



Technologies for a Cleaner Future

AN™ TECHNOLOGY

A Wastewater Treatment Solution...

AN™ TECHNOLOGY OVERVIEW

AN (ADVANCED NEUTRALIZATION)™ TECHNOLOGY

Cavitation-Enhanced Electrocoagulation for:

- TSS and Heavy Metal Precipitation/Removal
- Emulsion Disruption
- BOD/COD Reduction
- pH neutralization

The AN Technology is patented/patent(s)-pending in the US and abroad



AN™ Technology Components

- Electrolytic cell w/dimensionally stable/sacrificial electrodes
(Boron-Doped Diamond & other electrode combinations)
- Cavitation (controlled forms)
- Sonolysis (frequency range/modulation/intensity)
- Mixing – robust contact/static
- Clarification – conventional removal of precipitated solids
- Filtration-optional and as required for polishing



AN™ Technology for Water Treatment

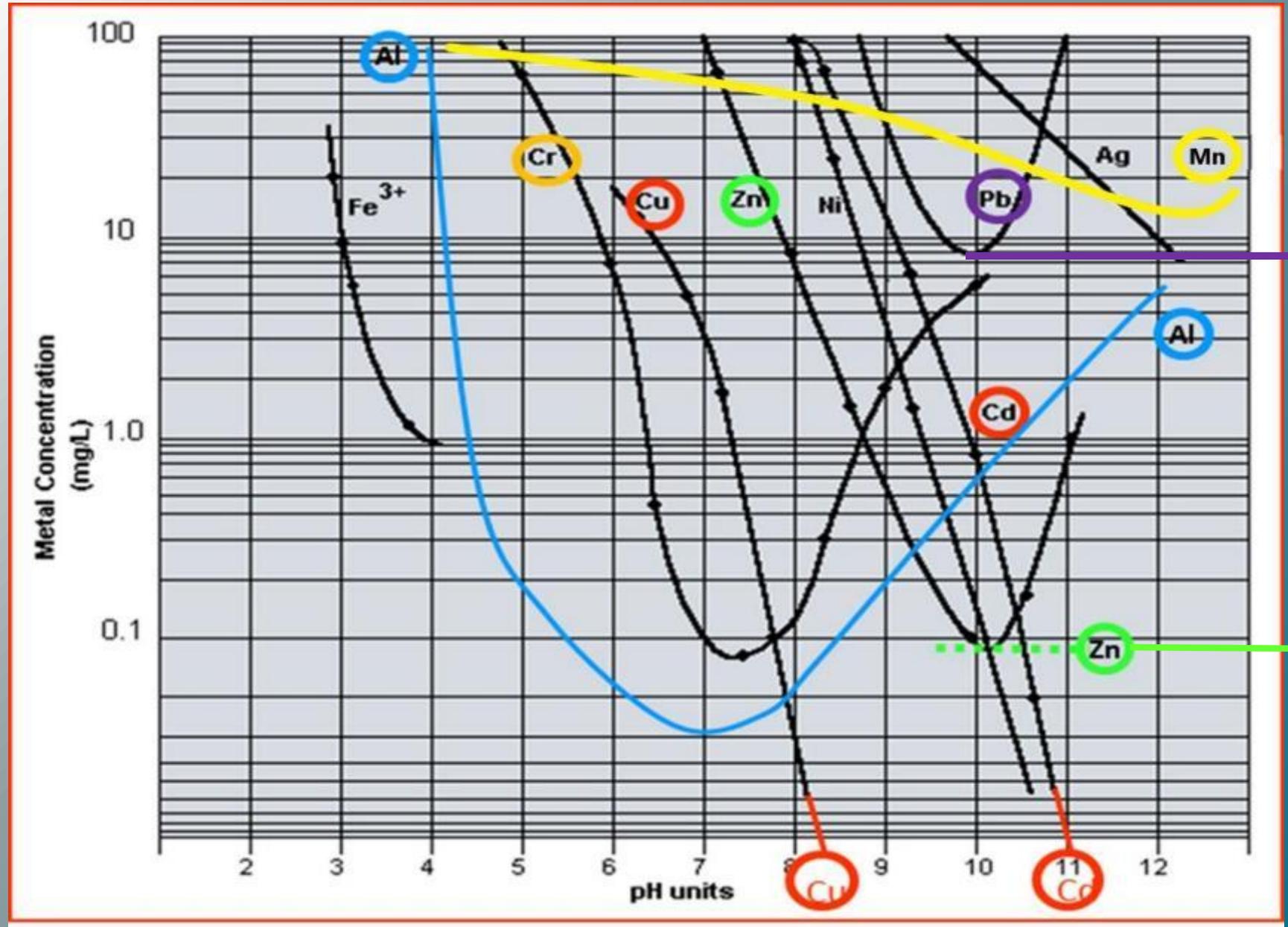
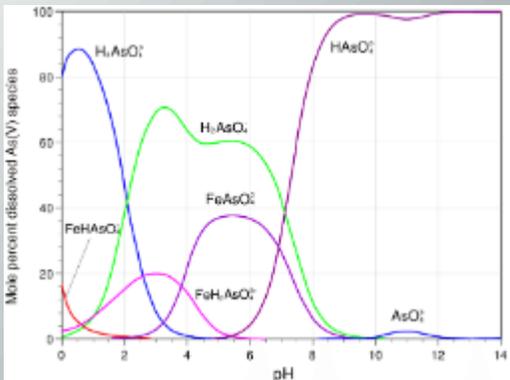
- Electricity to treat acidity, and remove total heavy metals from water (including dissolved forms)
- Forms hydroxide ions to neutralize acidity (pH 5.5 – 7.5)
- Converts heavy metals/Rare Earth Elements to oxides (no metallic hydroxides at alkaline pH condition).
- Precipitates containing heavy metals (and REE) coagulate with solids maturation to more dense/robust settleable forms
- Utilizes multiple electrolytic technologies, dimensionally stable and sacrificial electrodes and other reaction inducements with low power demand
- No filtration used to date
- Destabilizes ionic charge/disrupts emulsions
- Targets broad-spectrum range of metals at neutral pH



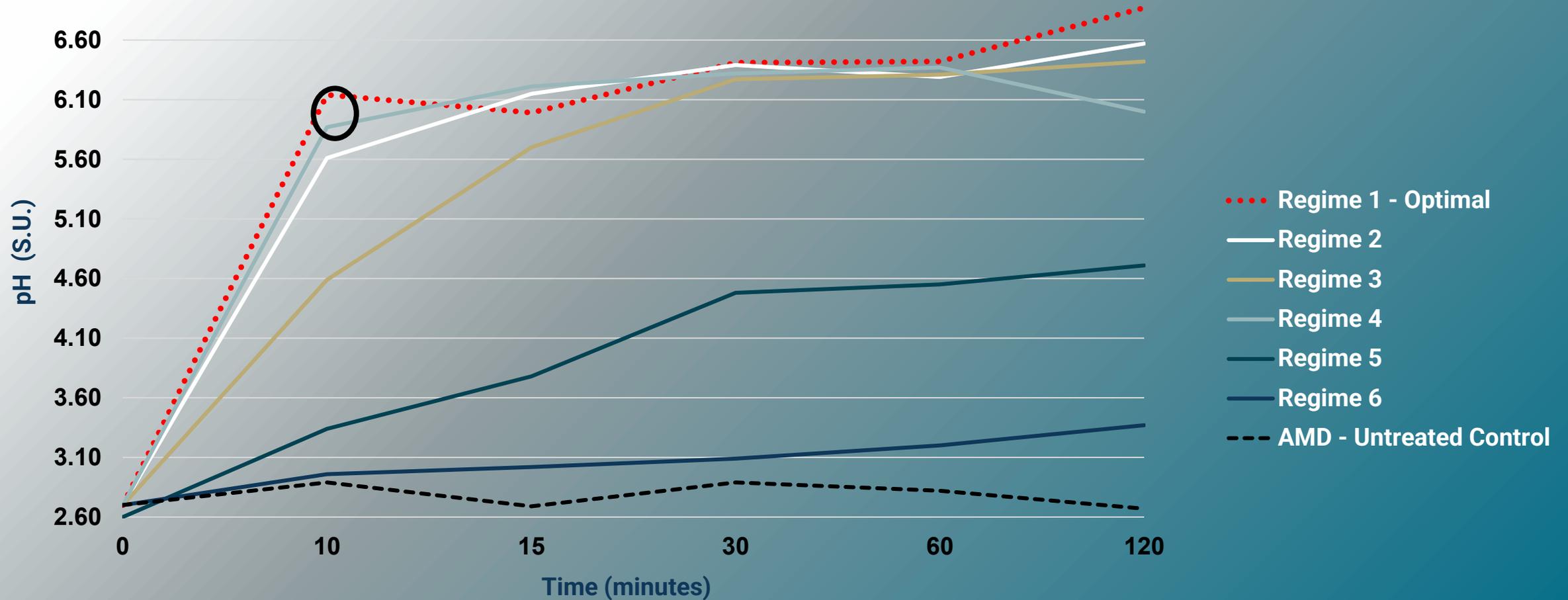
Conventional Metallic Hydroxide Problem: Precipitation Curves (R-OH⁻)

Multiple pH Points
Needed for
Maximized Heavy Metal
Removal from AMD Fluids

Arsenic Curves



AN (Advanced Neutralization™) Process: In-Water R-Oxide Manufacture: pH v. Time

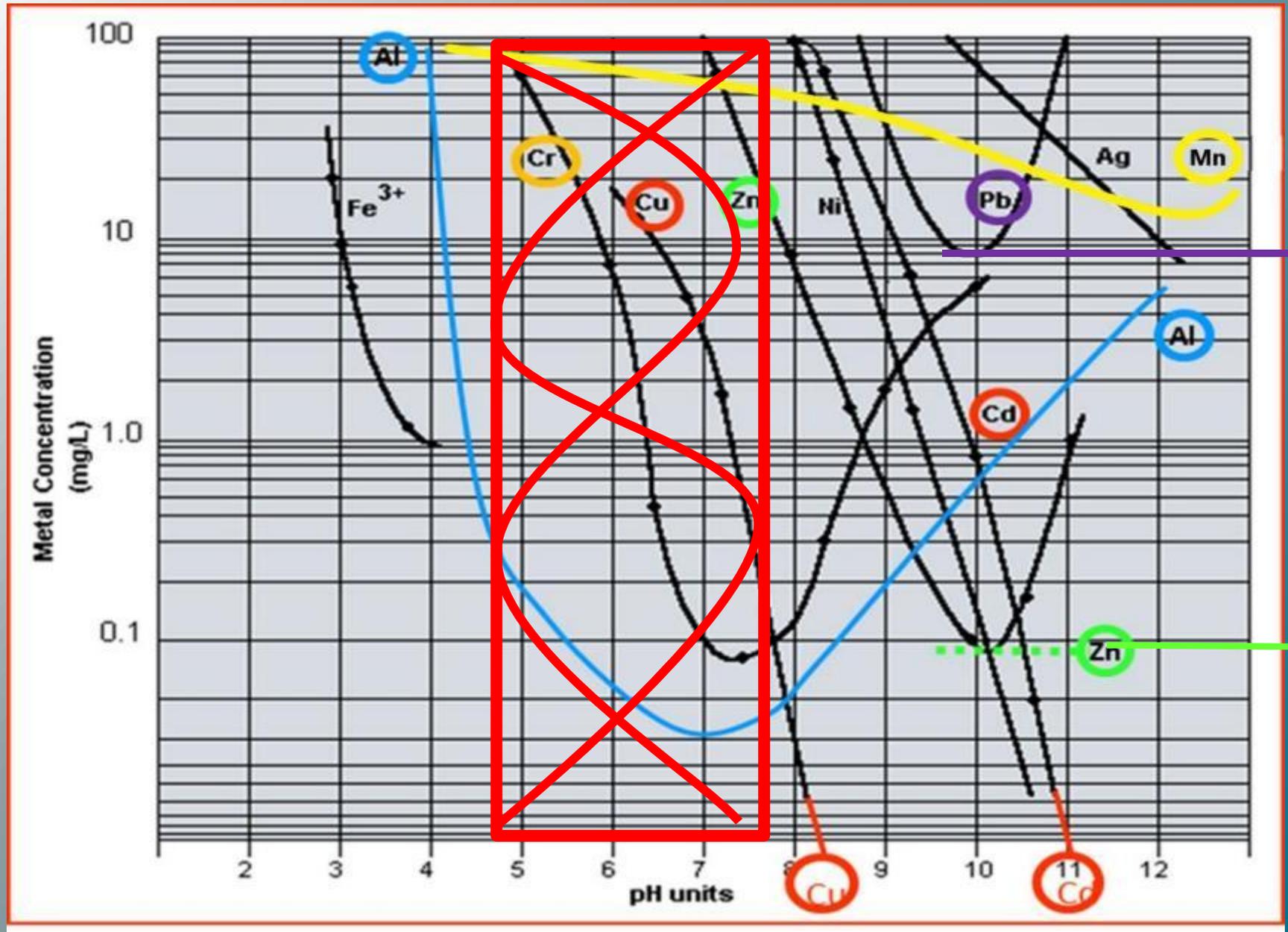
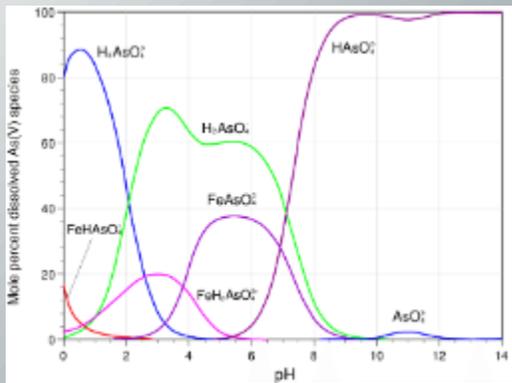


Advanced Neutralization™ (AN):

Typical End-Product
pH Range:

Metallic Oxides
(~4.8 – ~7.6 S.U.)

Arsenic Curves



Advanced Neutralization™

Pretreatment/Treatment Solutions:

TSS; Acidity; Metals; Foam; and Others in:

- Treatment of Landfill Leachate for COD/TSS
- Acid Mine Drainage for pH and Metals
- Frac Flow-back and Produced Water
- Apple Processing Water for TSS/BOD





Triaxial Mixing Reactor



Coagulating Solids – pH 6.2



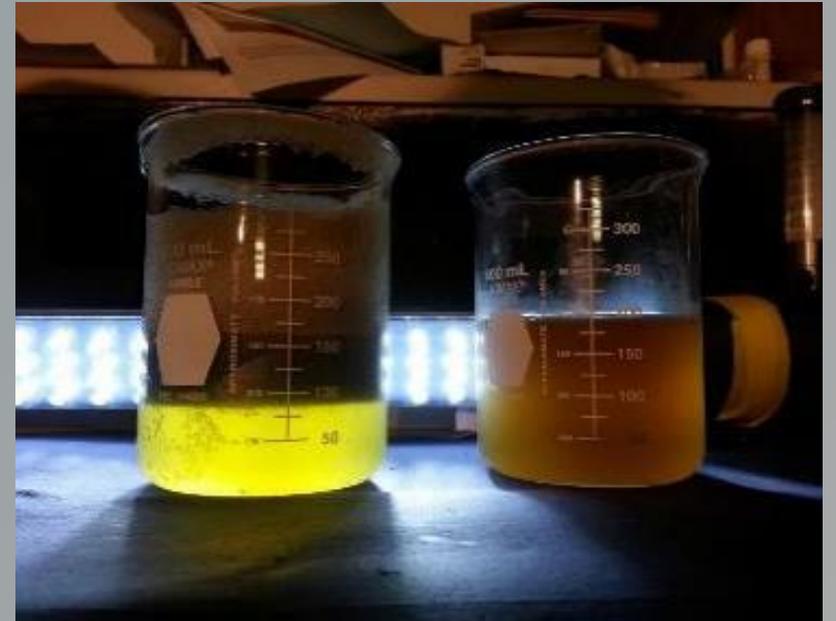
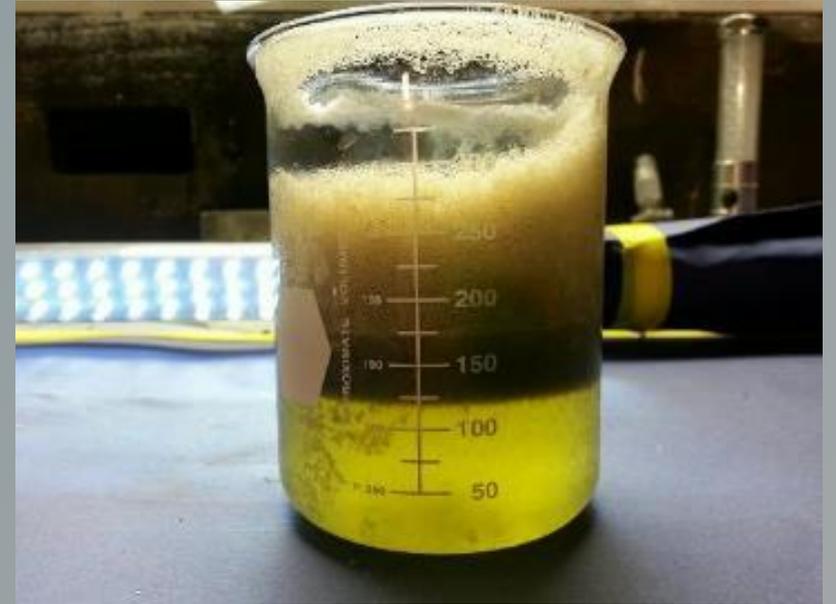
Shipping Container Clarifier



How AN™ & AMEOX® Originated

Subtitle D Landfill Leachate Treatment for Chemical Oxygen Demand (COD) Loading

(2015 - before PFAS was known to be present)



Subtitle D Landfill Leachate: DAF/AOP Trial

- Non-Hazardous Landfill - OR
- Target Parameters: [COD, TSS, pH](#)
- September 2015 (prior to PFAS knowledge)
- Treated w/air and mixed oxidants – 5 minutes
- Foam out and above tank hatch – 15 mins
- Study Halted – uncontrollable foam generation
- Lab/Bench Studies initiated to mitigate foaming
- Performed PRIOR to PFAS knowledge



Subtitle D Landfill Leachate – Foam and COD Resolution



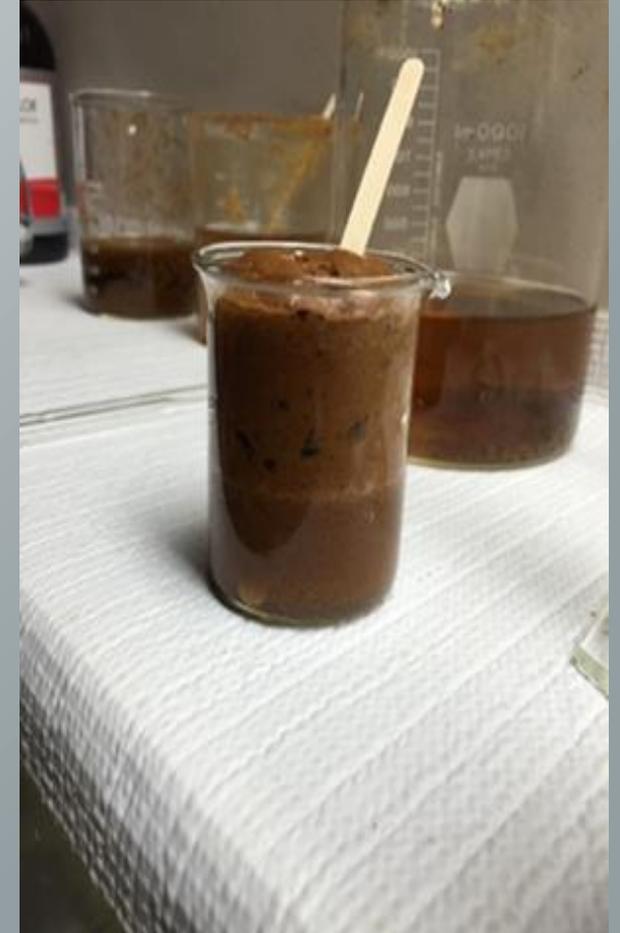
<u>Sample ID</u>	<u>Result (mg/L)</u>
Untreated	7375
AN-1	2275
AN-2	1650
AN-3	2600
AN-4	225

AN™ Treated Subtitle D Landfill Leachate (Oregon - 2015)

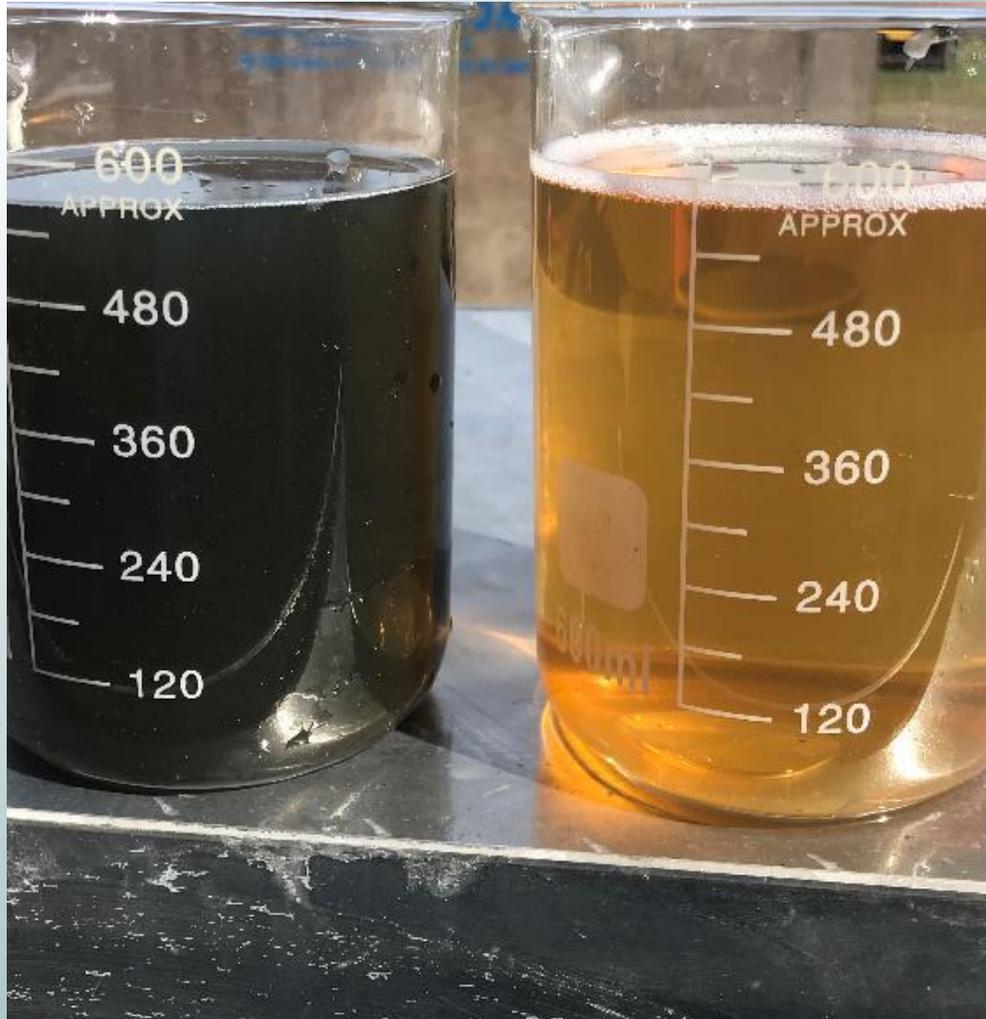
- Left: Untreated; Right : AN Viability Beaker Bench Tests (4)
- Far Right: **Suitable for AMEOX™ Processing for PFAS**



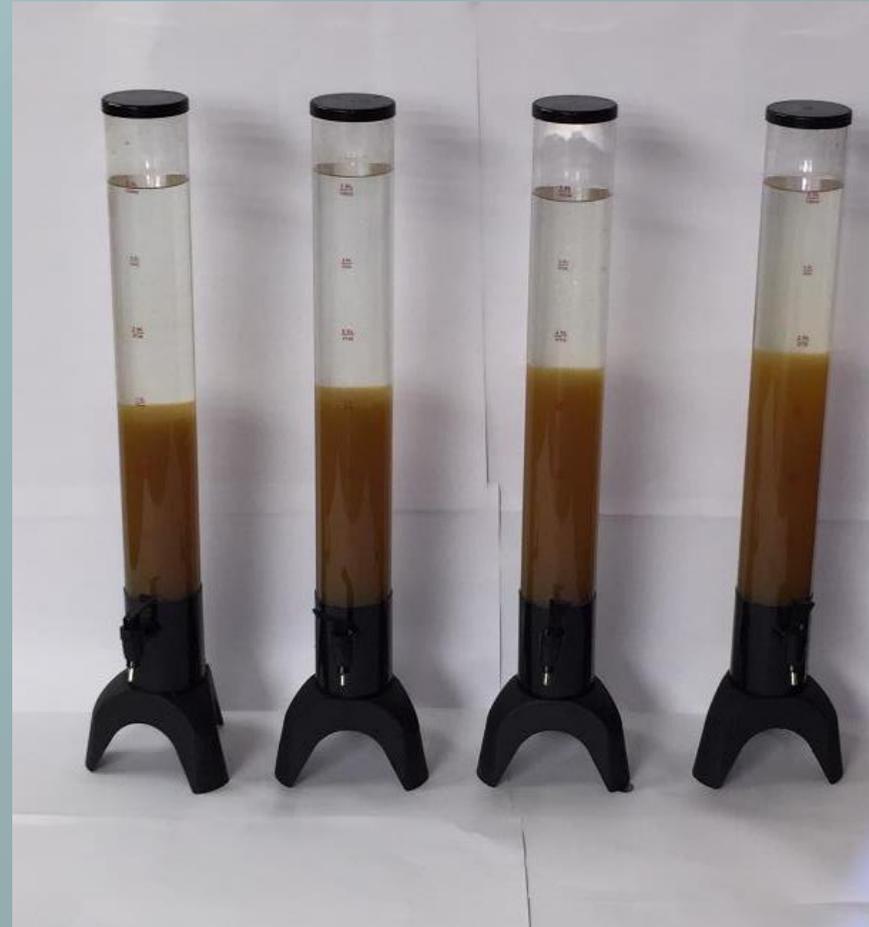
Foam Resolution Trials (with AN™ Technology)



Foaming Resolved



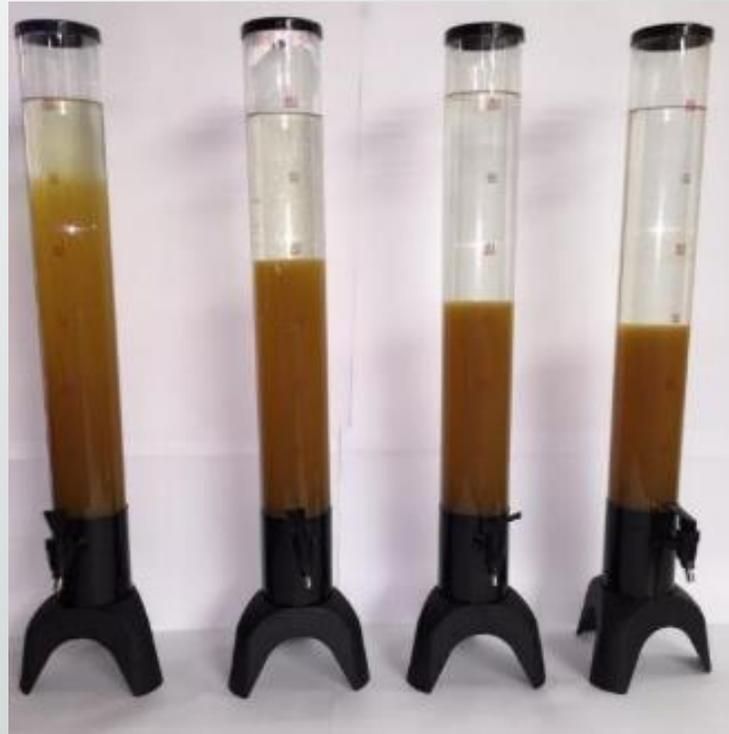
Landfill Leachate AN™ Treatment: AN Solids Maturation and Settling



AN Solids Settling Times

Left to Right:

2 minutes
5 minutes
7 minutes
10 minutes



30 minutes



9.86 gallons of AMD → 86.7 g of AN solids
(air dried to damp paste)



Advanced Neutralization™ (AN): Acidity and Heavy Metals in Acid Mine Drainage



Bunker Hill Mining and Metallurgical Complex NPL Site Kellogg, ID (Spring 2015)
AMD - Untreated (left)
AN Viability Beaker Bench Test (4 on the right)



Gold King Mine NPL Site, Gladstone CO

12 gpm AN™ Pilot - 2017



USEPA Capture of GKM AMD



AN Solids Maturation



Clarified AN Effluent @12 gpm

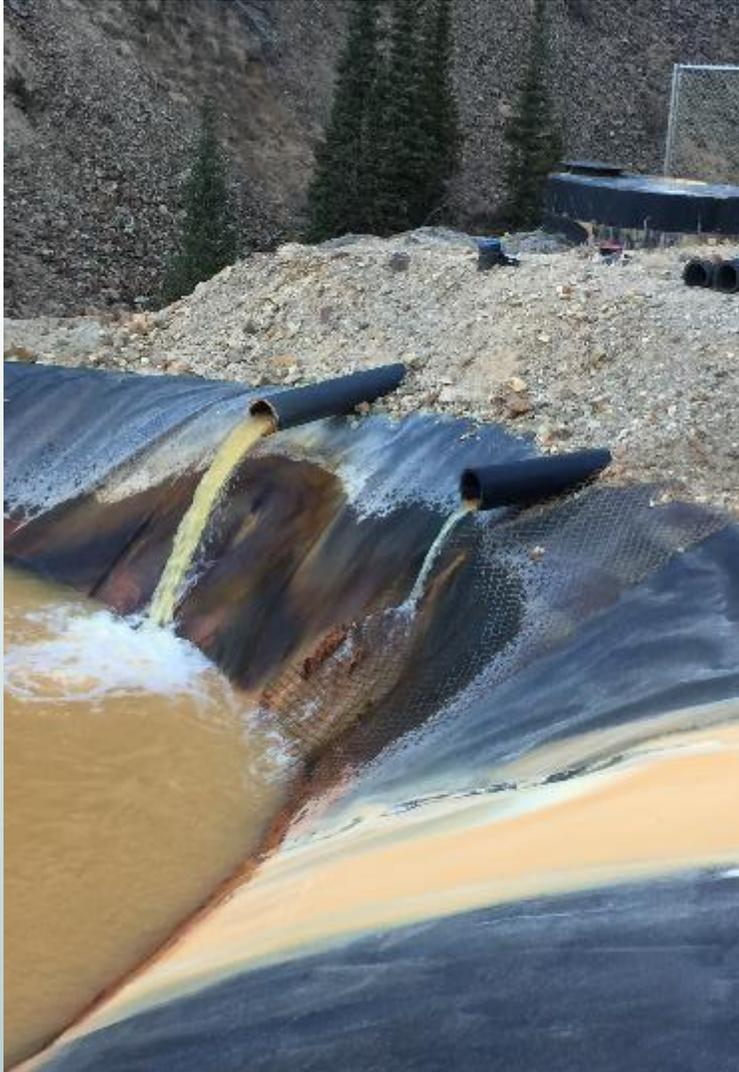


Gold King Mine NPL Site, Gladstone CO

12 gpm AN™ Pilot – 2017



Gold King Mine Field Trial (October 2017)



GOLD KING MINE

NPL Site

Location: Gladstone, CO

Legacy Site – Acid Mine Drainage

Issues: pH, Heavy Metals

Technology: AN

Unresolved: Sulfate, Sulfide, Sulfur



AN Treatability Results Gold King Mine AMD

April 12-15, 2016

AMD Parameter	Units	Untreated	AN Treated			
			R-1	R-1A	R-2	R-3
Aluminum, total	mg/L	13.9	1.43	1.39	DGap	DGap
Aluminum, dissolved	mg/L	8.94	<0.500	<0.500	DGap	DGap
Arsenic, total	mg/L	53*	NT	NT	0.0004 J	0.00035 J
Arsenic, dissolved	mg/L	62*	NT	NT	0.0005	0.00036 J
Calcium, total	mg/L	367	342	340	143.8	102.2
Calcium, dissolved	mg/L	371	335	302	151.2	90.8
Cadmium, total	mg/L	0.0379	0.0285	0.0017	0.0012	<0.00025
Cadmium, dissolved	mg/L	0.0384	0.0302	0.0014	0.0009	<0.00025
Copper, total	mg/L	2.96	0.114	<0.0100	0.008	0.002
Copper, dissolved	mg/L	2.69	0.109	<0.0100	0.0016 J	0.0013 J
Iron, total	mg/L	58.5	5.58	<0.500	23.54	2.05
Iron, dissolved	mg/L	43.8	4.28	<0.500	0.03 J	0.007 J
Lead, total	mg/L	0.0193	<0.0050	<0.0050	0.00017 J	0.0017
Lead Dissolved	mg/L	0.0086	<0.0050	<0.0050	<0.0005	<0.0005
Magnesium, total	mg/L	17.7	16.4	13.4	7.4	2.8
Magnesium, dissolved	mg/L	17.4	16.3	12.1	7.7	2.5
Manganese, total	mg/L	21.5	18.2	5.53	7.762	0.303
Manganese, dissolved	mg/L	20.0	18.6	5.44	4.631	0.012
Sulfate	mg/L	1685*	983	811	NT	NT
Sulfide, total	mg/L	NT	NT	NT	<0.05	NT
Sulfur, total	mg/L	NT	NT	NT	157	153
Sulfur, dissolved	mg/L	NT	NT	NT	167	166
Zinc, total	mg/L	21.5	5.54	<0.100	0.038	0.019
Zinc, dissolved	mg/L	10.1	5.69	<0.100	0.0074	0.001 J
pH	S.U.	5.2	5.75	7.66	6.62	7.24
pH	S.U.	3.28*				

* Historic average



Gold King Mine AMD, Gladstone, Colorado

Yost Brothers, LLC Field Trials - October 24-30, 2017

Advanced Neutralization Treatment Technology

Water Treatment Analytical Data Summary - Metals as Totals

Sample ID	BLM/EPA Provided Data	BLM/EPA Provided Data	GKM 08152017	GKM 1030-1000	GKM 102617-1523	GKM 102617-1512	GKM 102617-1455	GKM 102617-1546	GKM 102617-1555	**GKM 1027-2015	GKM 1030-1730
Sample No.	NA	NA	NA	NA	1	2	3	4	5	6	7
Date	10/19/15 - 9/21/16	10/19/15 - 9/21/16	8/15/2017	10/30/2017	10/26/2018	10/26/2018	10/26/2018	10/26/2018	10/26/2018	10/26/2018	10/30/2017
Water Type	Raw Influent	EPA Lime Effluent	Raw Influent	Raw Influent	AN Treated	QA/QC Blind Field Blank					
Flow Rate (gpm)			NA	NA	5	5	6	10	12	12**	NA
Parameters* (mg/L)											
Aluminum	18.7	4.3	45.5	4.65	26.1	6.4	12.8	1.59	1.30	<0.046	<0.046
Arsenic	0.033	0.005	<0.0050	<0.0050	<0.0250	<0.0250	<0.0250	<0.0250	<0.0250	<0.0250	<0.0050
Calcium	362.5	362.5	377	441	364	356	347	337	350	344	<0.152
Iron	84.8	13.1	174	114	61.7	41.8	28.5	58	63	13.1	<0.102
Cadmium	0.049	0.014	0.113	0.025	0.074	0.071	0.073	0.069	0.067	<0.0025	<0.0025
Cobalt	0.07	0.02	0.121	0.148	0.0882	0.0766	0.0788	0.075	0.071	0.0395	<0.0025
Copper	4.07	0.78	10.5	0.0441	5.84	2.00	2.97	0.349	<0.0025	<0.0025	<0.0025
Lead	0.028	0.006	0.055	0.0157	0.024	<0.018	<0.018	<0.018	<0.018	<0.018	<0.0025
Manganese	19.1	16.3	30.6	48.2	30.1	30.6	29.3	28.6	29.2	<0.0100	<0.0100
Nickel	0.043	0.018	NR	0.0884	0.088	0.193	0.18	0.191	0.16	<0.0050	<0.0050
Zinc	17.2	3.62	22.7	18.4	22.22	18.8	20.2	15.1	14.4	0.064	<0.0500
pH (S.U.)	NR	NR	2.81	3.62/2.95	4.32	3.33	4.51	4.29	4.95	6.12	6.71



Hydraulic Fracturing Produced/Flow-back Fluids



Viability Trials



Barnett/Permian Basin



Eagle Ford Formation



Hydraulic Fracturing Produced/Flow-back Fluids

Produced Frac Water Treatment Results

<u>Sample ID</u>	<u>TSS (mg/L)</u>	<u>TDS (mg/L)</u>	<u>Paraffin C18-C36 (mg/L)</u>	<u>Total Sulfide (mg/L)</u>
Eagle Ford -Raw	476	42,440	7.36	N/A
Eagle Ford -Treated	4	32,220	<0.976	<0.05
Barnett – Raw	2510	191,000	27.8	N/A
Barnett – Treated	40	131,733	<0.902	<0.05

NOTES:

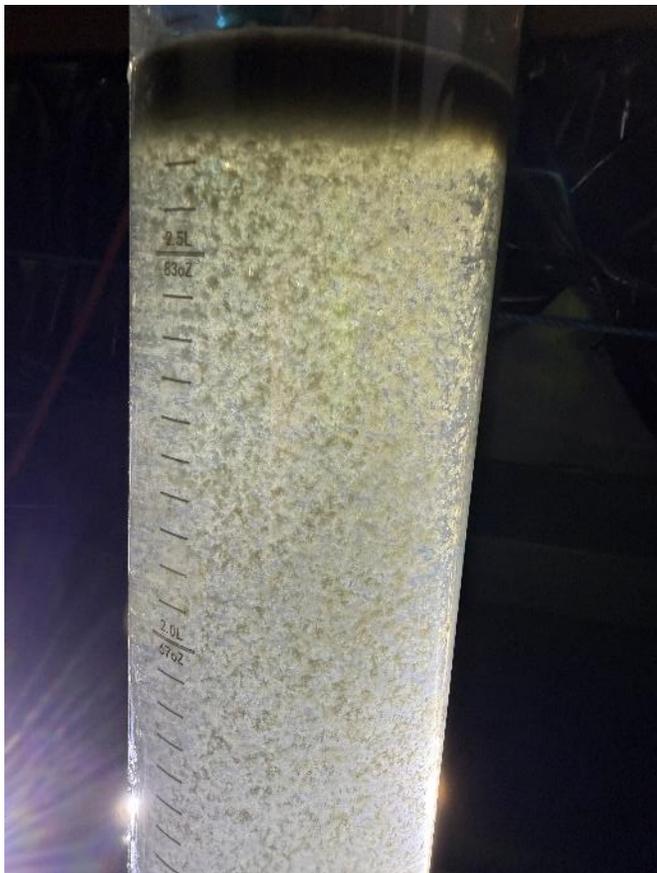
- 1) N/A – not analyzed
- 2) TSS and TDS analyzed by Edge Analytical, Burlington, WA
- 3) Paraffin analyzed by Ana-Lab Corp., Kilgore, TX



Apple Processing & Facility Wash Water



AN™ Technology Treatment (Full-Scale Pilot) Apple Processing & Facility Wash Water



Solids Coagulation and Separation



Turbidity Vial- Final Effluent



Clarified Solids (Air Dried)



AN™ Technology Treatment (Full-Scale Pilot)

Twister “Enhanced” AN™ Technology Pilot Study Data Summary Table

<u>Water Type</u>	<u>Sample ID</u>	<u>BOD (mg/L)</u>	<u>TSS (mg/L)</u>	<u>Turbidity (NTU)</u>	<u>pH (S.U.)</u>
Apple	Process-Untreated	1332	440	>200	6.83
Apple	Wash-Untreated	272	106	92 / 95 / 90	6.94
Treated	Treatment A	<2	6	6 / 9 / 10	7.65
Treated	Treatment B	<2	8	2 / 2	5.64
Control	Source Water	<2	2	1 / 1 / 3	7.85 – 8.14



Technology Pairing:

Advanced Neutralization™ (AN™) for precipitation, coagulation, and separation of solids followed by GAC/Other for PFAS removal; **with**

AMEOX® Technology to **destroy of PFAS** in GAC or concentrated PFAS stream removed from source water



SUMMARY



At YB Technologies, we strive to provide THE technologies for cleaner Wastewater. Our solutions integrate **advanced technology, engineered systems, and field-tested treatment expertise** to easily reduce contaminants and lifecycle costs for industrial, mining, food processing, agricultural, and private and public sector clients.



THANK YOU

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www.ybtechs.com