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BIO-CARB AND WETLANDS - PASSIVE, AFFORDABLE ACID MINE DRAINAGE TREATMENT

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ABSTRACT

Treating soil and water pollution from acid mine drainage to industrial waste to landfill leachate to underground storage tanks to agricultural run-off has been and is an expensive and frustrating undertaking. Multiple treatment methods have been employed with varying success, sometimes creating worse messes and spiraling treatment costs. One answer may be bioremediation, or the use of natural biological methods to remedy polluted soil and water. Bioremediation can be done using natural or genetically engineered microbes alone and/or in conjunction with man-made or natural wetlands.

The Lambda process does not employ any genetic engineering. It is based upon the natural biological and physical principles which have been present on Earth for over a billion years. Using these principles, we have developed a process whereby biologically active microbes enhance chelation, oxidation and deposition of various minerals and heavy metals by removing them from their dissolved states in water and fixing them in underlying soil, thereby returning them to the ore cycle. These are

self-sustaining, balanced ecosystems that work alone to provide the basis for a beginning food chain or in conjunction with macro-ecosystem wetlands to provide multiple trophic levels.

These concepts have been successful at the bench and in in-situ, in multiple applications. The heavy metals in coal acid coal mine drainage sites in West Virginia and Pennsylvania have been significantly reduced, often to and maintaining N.P.D.E.S. standards and always with great treatment cost reduction. Ponds at a Maine country club were taken from toxic pollution levels to drinking water standards. Both soil and water at the sites have shown rapid and sustained recovery with little or no sludge production and no deleterious effects to the environment in the short or long term.

INTRODUCTION

Effective control of mine drainage discharge continues to be one of the most frustrating and expensive aspects of mining today. The standards and the enforcement agencies get tougher, construction costs and chemicals sky rocket and profits are harder and harder to achieve. Long after the coal is mined and gone and the land has been reclaimed, the polluted water continues to flow from the sumps and seeps. You're throwing good money after bad treating with more and more chemicals and the sludge grows daily filling in your ponds and emptying out your pockets with removal costs. Some companies just keep treating and dredging, some go bankrupt and some just throw up their hands and walk away, but the problem water remains. There are no easy answers, no cheap solutions and no "magic bullets", but there are two emerging technologies that we're merging, and they offer some hope for the future.

BIOREMEDIATION

Biological remediation is a multi-faceted group of technologies that utilize living biologicals and/or their components, to clean polluted water and soil. There are no gadgets or gimmicks involved, no "black boxes", no pagan rituals and no magic, just good biological science. Bioremediation encompasses not one but multiple techniques to clean pollution by rebalancing the ecosystems involved.

Microbial ecology uses microbes to rebalance the microorganisms that are needed as a foundation for any viable ecosystems. These microbes can be genetically engineered "super bugs", a field known as Biotechnology or genetic engineering, or by natural selection. The goal is to create biochemical activity that chelates, oxidizes, decomposes, degrades and/or binds up non-degradable material like heavy metals, in non-soluble forms in the sub-soil where they will not impact ground water or root structures. Another goal is to set up a viable food chain that can reestablish a viable ecosystem that will perpetuate itself. Biostimulation is sometimes used as a cheap alternative to stimulate the growth of whatever critters might be in the system in hopes that they will develop on their own. You do this by adding the sugar, peptone and vitamins they like best and hope that no opportunistic pathogen grow first and crowd the "good guys" out. These treatments can cost $30,000 to $5,000,000.

Wetlands technology uses man-made marshes to slow flow rates, absorb metals, and decompose organic matter. It has been employed with varying degrees of success in Pennsylvania, Kentucky and the area served by TVA. It is the least expensive treatment technology available, averaging $20,000 to $30,000 per site. it requires 25 acres of treatment space per 1,000,000 gallons per day of discharge, as a rule of thumb for organics. Wetlands constructed to treat acid mine drainage should have 9-15 square feet for each ppm per minute of iron and manganese entering the system. Demonstration site costs have varied considerably from $20,000 to as high as $360,000 depending on the site, the construction techniques employed and the loading rates.

THE BEST OF BOTH WORLDS

Both microbial treatment and wetlands have limitations and individual strengths. I was a graduate student at West Virginia University in 1972 when Dr. Jerry Lange first discovered the capability of wetlands to control acid mine drainage, and have followed its evolution with great interest. Lambda's microbes were the first ones combined in their natural state and applied as a mixatrophic culture in an acid mine seep at Fort Hill Mine in Somerset County, Pennsylvania in the March blizzard of 1985. Like the wetlands technology, we have had successes and failures. Also like wetlands technology, the successes made the technology worth pursuing.

We put the microbes in "jelly balls" to compensate for flow rates. They work in flows under 10-20 gpm, but not in flows greater than that, and raccoons and deer eat them as a supplementary protein source. Bio-Carb embeds the microbes in charcoal which protects them from being confused with forage material, but still won't stay in place under high flow rates and the get buried by sedimentation. Putting them in 100 pound flow-through bags holds them against high flow rates and high bags don't easily cover over with sediment. High flow rates and high loads of heavy metals require high tonnage of Bio-Carb for effective year-round treatment - 3 to 20 tons in some cases - and the cost, which is calculated by load, flow rate and area, rises accordingly. Add multiple pollution loads, such as organics, TPH, volatiles, lead, mercury, arsenate and cyanide, and it multiplies the cost factor. Work done, even by microbes, is not free.

The same is true of wetlands. The more complex the problem, the more "work" and area are required and the cost goes up accordingly.

But what if the two technologies are combined? More "work" could be accomplished in a smaller amount of space. Less area and better utilization of the area used would decrease construction costs and improve efficiency per acre involved. Less "bugs" would be required, because wetlands provides a more efficient habitat for them to work in. Wetlands also helps control flow rate and provides a greater retention time for the microbes to operate in, giving an increased efficiency to the microbes used, thereby requiring less microbes.

The best wetlands man I know is Bob Deason at PBS Coal in Friedens, Pennsylvania. Last summer we rebuilt part of the existing pond system at their Somerset, Pennsylvania reclamation site, and combined it with the Bio-Carb technology. We also teamed up with Pat Lewis, the greenskeeper at Portland Country Club in Falmouth, Maine, to see how it would work in an estuary - fresh water combination of marsh-ponds.

PBS - JOB #14

This was a strip mine that ceased operation five years ago and has been completely reseeded and reclaimed. Treatment of the water discharging from their sump was aerated and pumped into a series of four ponds at about 200,000 to 400,000 gallons per day. A large caustic tank located between ponds 1 and 2 delivered liquid sodium hydroxide at a cost of about $5,000 per month. The total area involved for water treatment was less than four acres and three-fourths of an acre of that was built as a wetlands with compost and cattails. The pH was not a problem. It was already a 7 coming out of the sump. iron averaged 20 ppm and manganese 10 ppm.

In June, the last purchase of caustics was make for their tank. In July, the fourth pond was re-excavated and a three cell wetlands was built and we loaded in two tons of Bio-Carb in the three remaining ponds and the three celled wetlands area.

Compliance was achieved in one week, then the oversaturated land and extreme rain of 1990, 1991 made itself felt. The sump reached dangerously high levels that required around the clock pumping. The system is now treating twice the amount of water and twice the load it was designed for. Iron stayed in compliance, but manganese jumped up. By diverting the discharge to a fifth pond from the wetlands, compliance was reached and held on manganese as well without reverting back to chemical treatment. Graphs in Appendix A show the parameters through November 1990 charting the raw water, pond 2 and pond 4 cell " c". (*See* case study)

PORTLAND COUNTRY CLUB

Pesticides, fungicides and heavy duty fertilizers had built up for 125 years and washed into a five acre pond system that was a combination fresh water - estuary complex on the Atlantic Ocean at Falmouth, Maine. All muskrats, turtles, foxes and birds that once used the ponds as primary habitat had been killed off and only cattails still lived in the ecosystem. Now the cattails were out of control and beginning to choke off and fill in the ponds. The pH was 4.1. In August of 1990, we loaded three and a half tons of Bio-Carb in all three pond systems. One month later, the lead, mercury, arsenate, cyanide and other heavy metals were reduced to drinking water standards, the pH was at 7.5, and it has held at those parameters.

The birds, muskrats and turtles are back, the system is in balance and the cattails are dying back. (*See* case study attached)

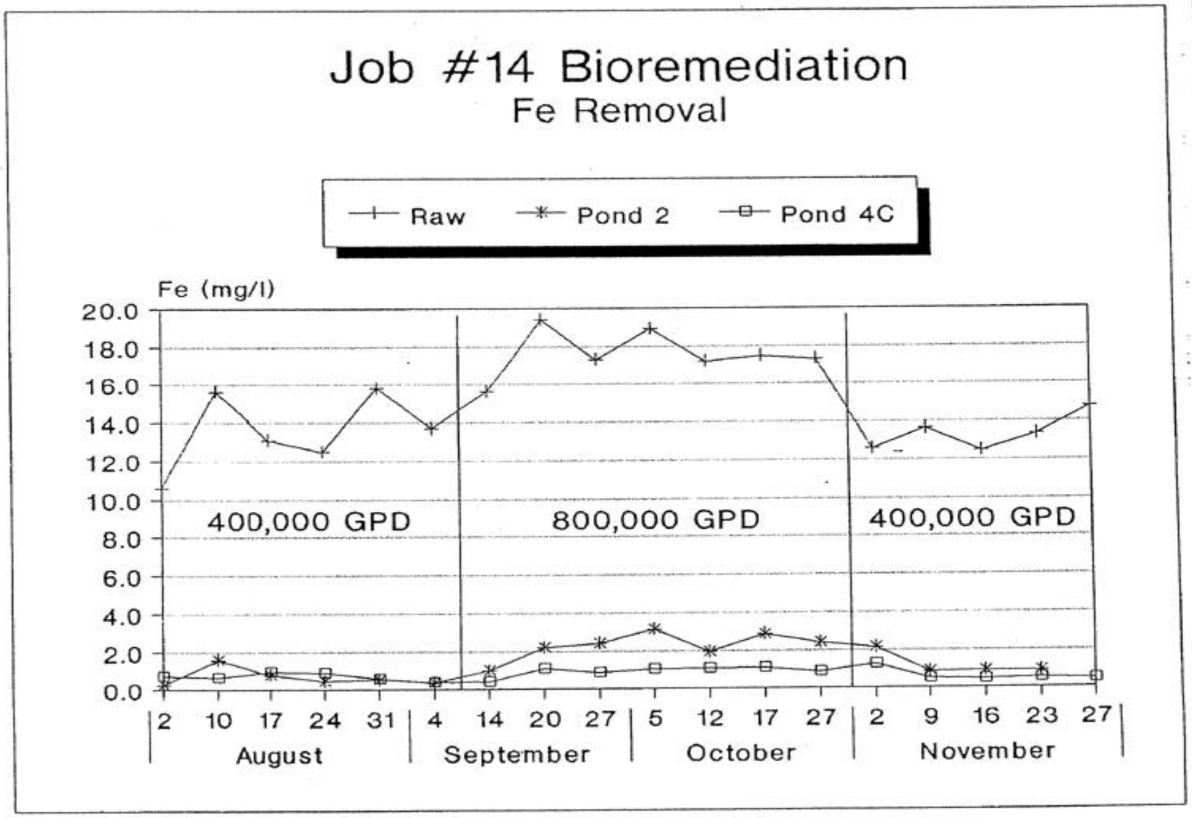
This was a chance to use Bio-Carb with a well-established marsh land, and results were very good. It worked. No construction was required. The cost was $35,000, less than one-third what it would have cost using any other technology. Results are in the chart in Appendix B.

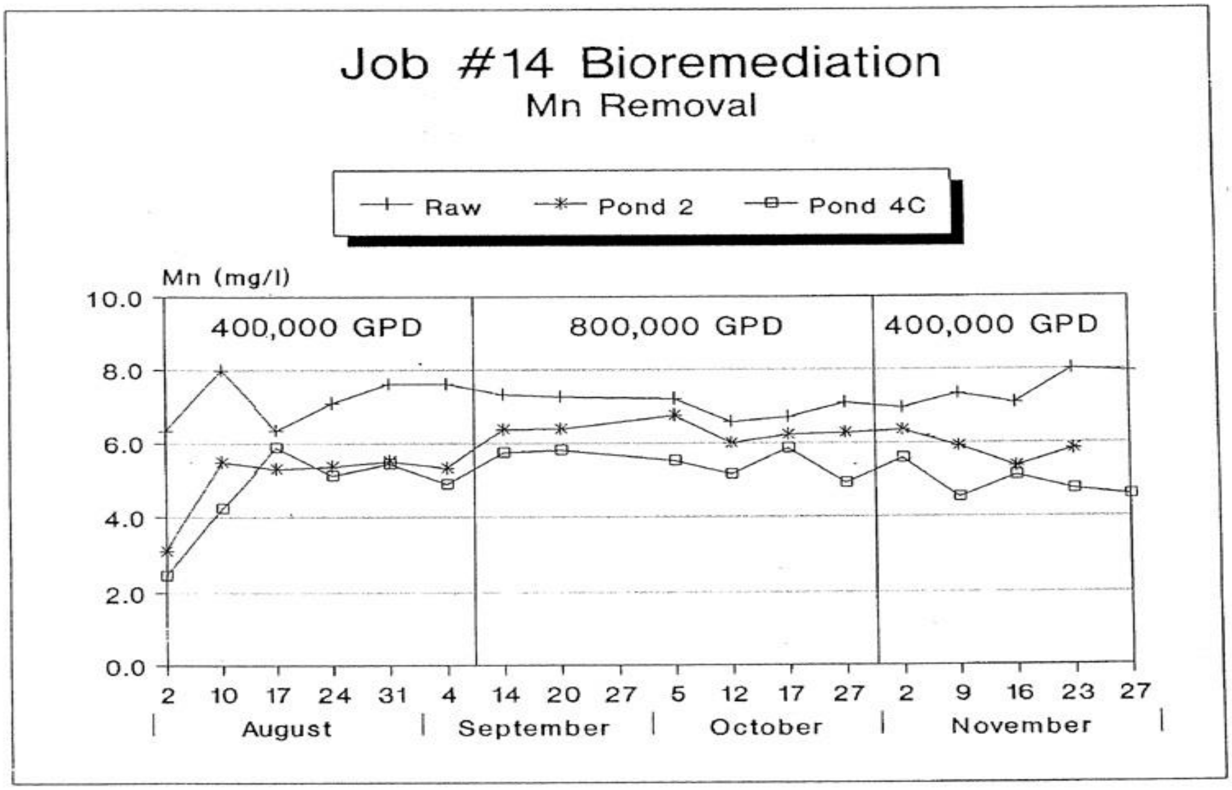
THE FUTURE

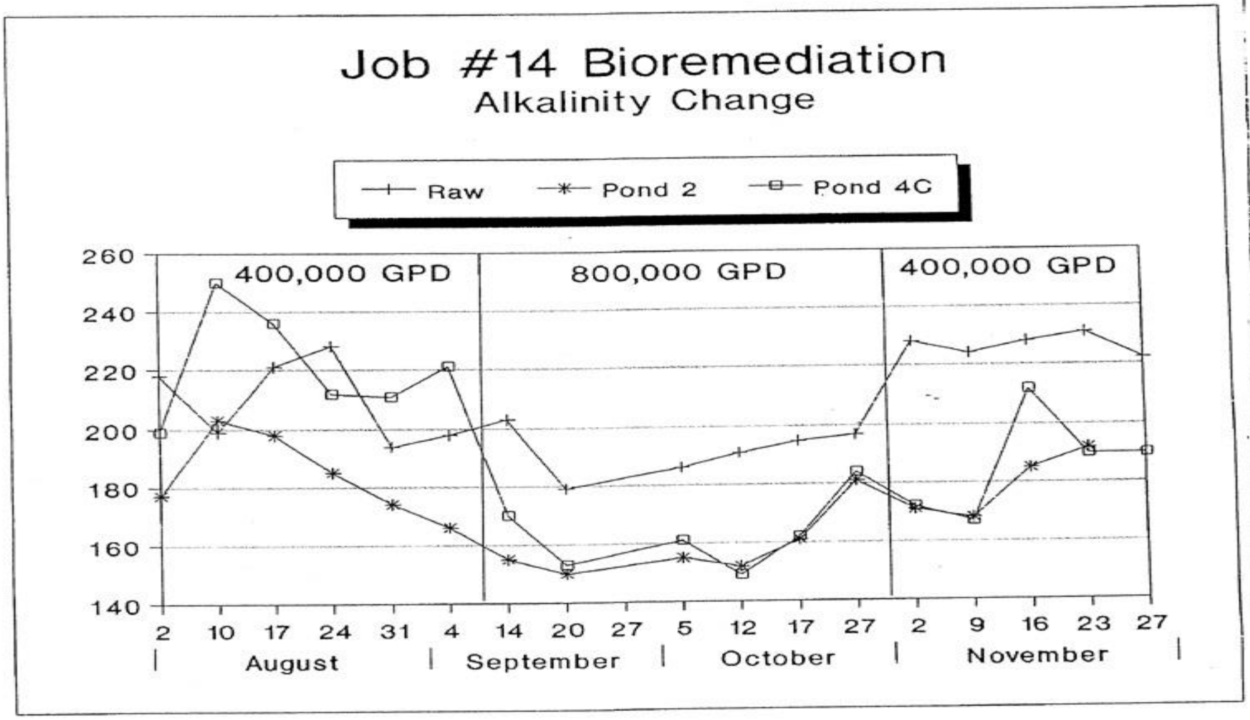
New sites are in the planning and/or construction phase for 1991. We are continuing to collect data from our pilot test tanks and from the Portland and PBS sites. We have a great deal left to learn about the synergistics of both technologies, despite the reams of data we have accumulated.

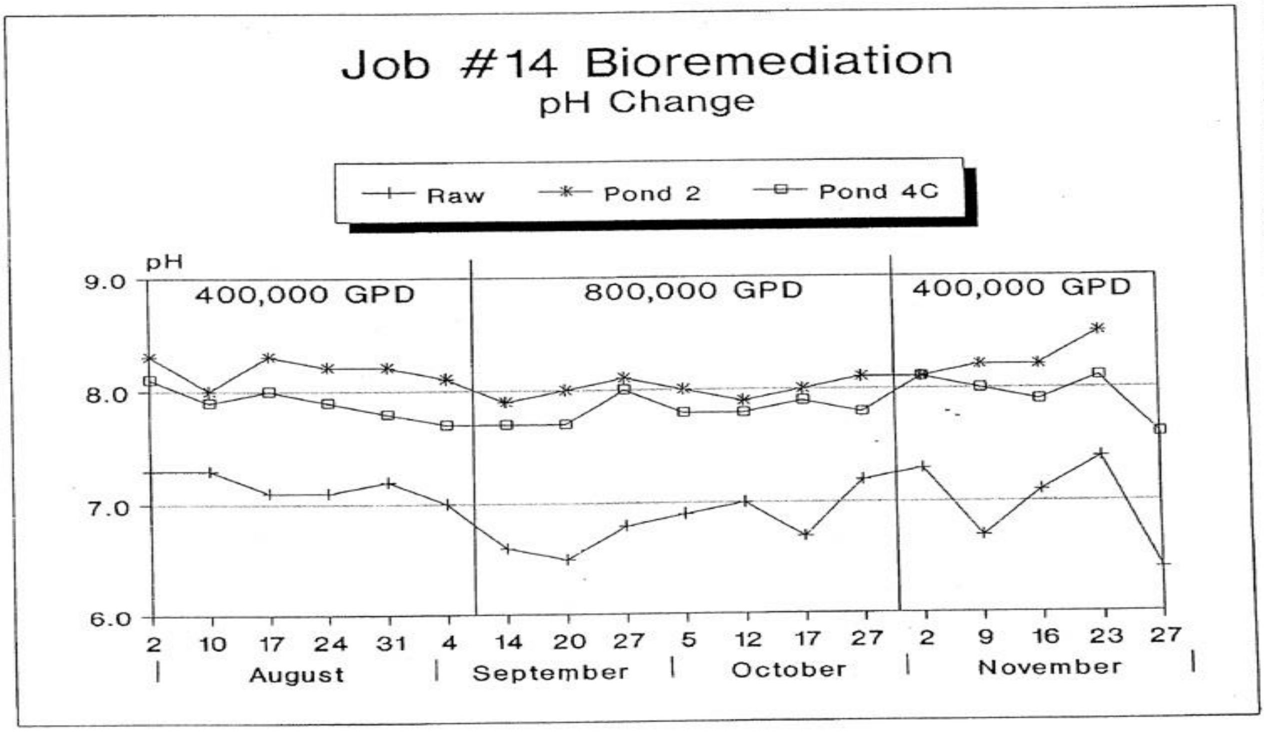
We believe that there are limitations, but the courage to try new techniques and change out-dated methods is the most difficult hurdle we face in developing new demonstration sites. I think it will finally come down to not "what does it cost?", but "can I afford not to?", as construction and chemical costs continue to soar and compliance becomes tougher to maintain and afford. The industry is slow to change, but when they're ready, we'll be ready too. It can't be done by lunch yesterday and it can't be done cheaply, but it can be done, whenever you're ready to do it.

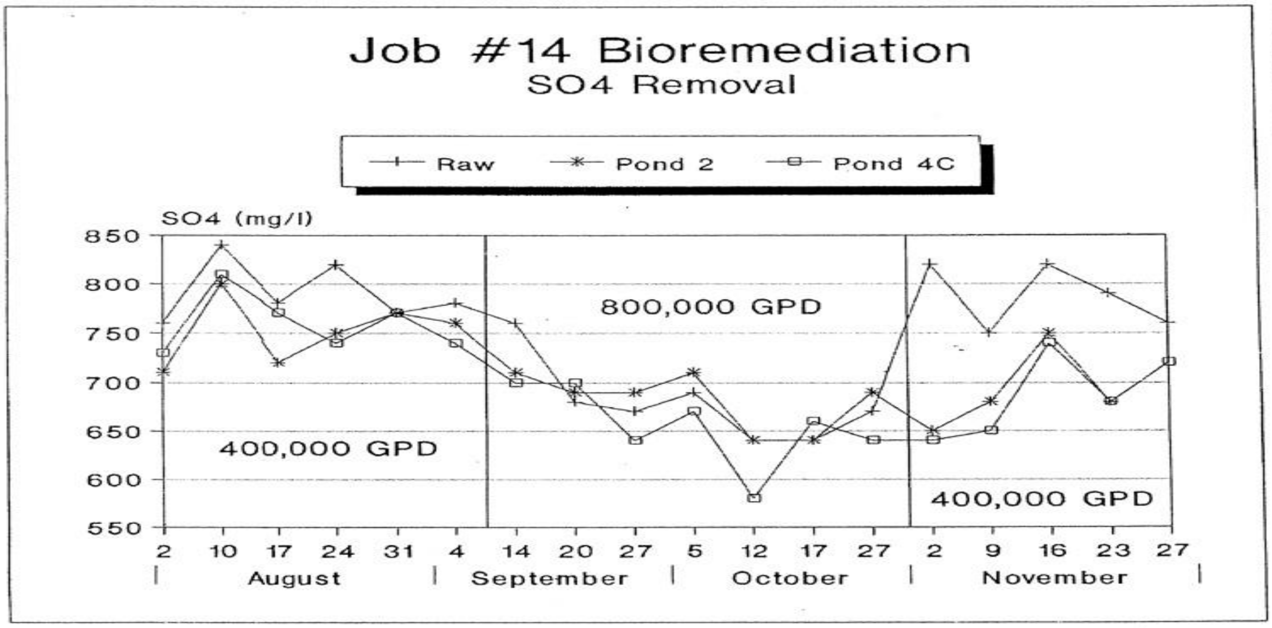
APPENDIX A


Job #14 Bioremediation
Fe Removal
Raw
Pond 2
Pond 4C
Fe (mg/l)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
400,000 GPD
800,000 GPD
400,000 GPD
2
10
17
24
31
4
14
20
27
5
12
17
27
2
9
16
23
27
August
September
October
November

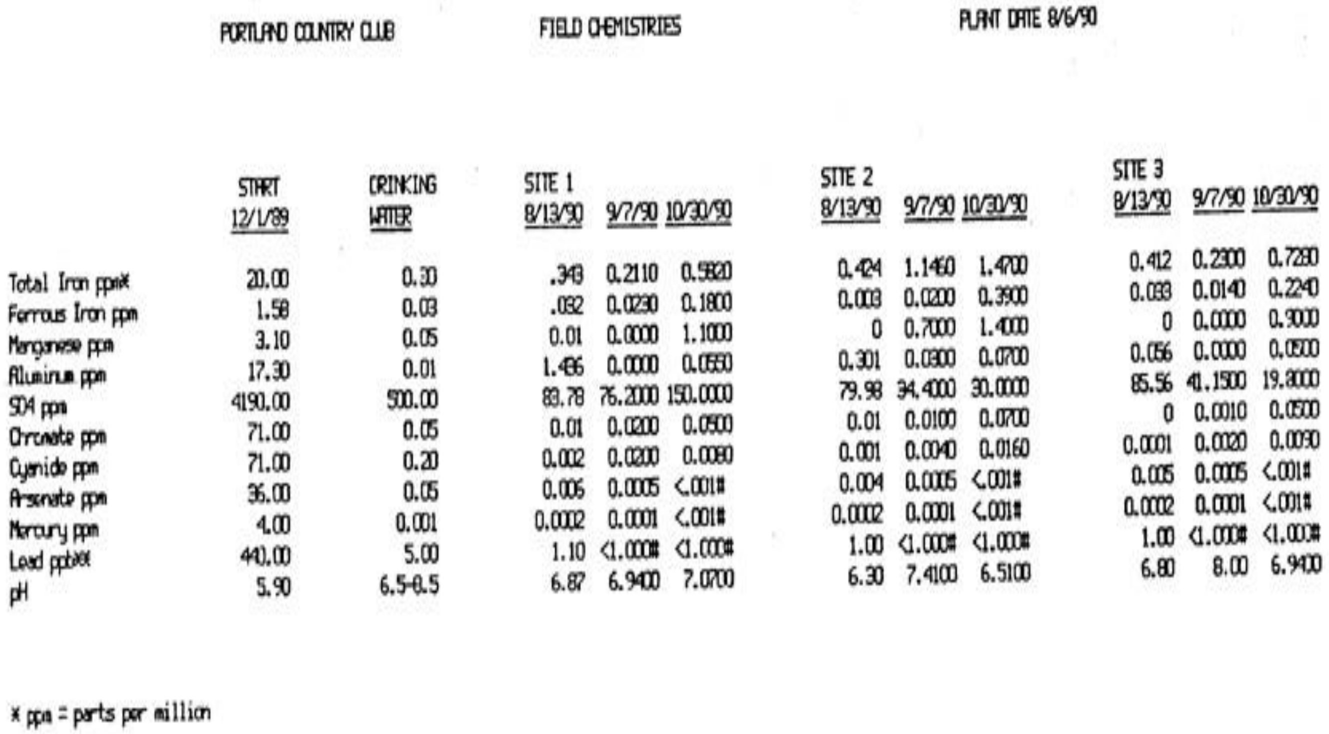

Job #14 Bioremediation
Mn Removal
Raw
Pond 2
Pond 4C
Mn (mg/l)
10.0
8.0
6.0
4.0
2.0
0.0
400,000 GPD
800,000 GPD
400,000 GPD
2
10
17
24
31
4
14
20
27
5
12
17
27
2
9
16
23
27
August
September
October
November


Job #14 Bioremediation
Alkalinity Change
Raw
Pond 2
Pond 4C
260
240
220
200
180
160
140
400,000 GPD
800,000 GPD
400,000 GPD
2
10
17
24
31
4
14
20
27
5
12
17
27
2
9
16
23
27
August
September
October
November


Job #14 Bioremediation
pH Change
Raw
Pond 2
Pond 4C
pH
9.0
8.0
7.0
6.0
400,000 GPD
800,000 GPD
400,000 GPD
2
10
17
24
31
4
14
20
27
5
12
17
27
2
9
16
23
27
August
September
October
November


Job #14 Bioremediation
SO4 Removal
Raw
Pond 2
Pond 4C
SO4 (mg/l)
850
800
750
700
650
600
550
800,000 GPD
400,000 GPD
400,000 GPD
2
10
17
24
31
4
14
20
27
5
12
17
27
2
9
16
23
27
August
September
October
November

Appendix B



PORTLAND COUNTRY CLUB FIELD CHEMISTRIES PLANT DATE 8/6/90

	START	DRINKING	SITE 1			SITE 2			SITE 3		
	12/1/89	WATER	8/13/90	9/7/90	10/30/90	8/13/90	9/7/90	10/30/90	8/13/90	9/7/90	10/30/90
Total Iron ppm*	20.00	0.30	.343	0.2110	0.5820	0.424	1.1460	1.4700	0.412	0.2300	0.7280
Ferrous Iron ppm	1.58	0.03	.032	0.0230	0.1800	0.003	0.0200	0.3900	0.033	0.0140	0.2240
Manganese ppm	3.10	0.05	0.01	0.0000	1.1000	0	0.7000	1.4000	0	0.0000	0.9000
Aluminum ppm	17.30	0.01	1.436	0.0000	0.0550	0.301	0.0300	0.0700	0.056	0.0000	0.0500
SO4 ppm	4190.00	500.00	83.78	76.2000	150.0000	79.98	34.4000	30.0000	85.56	41.1500	19.8000
Chromate ppm	71.00	0.05	0.01	0.0200	0.0500	0.01	0.0100	0.0700	0	0.0010	0.0500
Cyanide ppm	71.00	0.20	0.002	0.0200	0.0080	0.001	0.0040	0.0160	0.0001	0.0020	0.0090
Arsenate ppm	36.00	0.05	0.006	0.0005	<.001#	0.004	0.0005	<.001#	0.005	0.0005	<.001#
Mercury ppm	4.00	0.001	0.0002	0.0001	<.001#	0.0002	0.0001	<.001#	0.0002	0.0001	<.001#
Lead ppb**	440.00	5.00	1.10	<1.000#	<1.000#	1.00	<1.000#	<1.000#	1.00	<1.000#	<1.000#
pH	5.90	6.5-8.5	6.87	6.9400	7.0700	6.30	7.4100	6.5100	6.80	8.00	6.9400

* ppm = parts per million