THE ROTATING CYLINDER TREATMENT SYSTEM RCTS

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Ionic Water Technologies

Treatment of Acid Mine Drainage (Lime Precipitation)

-The addition of lime:

1. to raise the pH and precipitate metals as hydroxides
2. to precipitate sulfate as gypsum

-Requires:

1. oxygen addition if dissolved ferrous iron is present

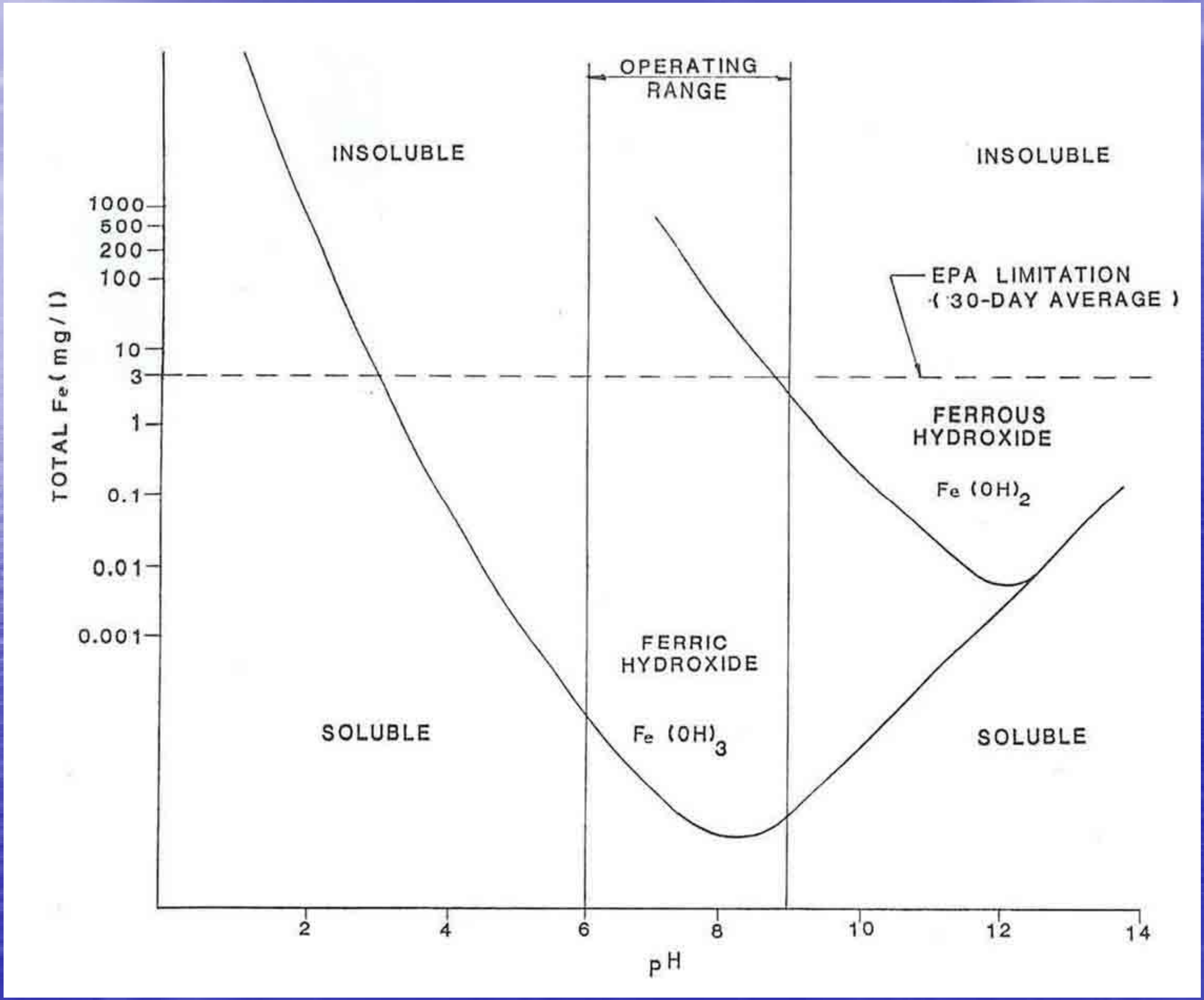
   Oxygen addition is typically accomplished with compressors and air diffusers placed in reaction tanks.

2. thorough mixing due to it's low solubility and slow dissolution rate.

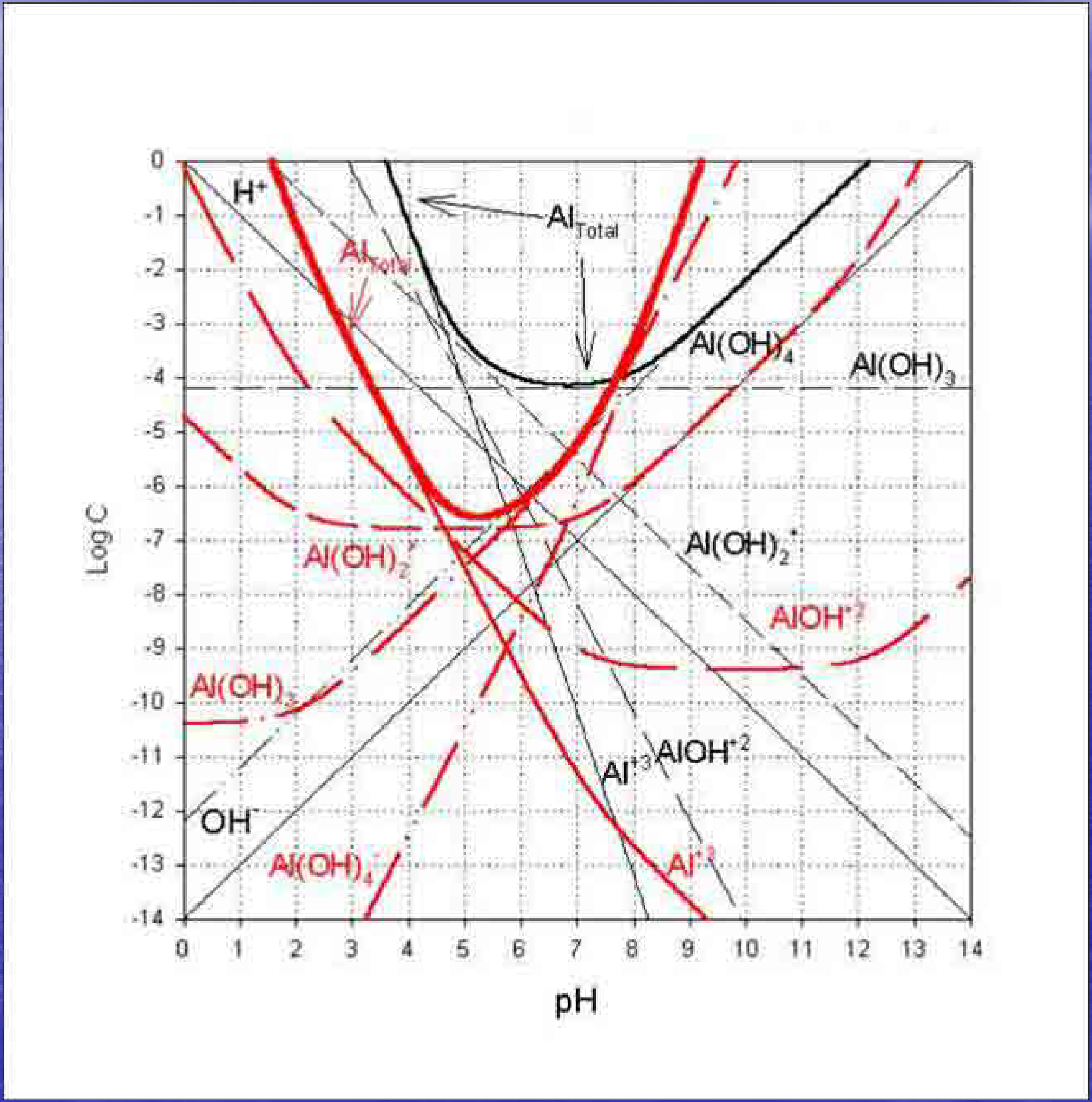
   Mixing is typically accomplished with mixers inside of reaction tanks.

-Typically labor intensive due to the requirements listed above

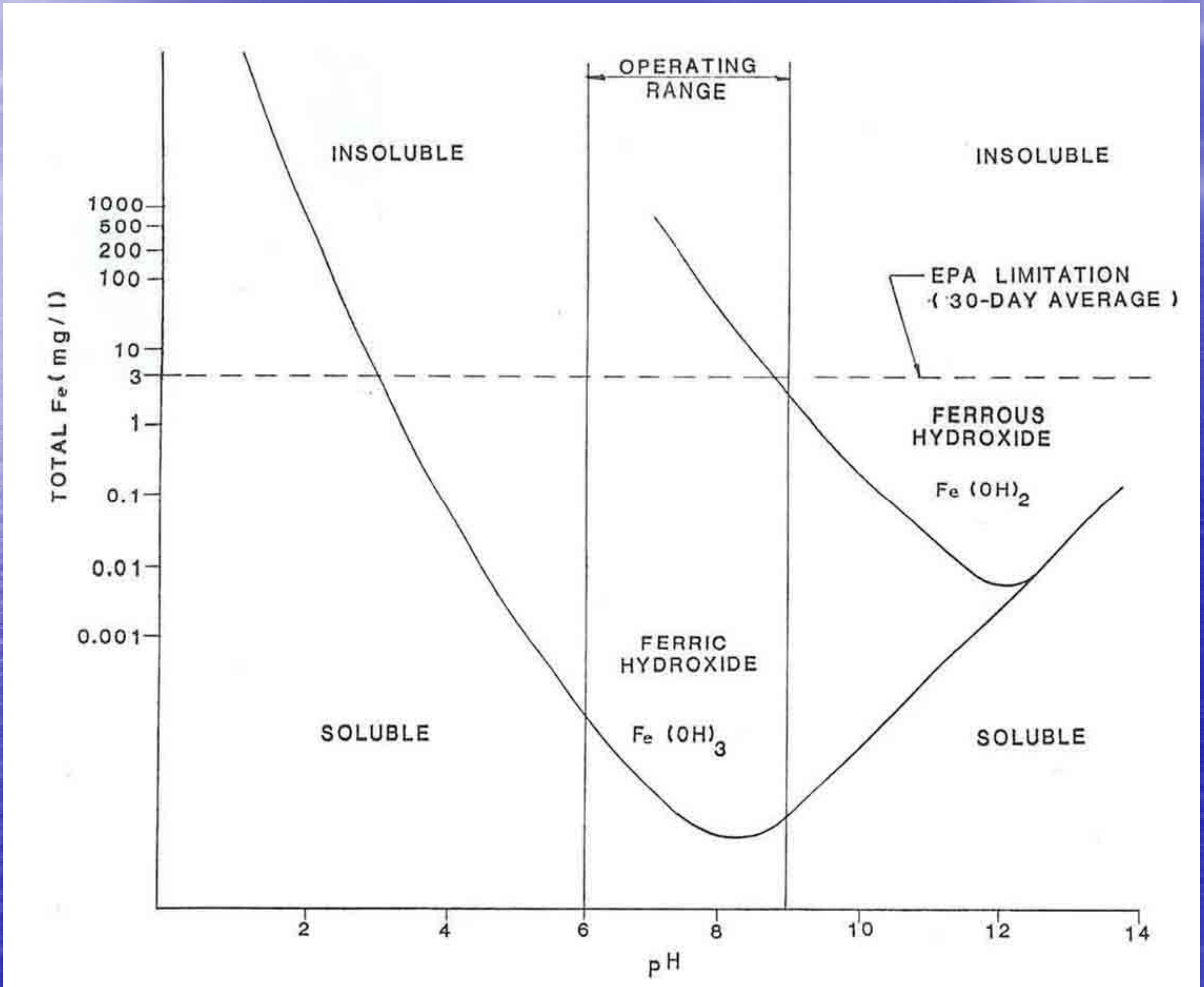
Iron Hydroxide Solubility vs pH



Aluminum Hydroxide Solubility vs pH



Iron Hydroxide Solubility vs pH



DESIGN AND OPERATIONAL CONCEPT OF THE RCTS TREATMENT SYSTEM

- Rotating perforated cylinders add oxygen from the atmosphere to the water
- Compressors and blowers are eliminated
- Aggressive agitation maximizes reagent efficiency

Improved Oxygen Addition

Provides more oxygen per energy consumed than conventional systems

- mechanical surface aeration systems provides 3.0-3.5 lbs of oxygen per horsepower hour (USEPA 1983)

- submerged turbine aerators utilizing dual impeller turbines provide 2.5-3.0 pounds of oxygen per horsepower hour (USEPA 1983)

- 600 gallon four rotor RCTS provided approximately 9 pounds of oxygen per horsepower hour

$$O_2 = Qw \times Fe \times 7.14 \times 10^{-5}$$

O_2 = Theoretical O_2 demand (lb O_2/hr)
Qw = Acid mine drainage flow rate (gal/min)
Fe = Fe^{2+} initial concentration (mg/L)

Operated on two cylinders powered by 0.375 hp and oxidized ~ 5,000 mg/L of iron at a flow rate of 10 gallons per minute.

Four Rotor RCTS Unit

Single Rotor High Speed RCTS Unit (RCTS-HS)

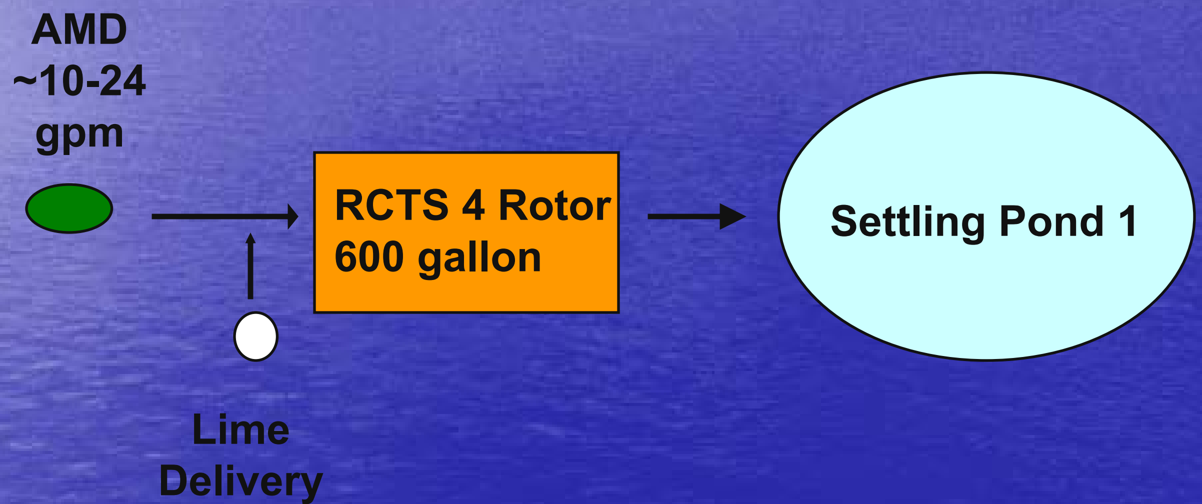
RCTS TECHNOLOGY AT THE RIO TINTO MINE IN NORTHEASTERN NEVADA 2003

THE RIO TINTO MINE

Highly concentrated AMD

- **The RCTS treated AMD with Fe^{2+} concentrations approaching 4,900 mg/l.**
- **Acidity was in excess of 12,500 mg/l.**
- **Sulfate concentrations were in excess of 18,000 mg/l.**

Treatment Schematic 2003 RCTS 4 Rotor Rio Tinto Mine



RIO TINTO MINE IN 2003

- 600 Gallon Prototype Unit met all Water Quality Standards applicable at the site
- Specific experiments undertaken for the Hybrid RCTS-Sulfate Reducing System
- Aluminum concentrations of 546 mg/l were removed to .009 mg/l during this experiment by the RCTS

Treatment Results 2003 RCTS 4 Rotor Rio Tinto Mine

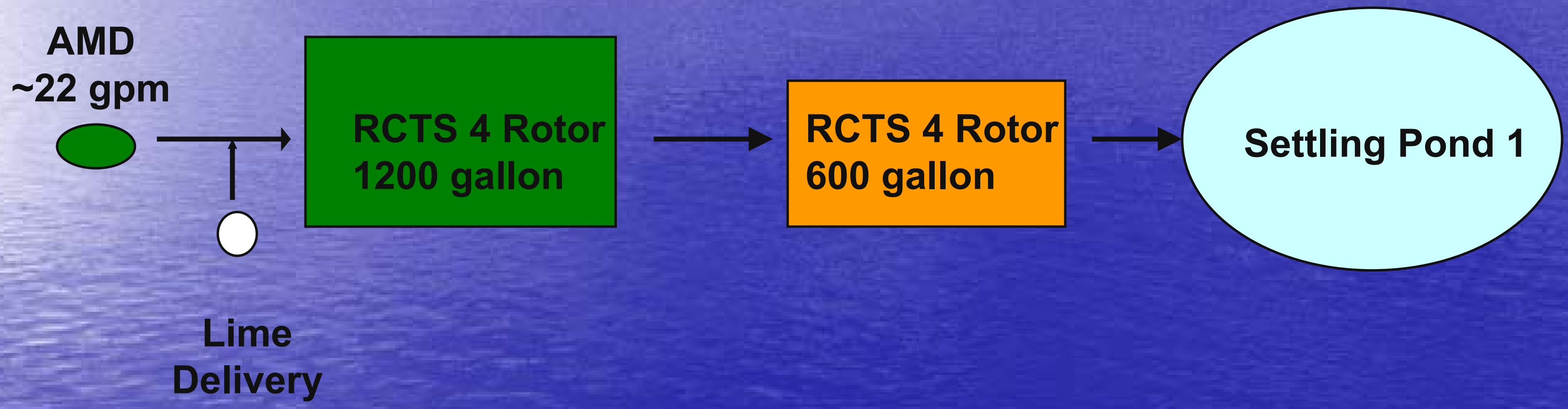
Table 2.4.1. 2003 RCTS Results

Date	TDS	Al	As	Cd	Cu	Cr	Fe	Mn	Se	Zn
Dissolved Influent Concentrations										
9/19//03	6510	124	0.0066	0.0964	53.7	0.0126	833	27.4	0.23	16.5
9/20/03	6960	133	0.0077	0.0968	57.9	0.0134	931	29.4	<0.05U	17.9
9/21/03	24200	528	0.024	0.338	215	0.044	4640	86.5	<0.2U	62.1
9/22/03	23300	540	0.026	0.342	220	0.044	4790	89.1	<0.2U	64.7
9/22/03	25200	546	0.026	0.340	222	0.044	4870	90.8	<0.2U	65.2
Dissolved Effluent Concentrations										
	TDS	**Al**	**As**	**Cd**	**Cu**	**Cr**	**Fe**	**Mn**	**Se**	**Zn**
9/19//03	4240	0.246	<0.005U	0.0006	0.016	0.0006	<0.05	3.54	<0.001U	0.06
9/20/03	4500	0.247	<0.005U	0.0007	0.017	0.0015	<0.05	4.18	<0.001U	<0.05
9/21/03	8780	0.109	<0.005U	<0.0005	0.019	0.0019	<0.05	3.35	0.001	0.05
9/22/03	7380	0.077	<0.005U	<0.0005	0.020	0.0019	<0.05	2.57	<0.001U	<0.05
9/22/03	12300	0.009	<0.001U	0.025	0.093	0.004	<0.10	52.2	<0.001U	0.70
9/24/03	9810	0.068	<0.002U	<0.0005	0.010	<0.002U	<0.10	3.46	0.001	<0.05
9/24/03	9780	0.071	<0.002U	<0.0005	<0.010	<0.002U	<0.10	3.46	0.001	<0.05

THE RIO TINTO MINE 2004

THE RIO TINTO MINE (4-ROTOR) TREATMENT 2004

Treatment Schematic 2004 RCTS 4 Rotor x 2

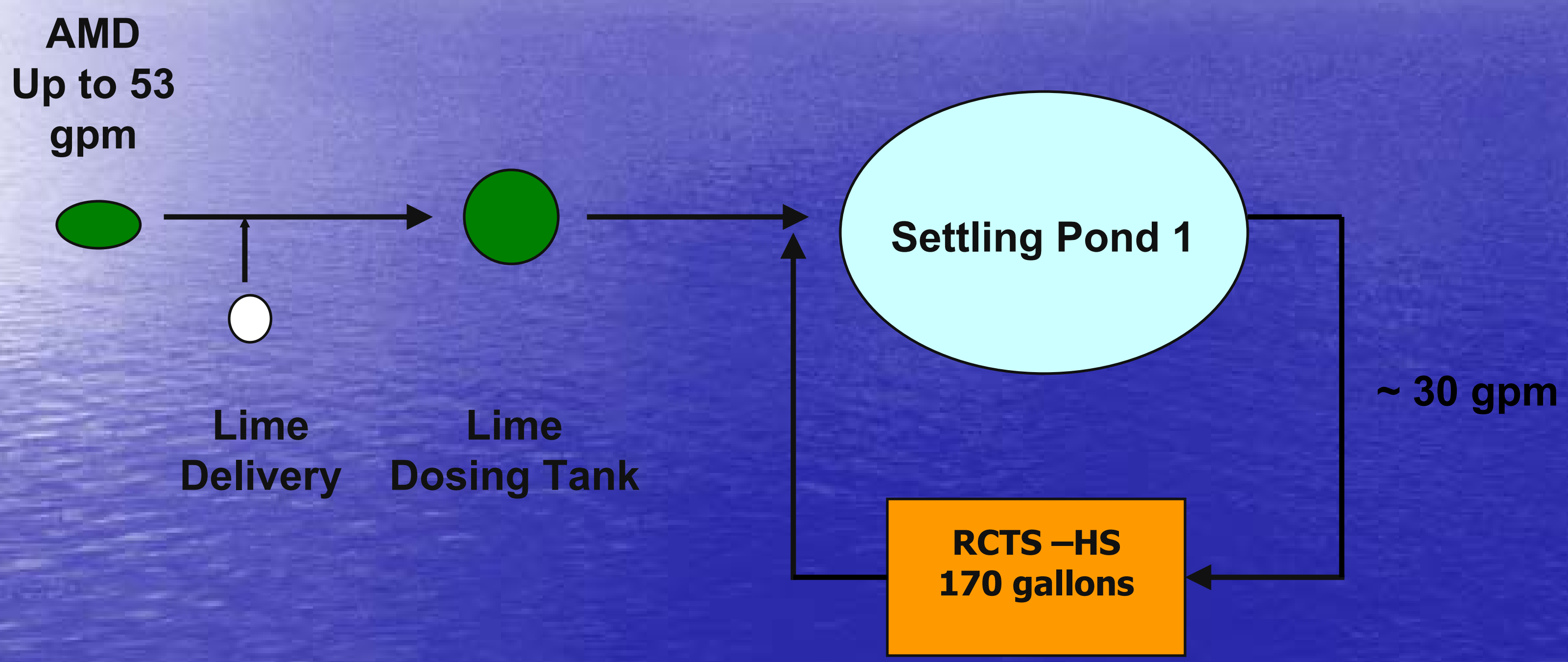


THE RIO TINTO MINE
RCTS-HS 2004

RCTS-HS 2004

- **The RCTS-HS prototype was utilized for an emergency water level adjustment of a hydraulic control pond in November of 2004.**

Treatment Schematic 2004 RCTS –HS Rio Tinto Mine



TYPICAL RESULTS
mg/l

INFLUENT	Unit Type	Al	As	Cd	Cu	Fe	Mn	Zn
10/4/04	RCTS 4 Rotor x 2	491	nd	.32	202	4170	77.5	54.6
10/6/04	RCTS 4 Rotor x 2	433	.03	.278	209	3550	82.6	50.9
11/9/04	RCTS-HS	683	.03	.365	293	4800	109	74.3

EFFLUENT	Unit Type	Al	As	Cd	Cu	Fe	Mn	Zn
10/4/04	RCTS 4 Rotor x 2	nd	nd	nd	.037	.74	4.51	.07
10/6/04	RCTS 4 Rotor x 2	nd	nd	.002	.097	.11	9.54	.09
11/9/04	RCTS-HS	nd	nd	nd	.003	nd	4.88	nd

RCTS TECHNOLOGY AT THE RIO TINTO MINE IN NORTHEASTERN NEVADA 2004

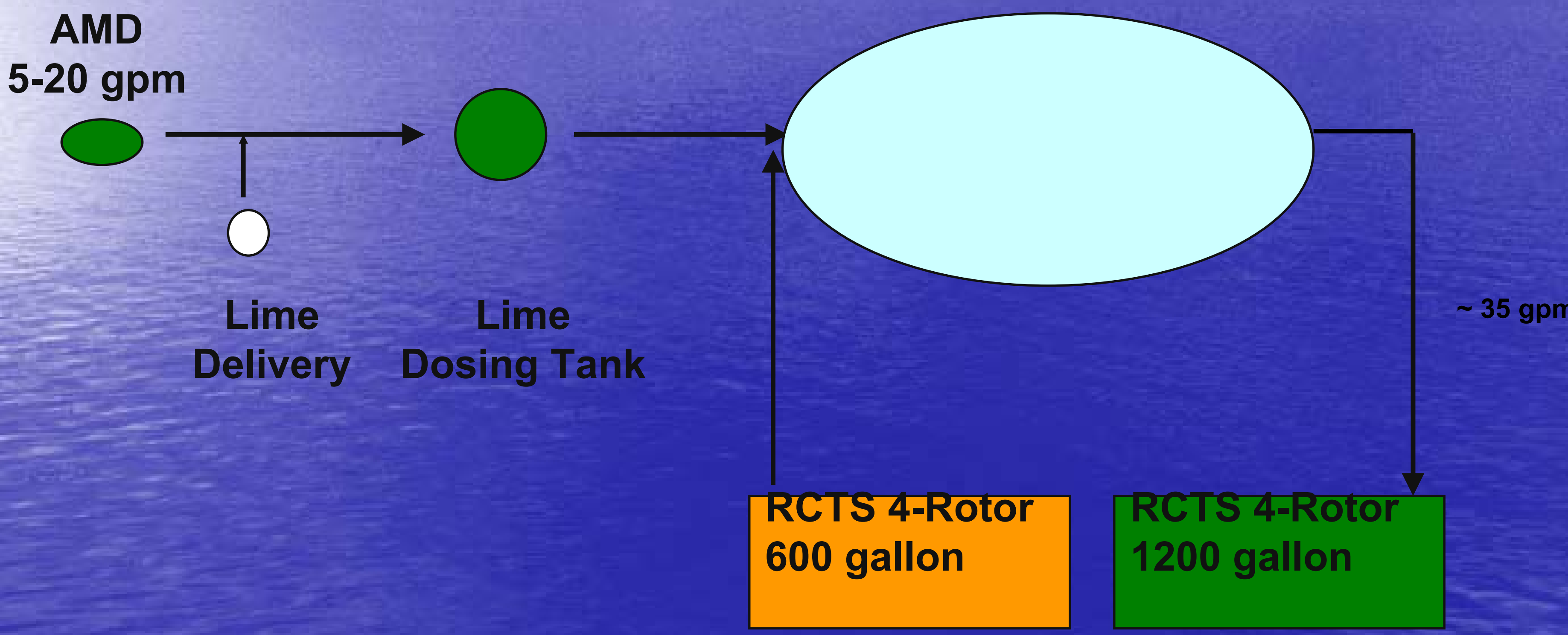
Results:

- The RCTS met all Federal Water Quality Standards applicable at the site in a single stage pH adjustment of the influent.
- The RCTS-HS met all Federal Water Quality Standards applicable during this emergency lagoon type treatment.
- Treated ~22 gallons/min (RCTS 4 rotor x 2)
  ~53 gallons/min (RCTS-HS)
- Operated on less than 1600 watts of electricity.
- Lime slurry efficiency ~98%

RIO TINTO MINE
2005

RIO TINTO MINE
2005

RIO TINTO MINE
2005



TYPICAL RESULTS
mg/l

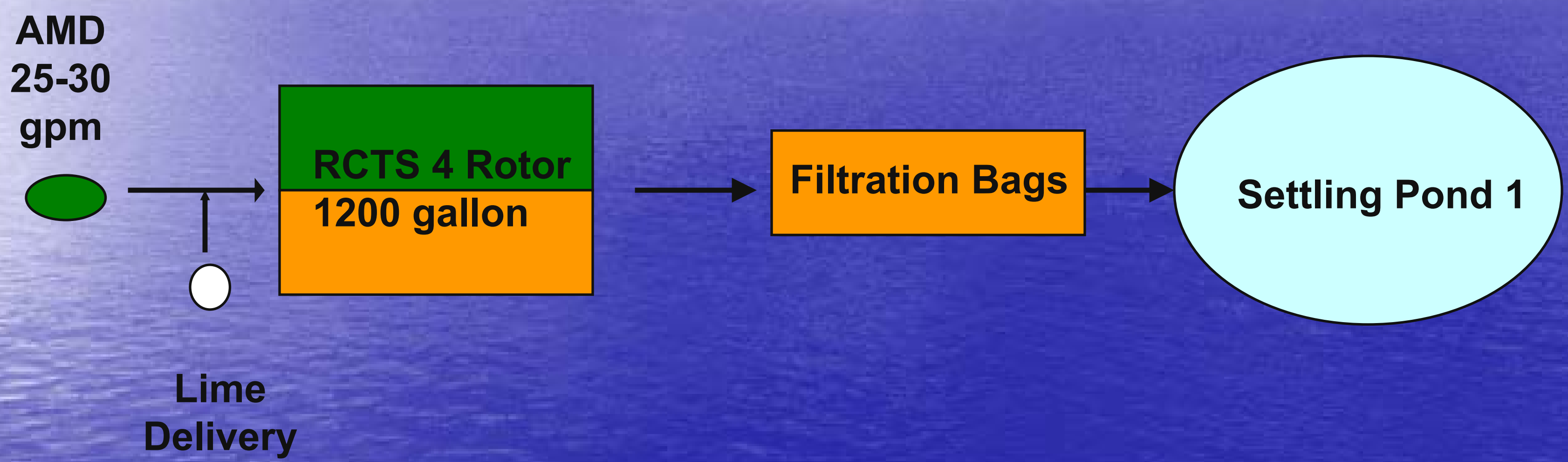
Table 1. Treatment Results for the Rio Tinto Mine 2005 Concentrations (mg/L)

Date	Sample location	Al	As	Cd	Cu	Fe	Mn	Zn	Sulfate
7/19/2005	Influent	726	nd	0.340	320	6780	87.3	73.6	24,100
7/19/2005	Effluent	0.2	nd	nd	0.005	nd	1.01	nd	4110
7/26/2005	Influent	793	0.03	0.359	314	6890	96	79.4	24,180
7/26/2005	Effluent	0.1	nd	0.0005	0.005	nd	0.52	nd	2,410
8/5/2005	Influent	540	nd	0.338	228	4990	80.3	60	17,600
8/5/2005	Effluent	0.08	nd	0.0002	0.002	0.05	0.41	nd	1,800
8/11/2005	Influent	297	nd	0.210	130	2840	63.9	36.7	10,200
8/11/2005	Effluent	0.13	nd	nd	0.01	nd	0.2	nd	1,950
8/18/2005	Influent	305	nd	0.200	128	2950	58.1	35.2	10,900
8/18/2005	Effluent	0.114	nd	nd	0.014	0.06	0.2	nd	2,070
9/7/2005	Influent	572	nd	0.301	248	5110	67.4	57.5	17,600
9/7/2005	Effluent	0.26	nd	nd	0.018	0.40	0.23	nd	2,560
9/23/2005	Influent	325	nd	0.198	139	2940	58.2	36.5	9,710
9/23/2005	Effluent	0.07	0.001	0.0002	0.009	nd	0.58	nd	2,390
9/30/2005	Influent	279	nd	0.230	131	2570	51.9	32.3	9,910
9/30/2005	Effluent	0.04	0.001	0.0002	0.011	nd	0.581	nd	2350

RCTS TECHNOLOGY AT THE LEVIATHAN MINE 2004

RCTS TECHNOLOGY AT THE LEVIATHAN MINE 2004

Treatment Schematic 2004 RCTS 4 Rotor Leviathan Mine

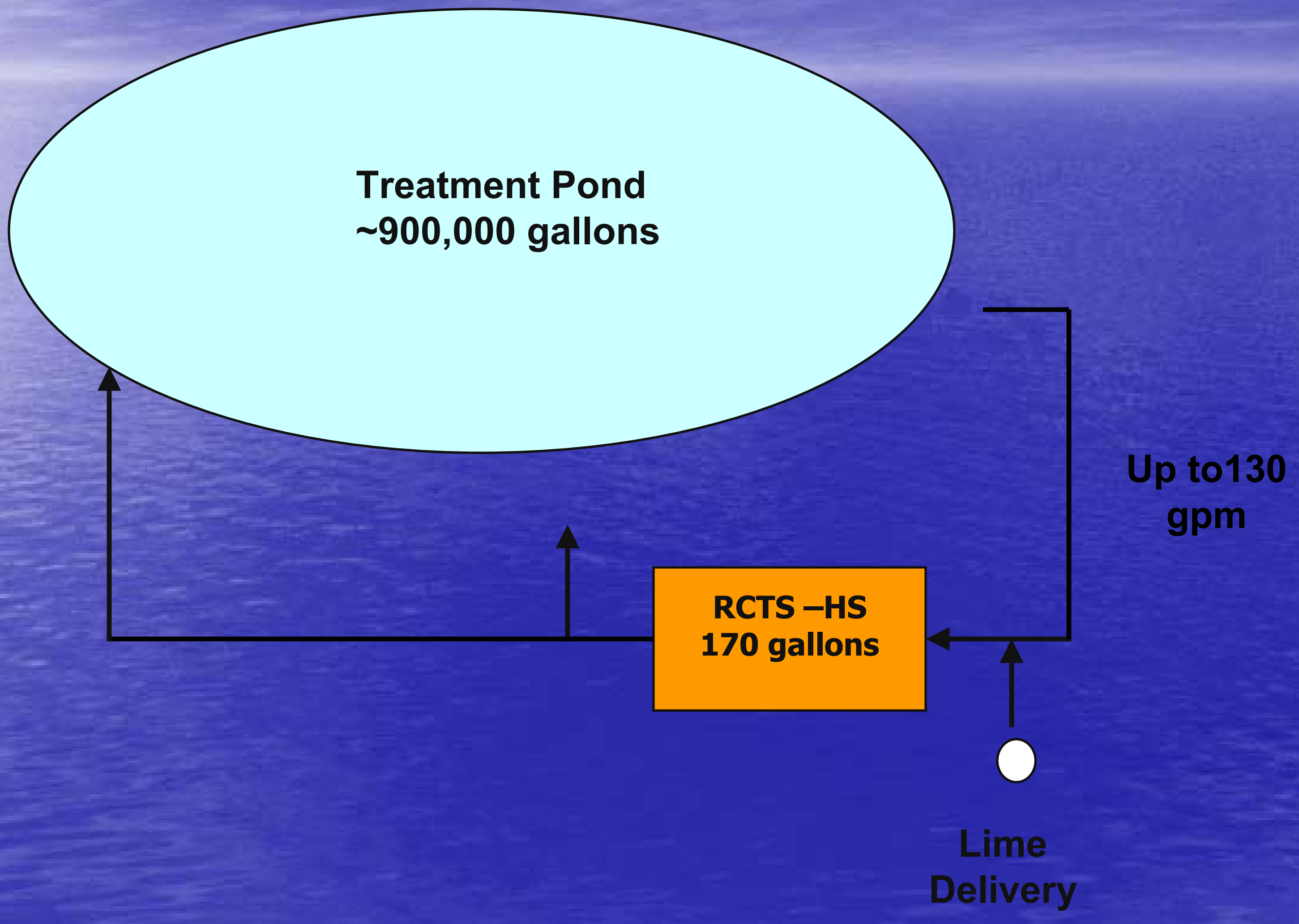


LEVIATHAN MINE 2004

- **The RCTS treated 25-30 gpm Fe^2 concentrations of 300 to 400 mg/l.**
- **Lime slurry efficiency was 41% better than the conventional tank reactor system onsite.**
- **Influent residence time within the RCTS was 75% less than the conventional tank reactor system onsite.**
- **Water Quality Standards were met by the RCTS in a single stage pH adjustment.**
- **The RCTS operated on less than 1600 watts of electricity during treatment operations.**

RCTS TECHNOLOGY AT THE LEVIATHAN MINE EMERGENCY BATCH TREATMENT 2005

Treatment Schematic 2004 RCTS –HS Northeastern Nevada



RCTS TECHNOLOGY AT THE LEVIATHAN MINE EMERGENCY BATCH TREATMENT 2005

- **Mobilize the system in 3 days**
- **The RCTS treated ~800,000 gallons of AMD in approximately 90 hours.**
- **Acidity ~ 1,300 mg/L mostly aluminum**
- **All applicable Water Quality Standards were met**
- **The RCTS operated on less than 1600 watts of electricity during treatment operations**
- **Lime efficiency > 89%**

RCTS TECHNOLOGY AT THE LEVIATHAN MINE EMERGENCY BATCH TREATMENT 2005

RCTS TECHNOLOGY AT THE LEVIATHAN MINE EMERGENCY BATCH TREATMENT 2006

EMPIRE MINE GRASS VALLEY CALIFORNIA

Flow ~ 6 gpm
pH ~ 6.6
iron ~ 4 mg/L

arsenic ~ 0.05 mg/L

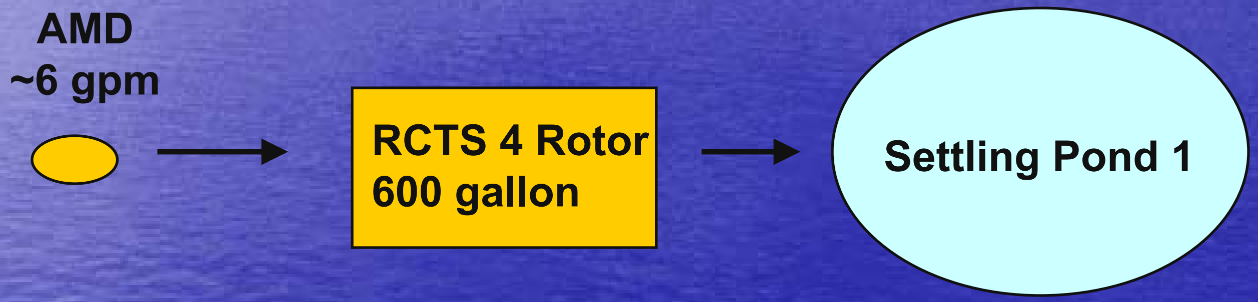
EMPIRE MINE GRASS VALLEY CALIFORNIA

Goals:

- **To oxidize and precipitate the iron and co precipitate arsenic from solution.**
- **It was initially proposed that sodium hydroxide would be added to raise the pH from 6.6 approximately 8.0.**
- **The addition of base was not necessary (Degassing of carbon dioxide from the water)**

$$HCO_3^- + H^+ \longrightarrow H_2O + CO_2 \uparrow$$

Treatment Schematic RCTS 4 Rotor Empire Mine



EMPIRE MINE GRASS VALLEY CALIFORNIA

Results:

Iron concentrations were reduced from 4290 µg/L to 80 µg/L. (without base addition)

The ferrous iron concentration was not sufficient to co-precipitate all of the arsenic from solution. Arsenic was reduced from 47 µg/L to 25 µg/L.

Suggested adding Ferrous iron to co-precipitate arsenic

Summary

- Can be rapidly mobilized.
- Efficient lime utilization
- Can reduce sludge production.
- Requires 60% to 90% less expended energy than conventional treatment.
- Less space required.
- Can treat as a batch or continuous.