



## AMS pH-stable Nanofiltration Membranes in U & R.E.M. Processes

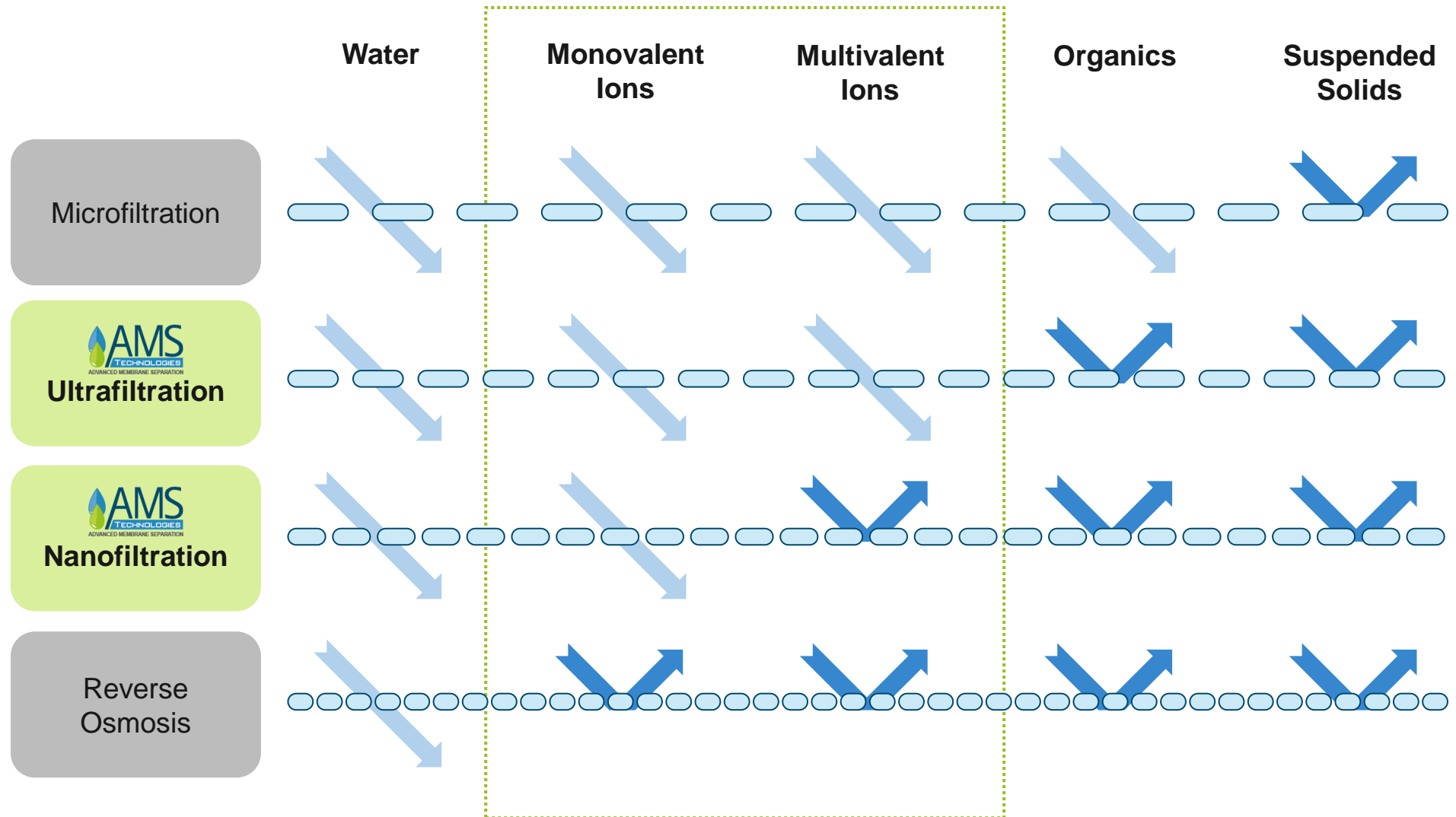
- ✓ AMS Technologies is a commercial membrane manufacturer that specializes in the treatment of in-process and wastewater streams
- ✓ Following a decade of cutting edge research, our team of scientist developed a unique line of highly durable nanofiltration and ultrafiltration membrane products enabling the treatment of aggressive industrial streams with great benefits to clients

**Visit us on:**

**[www.amsmembrane.com](http://www.amsmembrane.com)**

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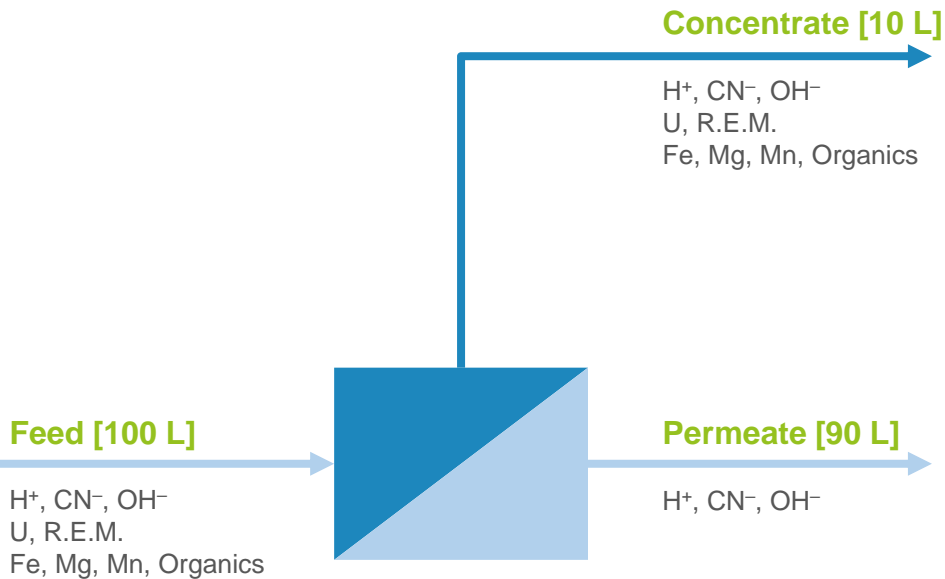
# Nanofiltration (NF) membranes have rejection selectivity: allowing components based on size and charge



# AMS membranes uniquely designed for uranium complex separation under aggressive conditions

## NF used to recover acid and concentrate metals

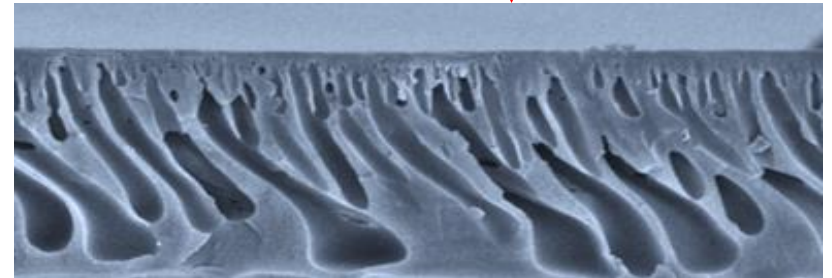
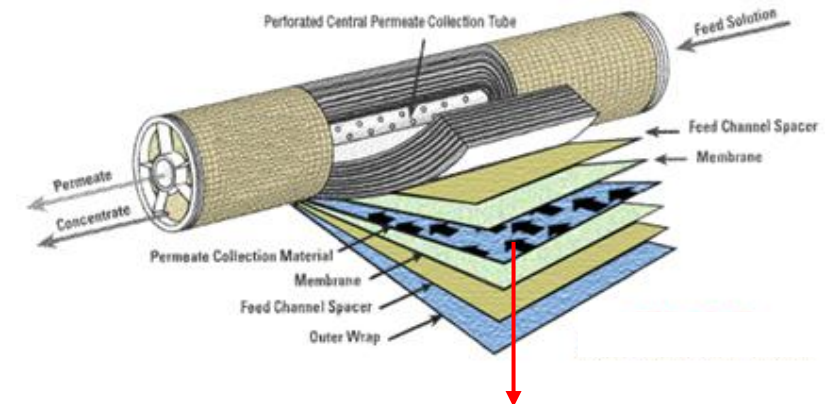
### NF Separation for selected components



## Spiral-wound structure

### maximizes membrane area per module

### Design of a spiral-wound element



# AMS membranes adhere to high stability requirements imposed by U & R.E.M. industry

Superior pH stability is mandatory — streams often have high acid, alkali, solvents ...

Stability	Membrane	MWCO <sup>1</sup> , daltons	Min. MgSO <sub>4</sub> Rejection <sup>2</sup>	pH range	Example Streams
Acid	A-3011	100	99%	0 — 12	20% H <sub>2</sub> SO <sub>4</sub> 20% HCl 30% H <sub>3</sub> PO <sub>4</sub> 5% HNO <sub>3</sub>
	A-3012	180	96%	0 — 12	
	A-3014	400	92%	0 — 12	
	A-3017	700	80%	0 — 12	
	A-3020	1'000	65%	0 — 12	
	A-U301	2'500	not appl.	0 — 12	
	A-1801	10'000	not appl.	0 — 12	
Base	B-4021	100	99%	3 — 14	20% NaOH 20% KOH 0.1% NaCN
	B-4022	180	96%	3 — 14	
	B-4027	700	80%	3 — 14	
	B-4030	1'000	65%	3 — 14	
Solvent	S-3011	100	99%	2 — 12	MeOH, Acetone, DMF, etc.
	S-3012	180	96%	2 — 12	
	S-3014	400	92%	2 — 12	
	S-U301	2'500	not appl.	2 — 12	
	S-1801	10'000	not appl.	2 — 12	

... as well as thermal and pressure stability

## Thermal durability up to 80 °C:

- ✓ No need for cooling;
- ✓ Higher flux and recovery.

## Pressure durability up to 70 bar:

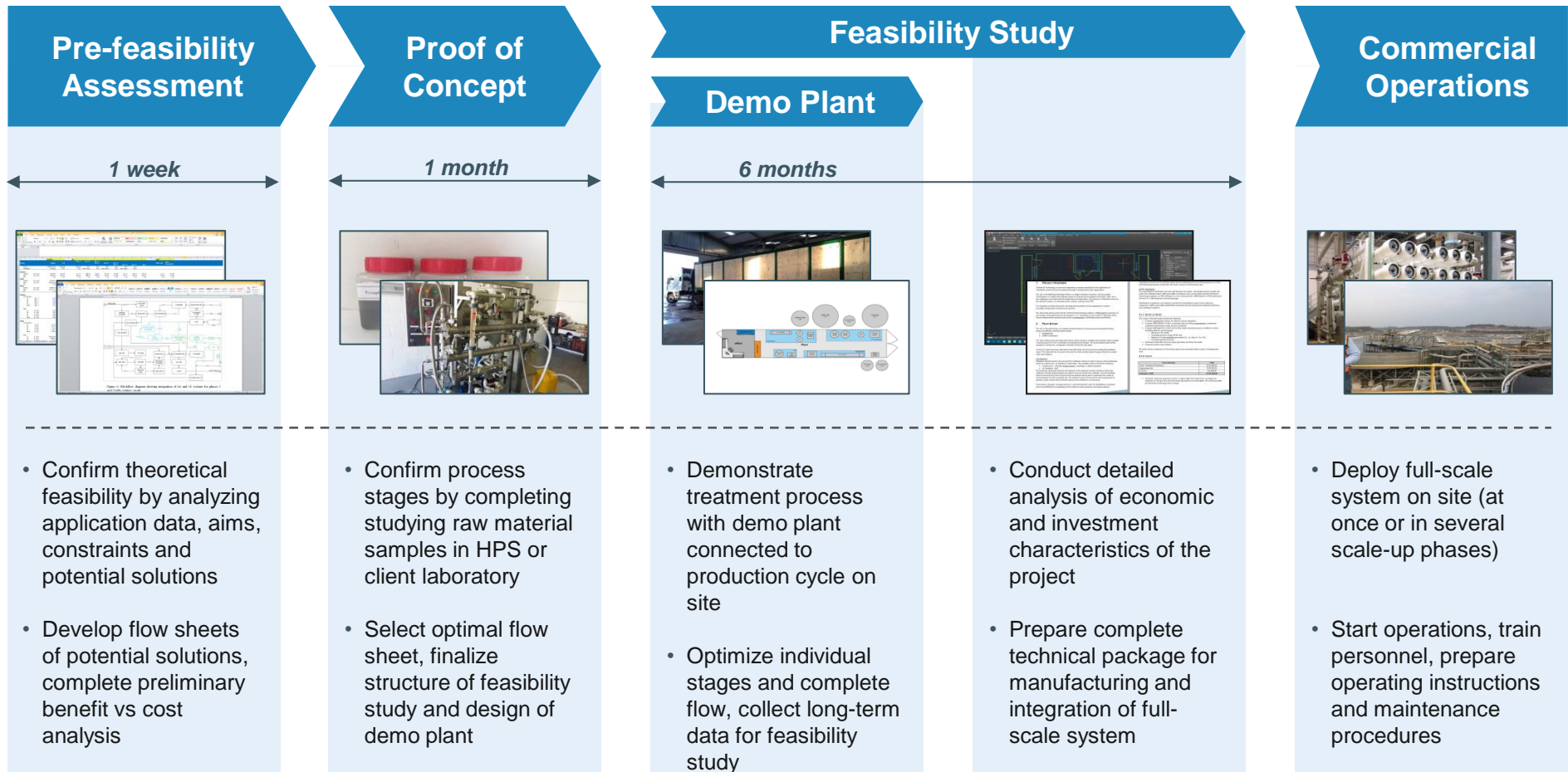
- ✓ Better recovery at high osmotic pressure conditions;
- ✓ Higher flux and recovery.

## Differential pressure up to 1 bar:

- ✓ Can treat viscous streams;
- ✓ Higher flexibility in system design.

1. MWCO = Molecular Weight Cut-Off, the lowest molecular weight solute (in daltons, 1 dalton = 1 g/mol) in which 95% of the solute is retained by the membrane; 2. Conditions: 0.2% MgSO<sub>4</sub> solution, 40 bar, 30 °C

# Project approach consists of several stages for better assessment and project risk mitigation

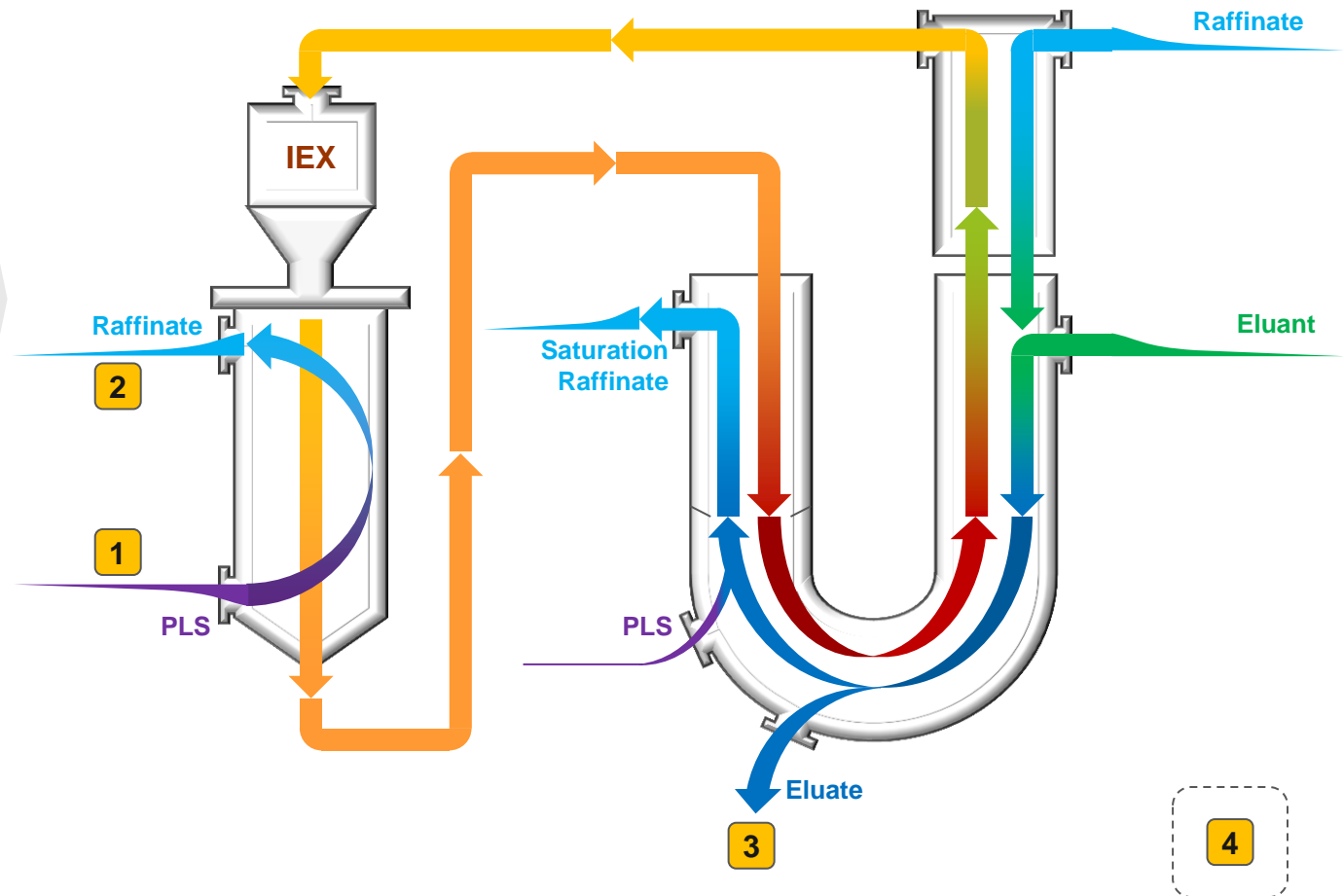


# Several applications developed for extraction plant to recover acid and concentrate uranium

## Potential applications on extraction stage

- 1 **PLS** treatment for acid recovery and uranium concentration
- 2 **Raffinate** treatment for acid cleaning and recovery of uranium
- 3 **Eluate** treatment for uranium concentration
- 4 **Mine drainage** water treatment for uranium recovery and decreasing eco-impact

### Exemplary applications in sorbtion-desorbtion uranium recovery



1

# PLS Upgrade process was developed for top U miner

Feed solution (100 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction, %
Uranium	0.09	100%
Iron	0.12	100%
Calcium	0.52	100%
Sulfuric Acid	0.70	100%

Permeate (75 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction, %
Uranium	< 0.01	1.0%
Iron	0.01	4%
Calcium	0.03	4%
Sulfuric Acid	0.60	64%

Concentrate (25 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction, %
Uranium	0.37	99%
Iron	0.46	96%
Calcium	2.00	96%
Sulfuric Acid	0.99	36%

## Pilot project confirmed high value of AMS technology in treating leaching stream

- **Productive Leach Stream** of top uranium miner was studied for uranium concentration
- **Tests confirmed** ability to achieve high rejection:
  - ✓ **99% of uranium by mass was concentrated in concentrate.** Its concentration increased 4 times.
  - ✓ **Around 65% by mass of sulfuric acid were recovered** from feed to filtrate with low impurities and insignificant concentration decrease;

2

# AMS membranes allow for efficient treatment of raffinate solution of African miner

Feed solution (100 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction
Uranium	0.0046	100%
Iron	17.2	100%
Aluminium	16.8	100%
Sulfuric Acid	8.79	100%

Permeate (95 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction
Uranium	0.0008	16%
Iron	0.49	3%
Aluminium	< 0.01	< 1%
Sulfuric Acid	8.66	94%

Concentrate(66 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction
Uranium	0.08	84%
Iron	333	97%
Aluminium	337	~100%
Sulfuric Acid	11	6%

## Pilot project confirmed high value of AMS technology in treating leaching stream

- **Pilot project started** at leaching site of African uranium producer
- **Tests confirmed** ability to provide high savings and benefits to customer:
  - ✓ **Around 94% by mass of sulfuric acid was recovered** from feed to filtrate with low impurities;
  - ✓ **84% of uranium by mass was concentrated in concentrate.** Its concentration increased 16 times.



3

# Together with Chimerical, S.A. engineering firm, NF process in implementation to upgrade eluate and recover reagents

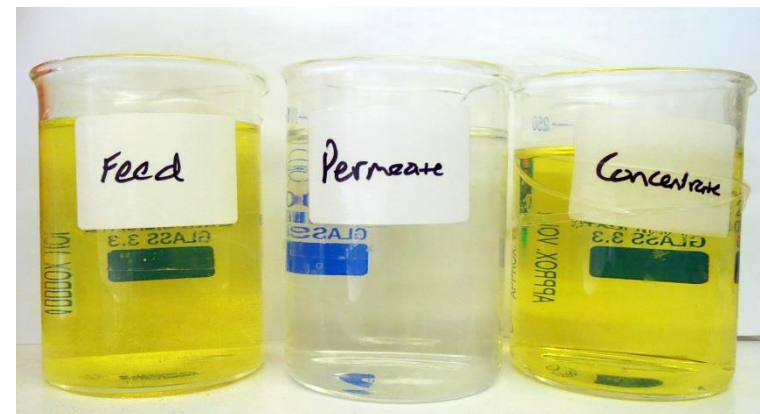
Feed solution (10 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction
Uranium	39.6	100%
H <sup>+</sup>	44.9	100%
NO <sub>3</sub> <sup>-</sup>	30.4	100%
SO <sub>4</sub> <sup>2-</sup>	93.9	100%

Permeate (5.5 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction
Uranium	1.6	2%
H <sup>+</sup>	32.5	40%
NO <sub>3</sub> <sup>-</sup>	35.6	64%
SO <sub>4</sub> <sup>2-</sup>	35.8	21%

Concentrate(4.5 m <sup>3</sup> /day)		
Component	Concentration g / L	Mass Fraction
Uranium	85.5	98%
H <sup>+</sup>	58.0	60%
NO <sub>3</sub> <sup>-</sup>	24.3	36%
SO <sub>4</sub> <sup>2-</sup>	16.3	79%

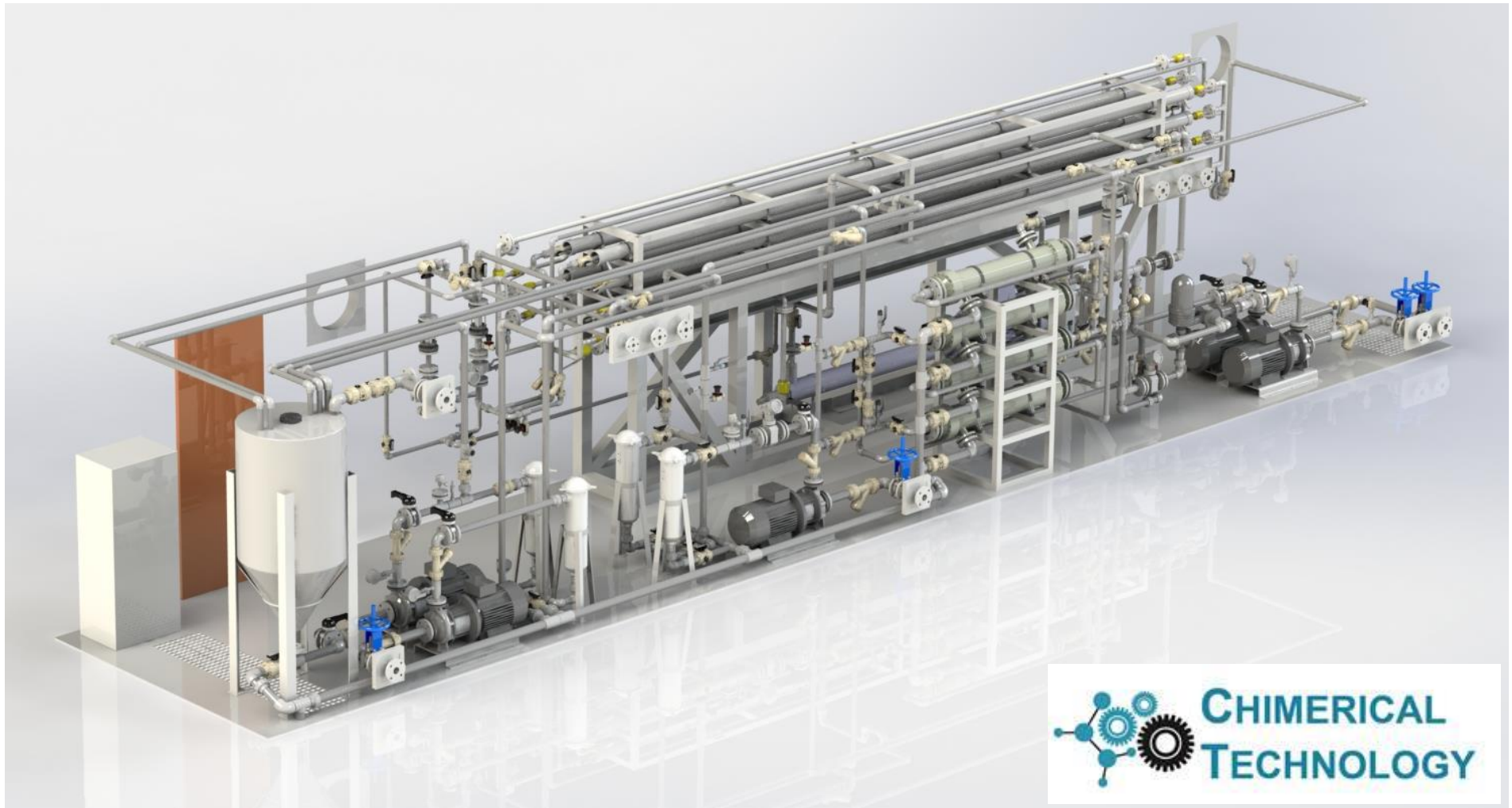
## Commercial eluate upgrade system scheduled for commissioning in Nov 2019

- Developed process brings multiple benefits to the mine:
  - Upgrade the eluate from 39.6 g/L to 85.5 g/L with 98% mass recovery, decreasing the cost of transportation and NaOH for neutralization;
  - Around 50% of reagents (sulfuric acid and ammonium nitrate) are recovered for re-use at IEX stripping phase.



3

# Chimerical Technology is fabricating a 10 m<sup>3</sup>/h containerized plant for eluate upgrade with AMS membranes



... the commissioning is scheduled for November 2019

