



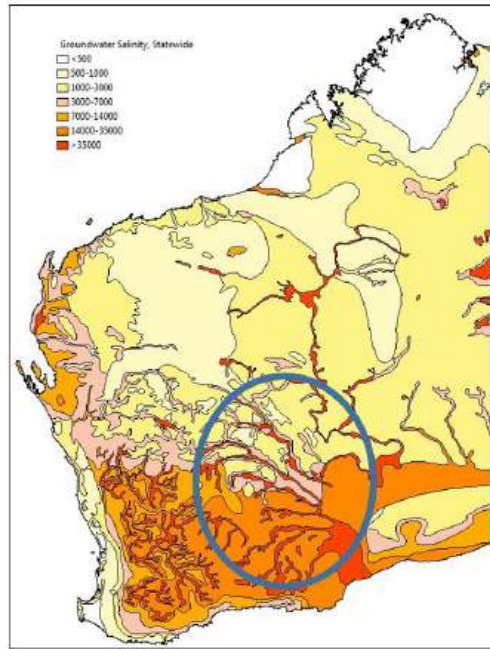
WATER TREATMENT SYSTEMS

RAW/BORE WATER HARDNESS REMOVAL VIA NANOFILTRATION (NF)

February 2023

Saline and hypersaline water around the Goldfields

Norseman
Kambalda
Kalgoorlie



Groundwater Salinity Map

Coolgardie,
Southern
Cross

Murchinson
Wiluna
Merridan

Region	Mg mg/L	pH	TDS mg/L	Na mg/L	Cl mg/L	Conductiv μ S/cm	Sulphate mg/L
Southern Cross	10020	6.76	249500	79900	144630	192900	13244
Norseman	9100	7.3	280000	82000	130000	382000	18000
East Kal	8150	6.54	260000	76000	150000	190000	17500
East Kal	7940	6.4	124000	78100	143400	206000	
NE Kal	7210		88000	36300	69000	150000	
West Kal	7190	7.42	177000	49900	84000		12900
Kambalda	6500	8.4	170000	51000	89000	140000	9800
Southern Cross	5400	6.7	150000	45000	75000	140000	8100
NE Kal	5300	7.07	100000	47000	82000	170000	11000
NE Kal	5300	7.1	100000	47000	82000	170000	11000
NE Kal	5000	8.1	89000	29000	49000	110000	5100
South Laverton	5000	7.4	230000	78000	130000		15000
Southern Cross	4327	6.76	109450	33200	62950	119400	6513
South Kal	4300	5.9	104600	34800	58700	147000	6100
NE Kal	4100	8.1	98000	41000	70000	160000	8200
Wiluna	4073	7.6	42528	35618	65518		12563
Southern Cross	4000	6.65	86800	24900	49500	158500	5700
North Laverton	4000	7.72				11010	800
North Coolgardie	3800	7.7	90200	28000	47000	-	
Southern Cross	3800	6.9	83200	24600	48000	160750	5400
Southern Cross	3650	7.1	78900	23400	45500	155250	5500
Southern Cross	3550	6.6	73100	20900	41000	130100	4950
Southern Cross	3450	7.1	77700	23400	44500	147250	5550
NE Kal	3414						6486
Kambalda	3272	3.8			49000	30900	2060
East Kal	3100	3.1	120000		61000	130000	4800
NE Kal	3100	6.6	91000	28000	49000	120000	7300
Southern Cross	3000	4.5	70000	19000	37000	90000	4900
North Kal	2800	6.8	58000	15000	28000	75000	6300
North Kal	2800		69850	18925	35075		
Coolgardie	2628	7.4	93000	24260	30000		
NW Meekatharra	2600		39300	14100	23000		
North Coolgardie	2570		66300	20300	36750		1900
SE Kal	2490	5.85	57950	25000	11800	96600	4365
Southern Cross	2264	6.97	63726	20100	35900	79400	4210
Coolgardie	2200	6.6	31000	6100	18000	48000	2900
West Coolgardie	2100		47000	17000	30000		
Southern Cross	1900	7.2	37000	7100.0	19000	47000	2400
Coolgardie	1900	7.4	26000	5100	14000	38000	2800
Northern Territory	1850	7.5	41000	10000	16000	50000	10000
East Kal	1795	7.7	45100	13450	24645	60500	
Coolgardie	1600	7.4	20000	3000	9500	28000	1800
NE Kal	1400	7.6	93000	30000	48000	110000	6200
Coolgardie	1400	7.3	21000	2900	10000	30000	2500
Widgiemoolltha	1300	3.4	37500	9900	19000	51000	2700
Southern Cross	1200	3.9	72000	20000	43000	100000	3000
Southern Cross	1200	5.6	51000	15000	28000	68000	1500
Widgiemoolltha	1100	3.2	38000	10000	19000	47000	2900
Merridan	1041	6.65	44300	12030	23600	52000	1830
Murchinson	850	8.3	24000	7000		36000	2900
Coolgardie	710	7.1	13000	2600	6300	20000	1400
Central NSW	362	4.72	6070	708.00	1420	7800	2740
Central NSW	350	6.02	7950	1290	2050	10300	2920
Murchinson	240	8.5	6200	1900	2900	9600	730
Wiluna	215	7.7	4525	945	1600	7125	985
Murchinson	138	7.8	4500	1300	1800	0	
Coolgardie	130	7.4	2100	420	1000	3700	180
NW Meekatharra	120		2380	680	970	-	
Wiluna	62	7.8	1200	190	300	1874	252
Wiluna	40	7.69	740	59	170	118000	120

HYPERSALINE WATER

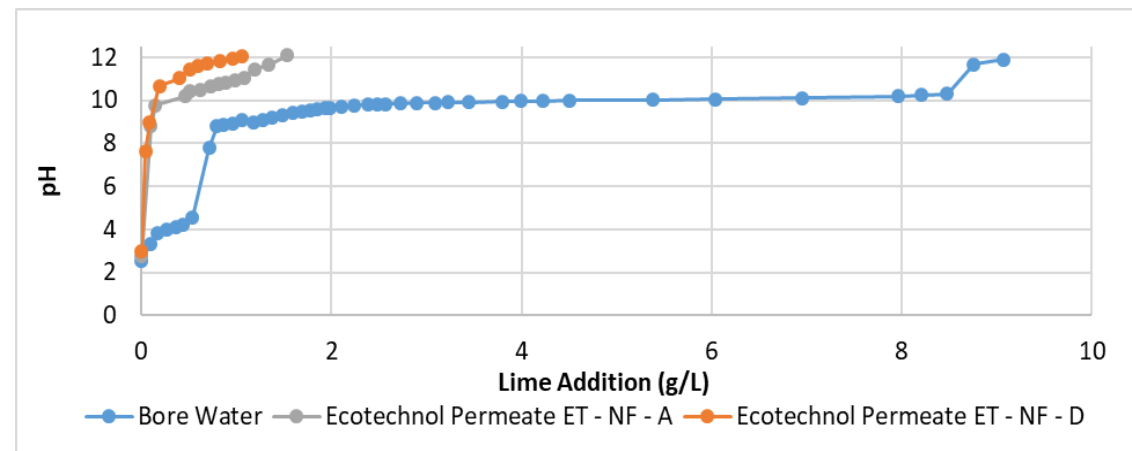
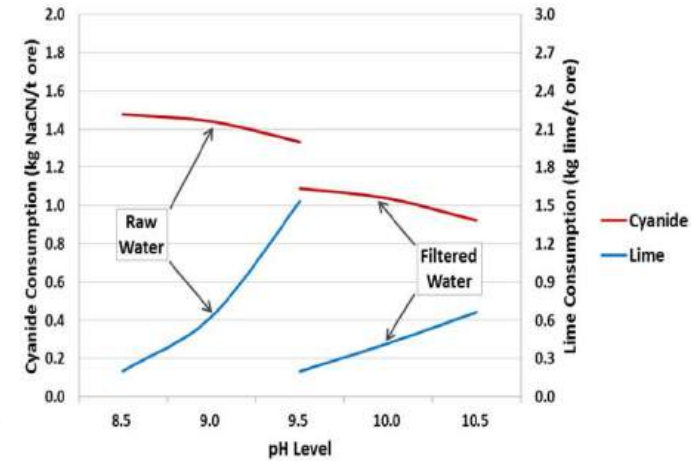
- Aim-** To concentrate Magnesium (Mg^{2+}) via NF
- Why-** To mitigate the buffering effect of hypersaline water reducing Lime & Cyanide consumption in Gold Processing
- Where-** Incoming Bore Water and/or return decant water

Observations:

1. >95% rejection of Mg^{2+} , >98% rejection of SO_4^{2-} into 10-20% volume;
2. **~80-90% reduction in Lime consumption, ~30% reduction in Cyanide;**
3. Concentration of gypsum thus reducing scale potential within the process plant



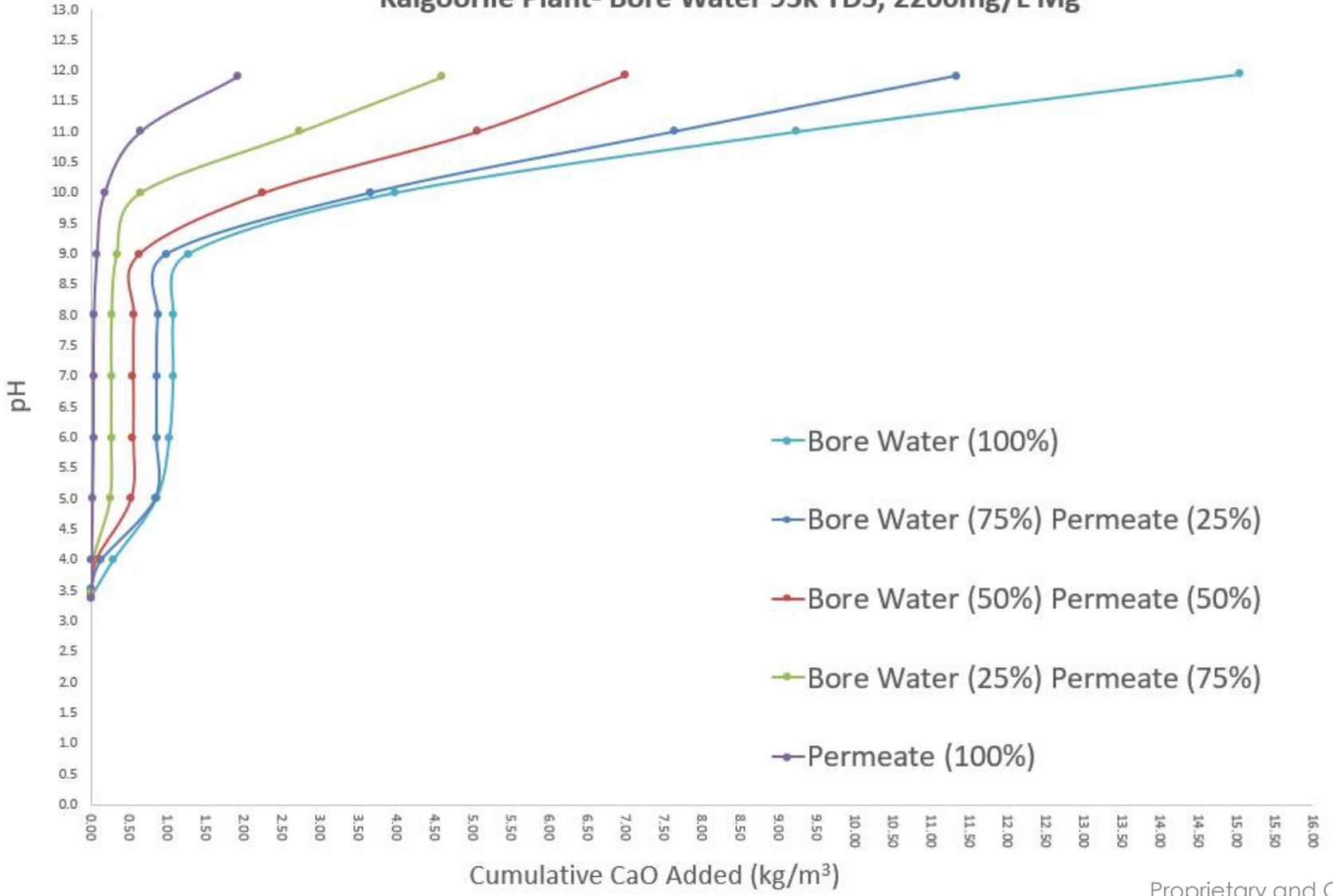
Gypsum Scale



Significantly reduce Lime/Cyanide Consumption

LIME DEMAND TESTS

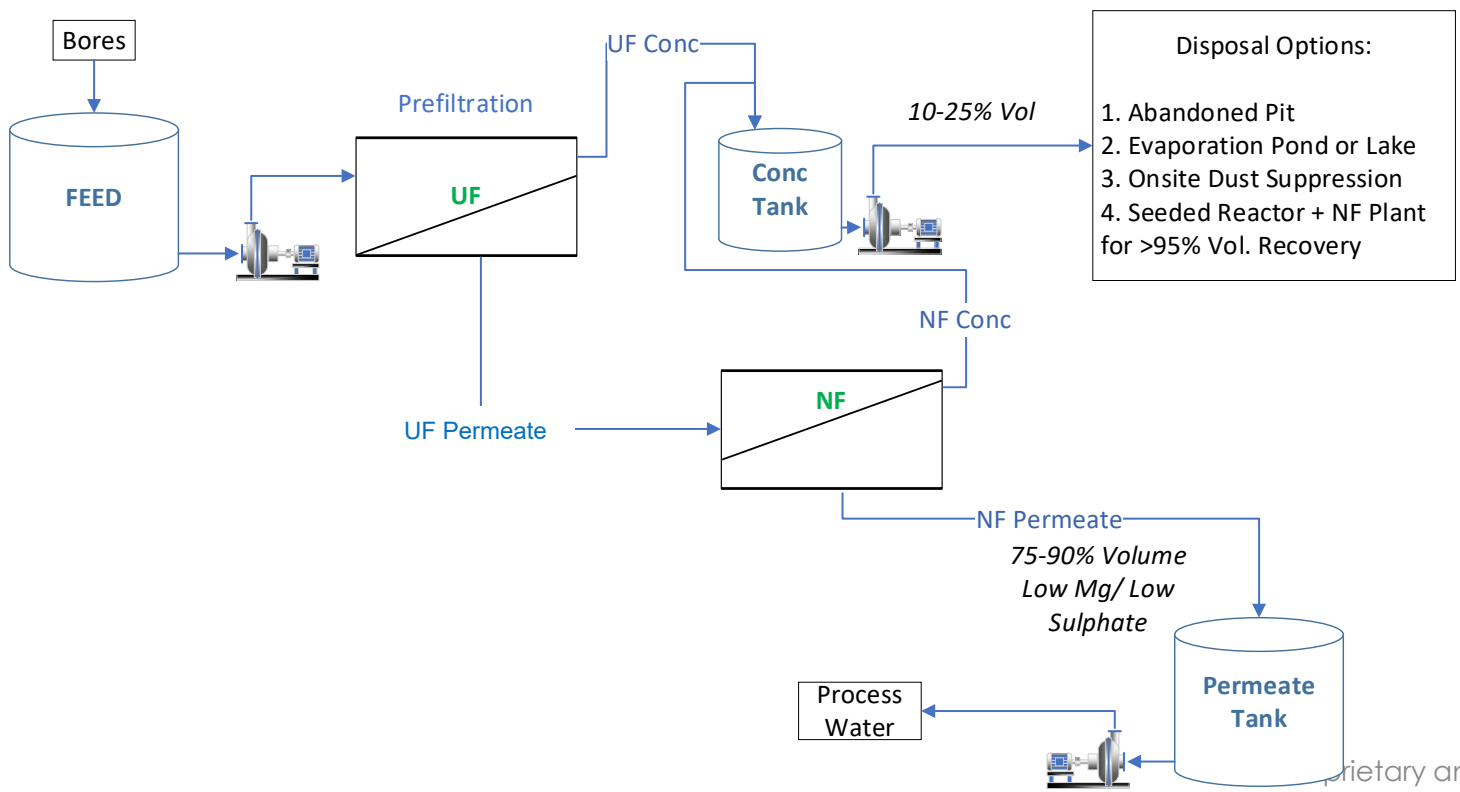
Kalgoorlie Plant- Bore Water 95k TDS, 2200mg/L Mg



GOLDFIELDS IMPLEMENTATION

Recent Analysis on Kalgoorlie Raw Water

		Feed	Perm @ 50% Vol Rejection	Perm @ 77% Vol Rejection	Conc @ 77% Vol Rejection	Ion Rejection
pH	pH Units	3.5	3.5	3.4	3.4	
Total Dissolved Solids (grav)	mg/L	95,000	76,000	76,000	120,000	20%
Calcium - Dissolved	mg/L	1,800	340	375	2,600	79%
Magnesium - Dissolved	mg/L	2,200	140	190	9,400	91%
Sulphate	mg/L	3,700	<200	<200	6,900	+95%
Hardness as CaCO₃	mg/L	14,000	1,400	1,750	45,000	88%



BENEFITS AND OPPORTUNITIES

1. Lower Reagent Costs (>80% less Lime and ~30% less Cyanide)
2. Paste Fill Plants- Reduced Cement Consumptions
 - a) 10-20% reduction in UCS in saline waters¹
3. OHS & International Cyanide Management Code
 - a) Minimise HCN and WAD generation by operating at elevated pH's
4. ESG: Reduced Carbon Dioxide Emissions²
 - a) Quicklime: 954kg CO₂/t
 - b) Cement: 766kg CO₂/t
 - c) Haulage
5. Value added by-products in Brine/Concentrate
 - a) Gypsum Production (CaSO₄.2H₂O) via Seeded Reactor (99.2% purity³)
 - b) Epsom Salt (MgSO₄.7H₂O): not yet tested
 - c) Mg(OH)₂: identified as a high value byproduct

¹ Wang C, "Influence of water salinity on the properties of cemented tailings backfill", 2001

² "Sustainability measures in quicklime and cement clinker production"- 2015

<https://umu.diva-portal.org/smash/get/diva2:882932/FULLTEXT01.pdf>

³ Via XRD on seeded reactor product, HW Process Technologies Inc (2009)

MEMBRANE CASE STUDIES

Applications

Hypersaline Water Treatment
(eg Goldfields, Western Australia)

Fine Carbon Removal
(eg Heap Leaches or post Elution)

Copper Rejection in Acid or Cyanide
(eg Cu/Au Fractionation)

Co, Mn and Ni Sulphate upgrade

Rare Earth Element upgrade in HCl or H₂SO₄

Lithium purification in Brine or as Hydroxide

Copper and Mercury separation from Gold within Elution Circuits



NF Conc (Left), NF Permeate (Right)



Carbon Fines Capture



Copper AMD – 2 Pass

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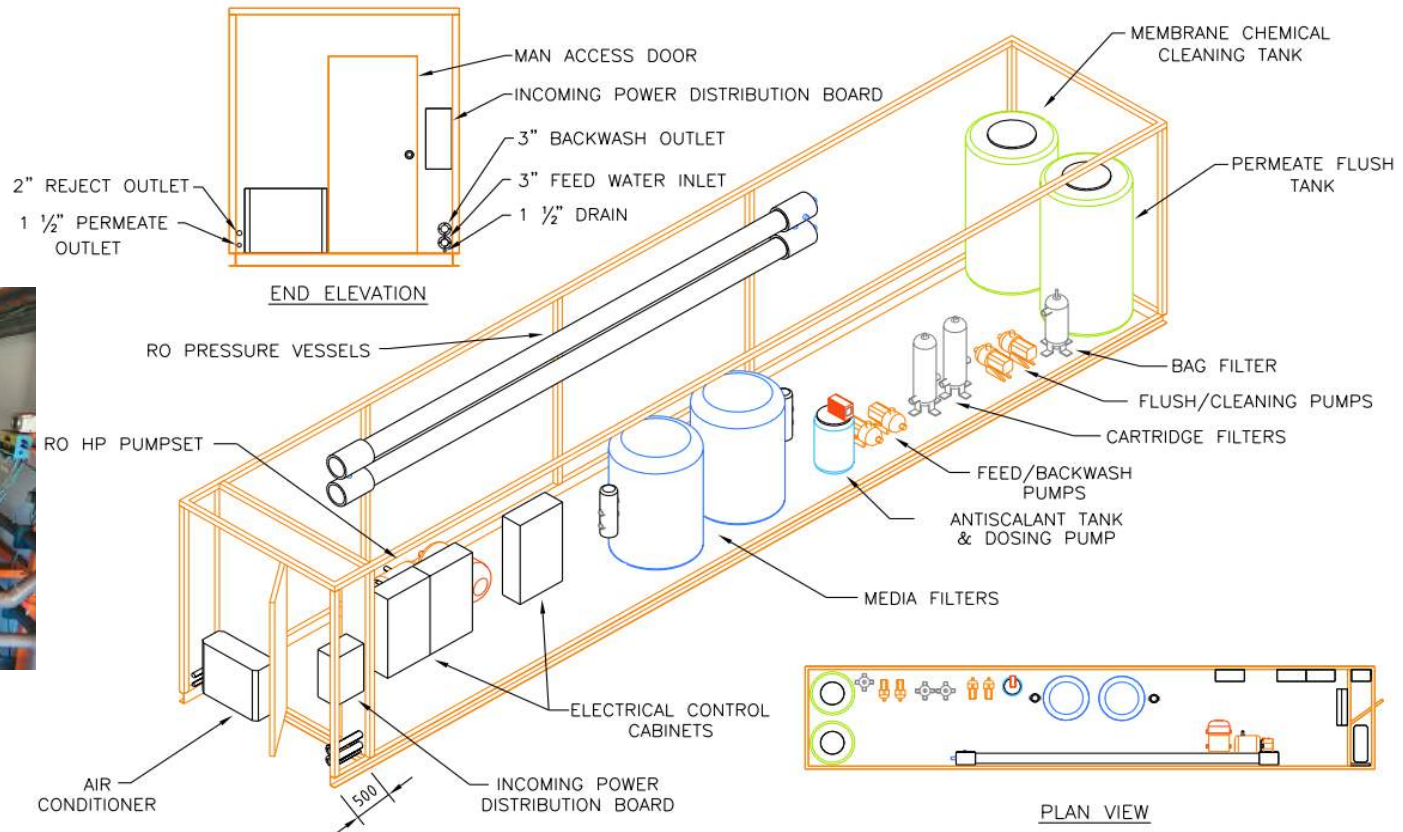
Focusing on mineral processing & environmental solutions

RENTAL UNIT - DESIGN BASIS (12m³/hr-PERM.)

Single Stage Containerised Water Treatment System

Site requirement is ~12m³ per hour (288m³ per day permeate production).

(Feed Water supply to WTP = 18 m³/hr to achieve ~12m³/hr of NF permeate).



REFERENCE LIST MEMBRANE INSTALLATIONS AND EXPERIENCE

PROJECT	DESCRIPTION	FLOWRATE (m3/hr)	YEAR
Barrick Gold Mine Barren-Lagunas Norte & Pierina	Barren leach post physical chemical treatment installation	910	2013
Cobre Las Cruces Sevilla- Spain	ARD MDS with Spanish partner	600	2011
Phelps-Dodge (Freeport-McMoran)- Texas	Acid Purification with NF & Concentration: RO	40	1992
Zijin Copper- China	ARD (acid rock drainage)	250	2009
Sun Metals Zinc Refinery- Australia	Post physical chemical high pH	250	1999
Korea Zinc Refinery- Korea	Post physical chemical	200	2001
Newmont Waihi Gold- New Zealand	HWP Technologies	250	2008
Asarco Refinery- Denver	MDS Membranes & HWPT	20	1995
Yanacocha Gold Mine	Barren Leach	3500	2003
Phelps-Dodge (Freeport-McMoran)	Acid rock drainage	150	2003
Cananea de Mexicana	Acid rock drainage	2000	1997
Kennecott Copper- Utah	Acid rock drainage	500	1998

Proven, long term operation

Tapley B, Stoitis N, Lien L; "Modified Nano-Filtration Membrane Treatment of Hyper-saline Goldfields Water- an Overview and Benefits to Gold Plant Operation and Economics", MetPlant 2015

Thankyou

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