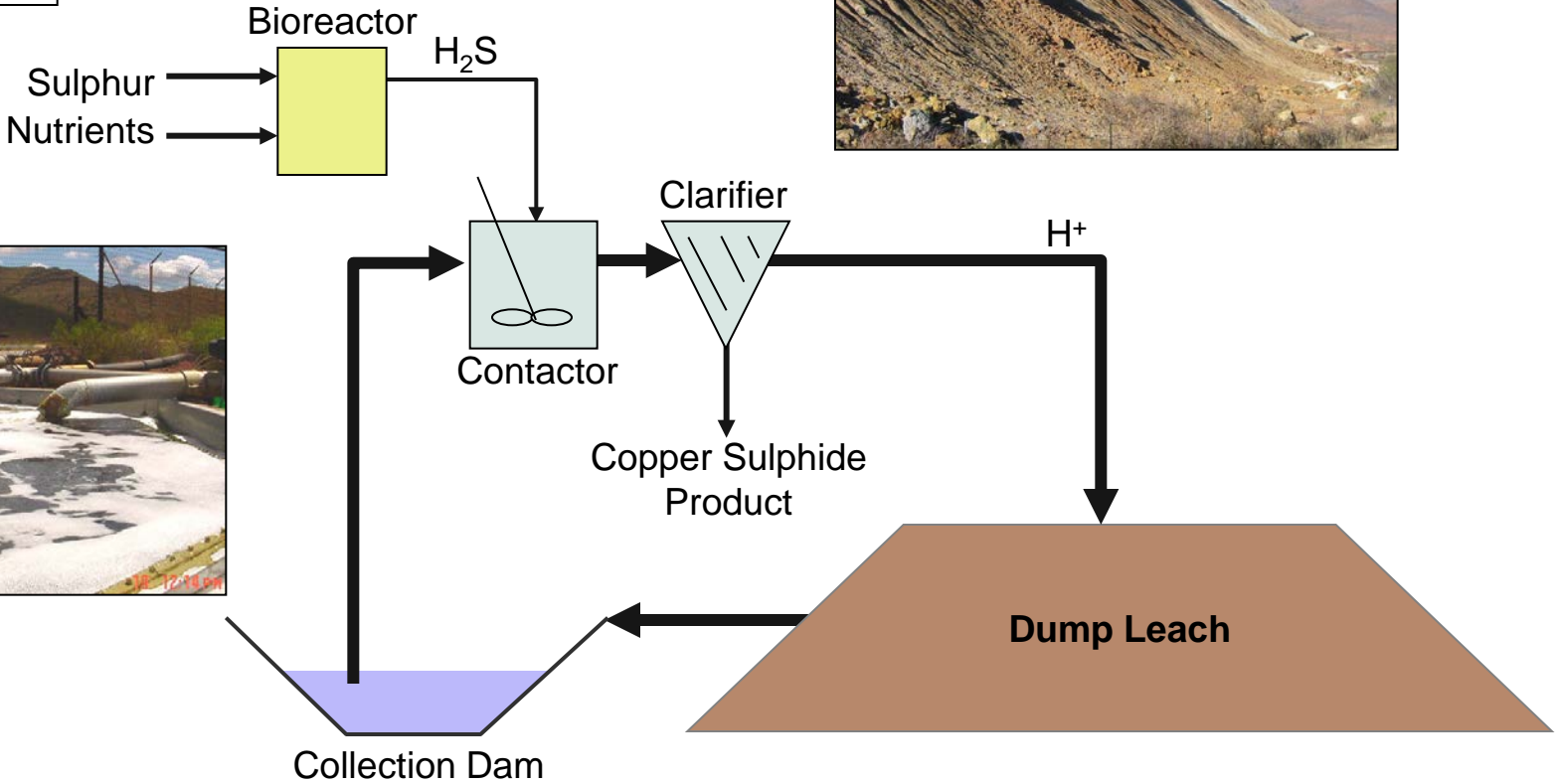
Case Study 3

S^o reduction for Metal Recovery in Dump Leach Operation Bisbee, Arizona



Bisbee Flowsheet

Design
10,300 m³/day
390 mg/L Cu
860 mg/L Fe (III)
pH 2.4



Bisbee Facts

- n Detailed engineering in progress
 - n Planned startup 3Q 2003
 - n 3.2 million lb Cu /year
 - n 3,500 tonnes Cu concentrate/year @ >45% Cu
 - n Reduced environmental liability
-
- n Projected capital cost CDN \$2.56 million
 - n Operating cost \$0.20 per lb Cu
 - n Capital payback < 2 years

Case Study 4

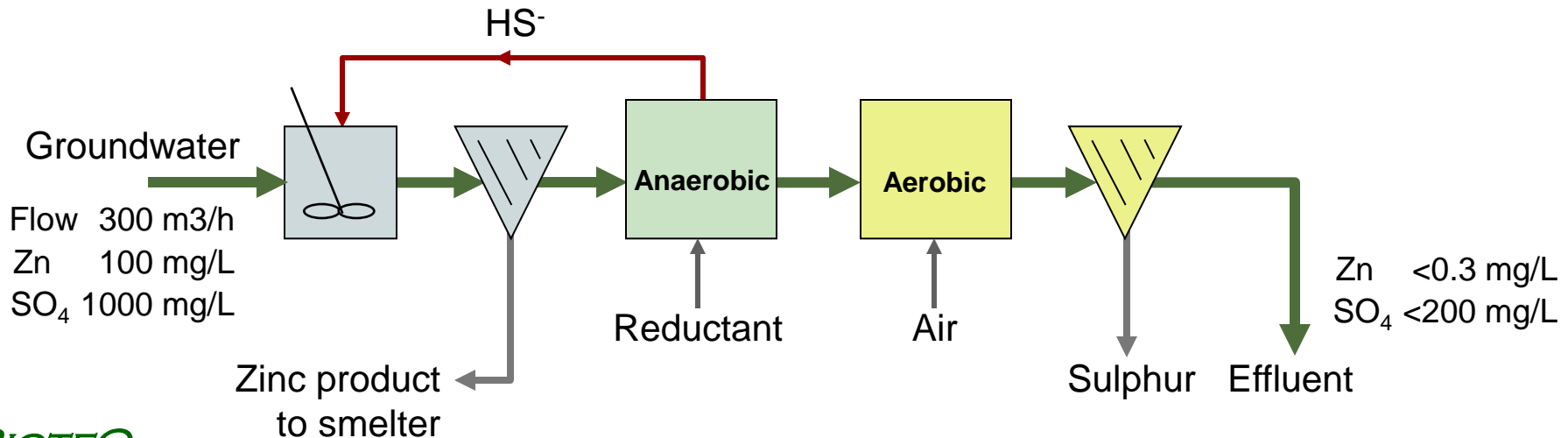
SO₄ Reduction for Groundwater Remediation Budel Zink, Netherlands



Sulphate Reduction at Budelco

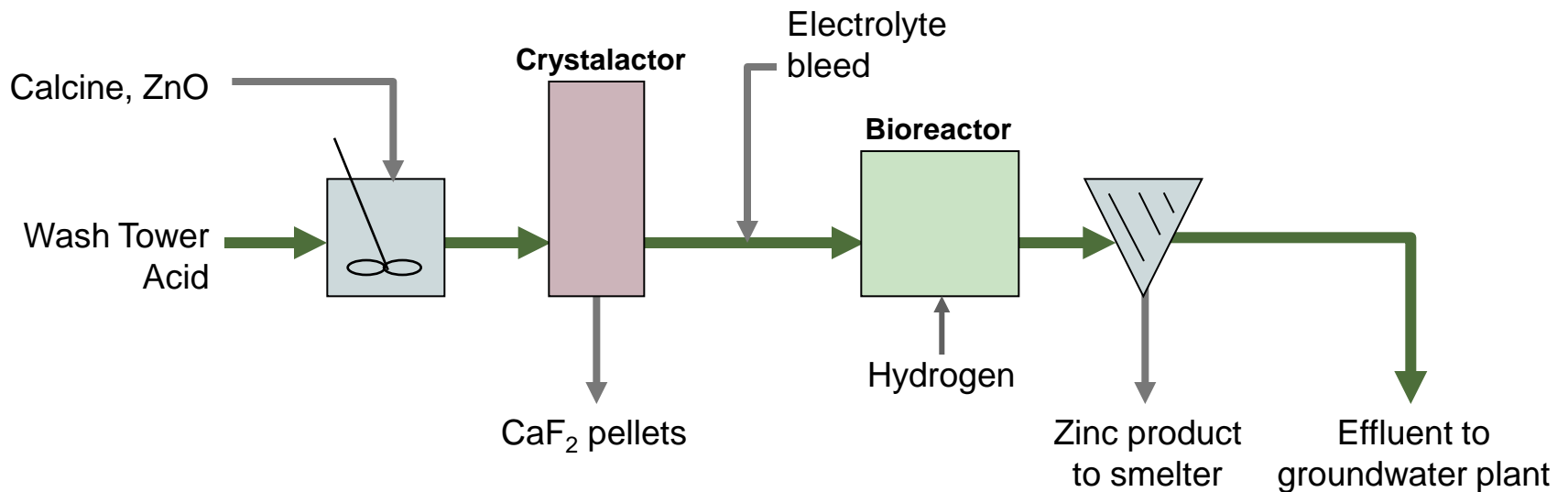


- n 200,000 tonnes/y zinc refinery
- n Original plant commissioned in 1992
- n UASB bioreactor
- n Metal sulphide and sulphur returned to smelter



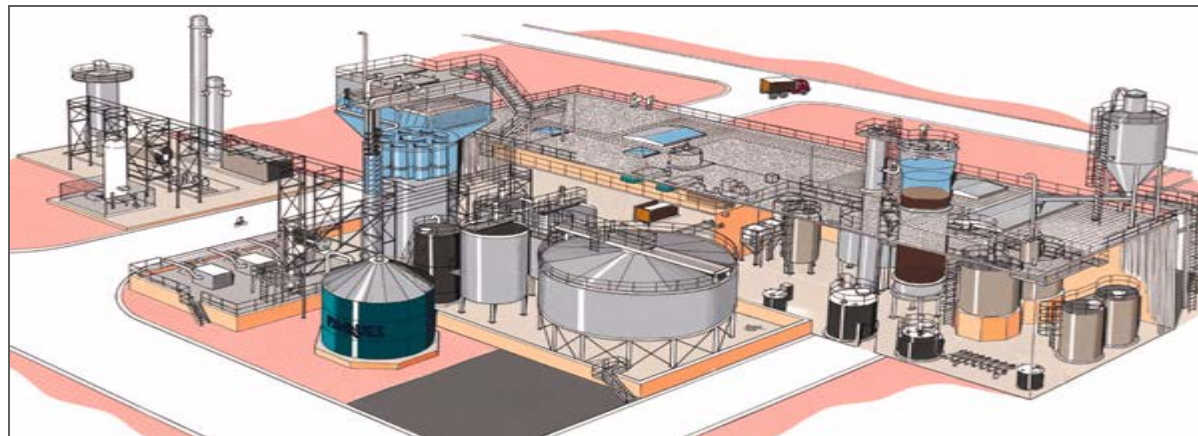
Thiopaq® Bioreactor at Budelco

- n Hydrogen-fed Thiopaq® bioreactor commissioned in 1999
- n 2 streams are treated...
 - | Wash tower acid (0.5 g/L Zn, 10 g/L H₂SO₄, 1 g/L HCl, 0.5 g/L HF)
 - | Electrolyte bleed (15 g/L Mg, 300 g/L SO₄)
- n Streams previously treated with lime



Budel Plant Data

Design Capacity	H ₂ S Influent	3,200 kg/day 40 m ³ /h	
Production	ZnS CaF ₂	10 t/day 0 - 0.9 t/day	
Water Quality		In	Out
	SO ₄	15,000	< 300
	Zn	10,000	< 0.2
	F ⁻	500	< 50



Conclusions

- n High-rate, engineered bioreactor systems offer many possibilities for application in mining and related industries
- n Commercially proven, safe and robust biological processes remove sulphur compounds and recover metals for sale
- n Current and potential applications include...
 - | treatment of ARD
 - | low cost H₂S production
 - | selective metal removal from metallurgical and waste streams
 - | sulphate reduction for environmental compliance
 - | sulphate reduction for industrial water control
 - | SO₂ removal