Reduction in Acid Loads at the Alton Project[1]

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Abstract: The Alton Project, a revoked coal surface mine site, has been the scene of chemical water treatment and several innovative acid mine drainage mitigative techniques for nearly 20 years. As a result of these innovative efforts and natural processes, the acid and iron loads from the site have decreased substantially. All drainage from regraded surface mine spoil decreased in flow, acidity, and iron concentrations except for those strongly influenced by AMD treatment pond sludge disposal. Even these sites demonstrated reduced acidity and iron concentrations, indicating the stability of the sludge. Sustained and improved successful acid load reductions were realized from both PVC liner applications and alkaline recharge efforts.

DLM Coal Company operated surface mine operations in the Buckhannon River watershed near Alton, West Virginia from 1974 to 1984 when the State of West Virginia revoked the permits because of poor water quality. The State of West Virginia has treated water at the property (hereafter referred to as the Alton Project) to protect the water uses of receiving streams, including the Buckhannon River. Acid mitigation strategies at the site have been the subject of many papers at this symposium as the Acid Mine Drainage Technical Advisory Committee (AMDTAC) and others conducted research on the formation and mitigation of acid mine drainage at the complex.

Implemented	Strategy	See Proceedings
1981	Plastic Liner over 45 ac. (-84% acid red.)	83 Caruccio; 82 Nicholas
1982-83	Alkaline Recharge Zones	84 Caruccio
1984	Wetland development at Cuttright site	* unpublished
1985-86	Sturm (SES) Report	* unpublished
1985-86	Alkaline post holes, surface lime	86 Caruccio
1990	Sturm (SES) Report on acid loads, efficacy	* unpublished
1997-1999	WV-128 NMLRC - lime slurry injection	* unpublished
1999-2000	WV-160 NMLRC - lime slurry injection	Ongoing
1999	Limestone sand in Swamp Run	Ongoing

The Alton complex includes twelve permits, covering approximately 740 acres in rural Upshur County, West Virginia. The primary coal seams extracted by area mining methods were splits of the Kittanning. Nearly all the surface mine acreage had been reclaimed by DLM prior to permit revocation, and vegetation has been maintained since revocation. Chemical treatment, initiated by the company before revocation, has been maintained by the state. An NPDES permit with 12 discharge outfalls has been in place since 1989. These outfalls encompass 12 watersheds and treatment centers seen in Figure 1 and detailed in Table 1.

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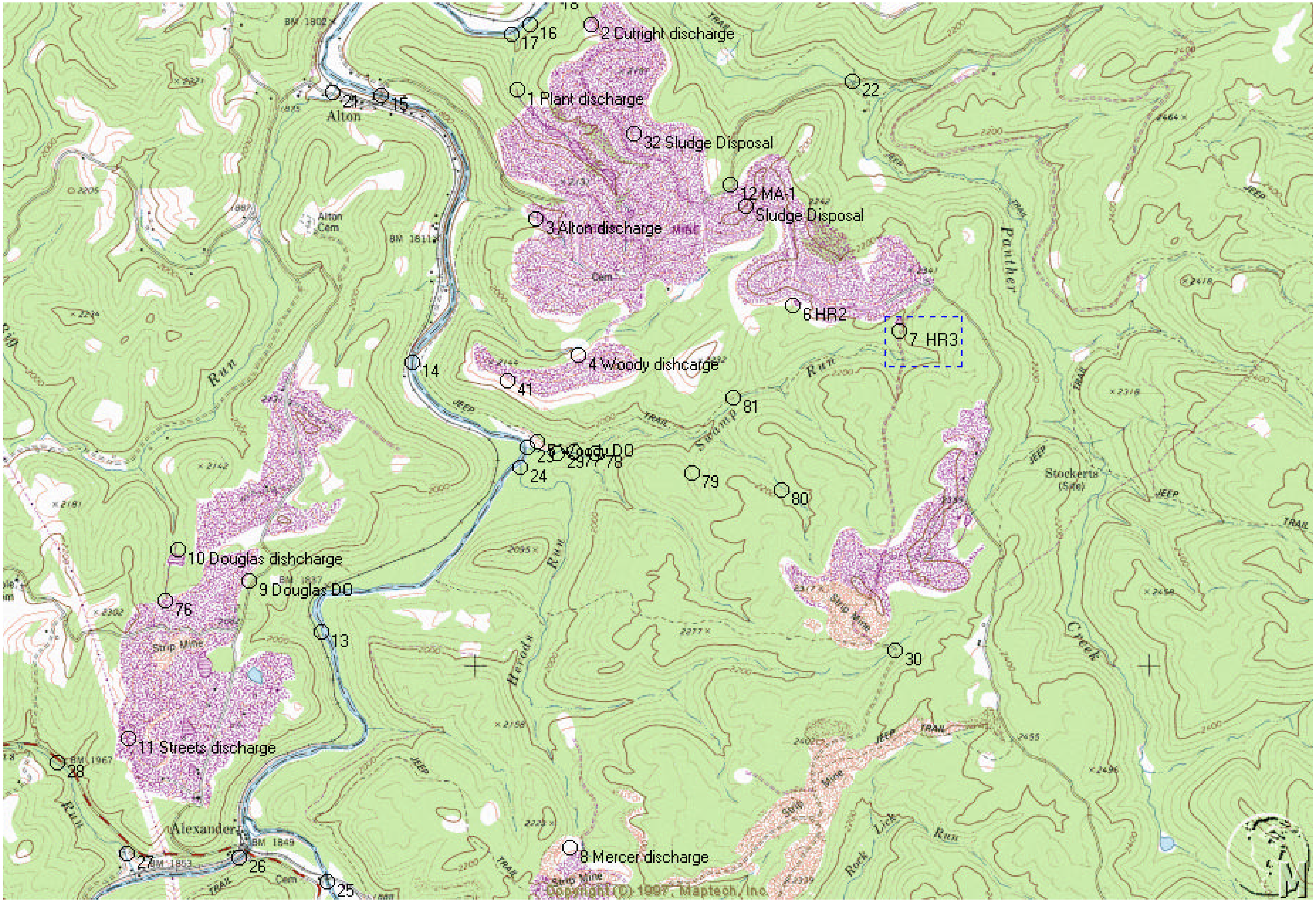

16
17
2 Cutright discharge
21
15
Alton
1 Plant discharge
22
32 Sludge Disposal
12 MA-1
Sludge Disposal
3 Alton discharge
6 HR2
7 HR3
14
4 Woody dishcarge
41
81
24
79
80
10 Douglas dishcharge
9 Douglas DO
76
13
30
11 Streets discharge
28
Alexander
27
26
25
8 Mercer discharge
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Table 1 summarizes data collected by SES and Alton staff during the period September, 1985 to October, 1989 against that collected by Alton staff from January, 1996 to December, 1999. The earlier dataset was not continuous. Additional flow data were discovered in 1999 for the earlier period, allowing the refinement of flow values from previous reports. Only one or two samples were collected in 1985, so the dataset is denoted 1986-1989. Flow at individual seeps was gauged very infrequently prior to 1989, but water analysis on untreated water was conducted quite regularly during this period.

Table 1. Acid and iron loads at The Alton Project.

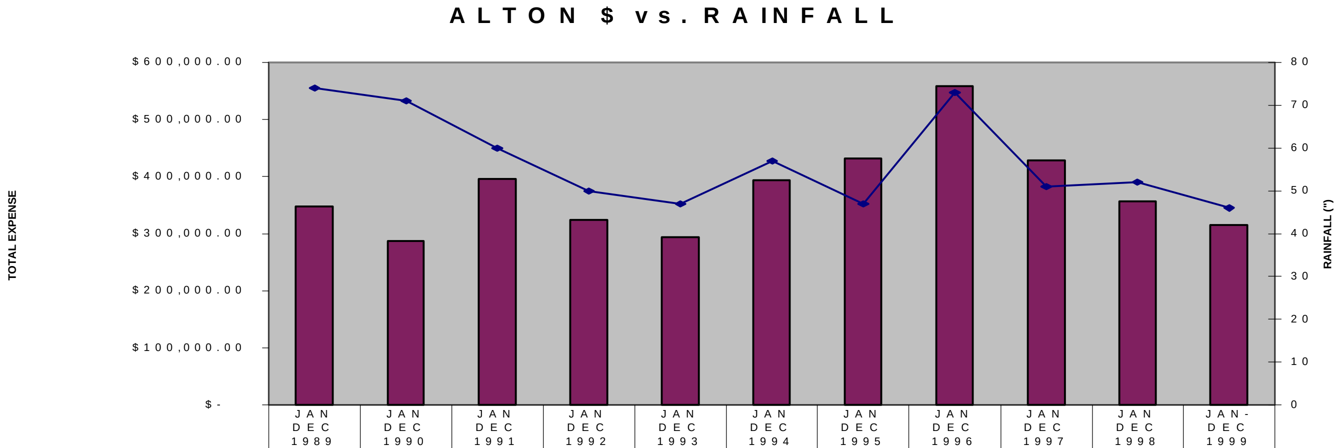
	raw water to	1986-89					1996-99					% change				
		gpm	mg/l	#/day	mg/l	#/day	gpm	mg/l	#/day	mg/l	#/day	#/day	#/day	gpm	mg/l	mg/l
site	discharge#	flow	acid	acid load	iron	iron load	gpm	acid	acid load	iron	iron load	acid load	iron load	flow	acid	iron
Plant	1	202	619	1500	25.0	61	281	260	877	10.3	35	-42%	-43%	39%	-58%	-59%
Cuttright	2	53	381	241	41.0	26	72	307	267	6.3	5	11%	-79%	37%	-19%	-85%
Alton	3	87	1179	1235	160.0	168	67	467	375	17.6	14	-70%	-92%	-23%	-60%	-89%
Woody	4	452	523	2837	6.6	36	466	292	1633	4.6	26	-42%	-28%	3%	-44%	-30%
Woody DO	5	31	65	24	1.3	0	25	321	96	16.5	5	293%	909%	-20%	394%	1167%
HR 2	6	13	394	63	0.7	0	14	227	37	1.0	0	-41%	49%	2%	-42%	46%
HR 3	7	36	229	98	5.3	2	30	170	60	1.4	1	-39%	-78%	-17%	-26%	-73%
Mercer	8	40	113	55	10.6	5	40	59	29	4.5	2	-48%	-58%	0%	-48%	-58%
Douglas DO	9	5	137	7	25.6	1	8	25	2	1.3	0	-68%	-91%	75%	-82%	-95%
Douglas	10	115	63	87	23.1	32	51	17	10	12.0	7	-88%	-77%	-56%	-73%	-48%
Streets	11	36	29	12	15.6	7	31	7	3	6.3	2	-79%	-65%	-13%	-76%	-60%
MA-1	12	23	259	71	23.8	7	67	108	87	1.3	1	22%	-84%	194%	-58%	-95%
Total		**1093**		**6232**		**344**	**1152**		**3477**		**99**	**-44%**	**-71%**	**5%**		

Since flow values are so critical in determining acid and metal loading, a serious critique should be made to determine the best values to use for the baseline. I offer the following discussion in defense of the earlier studies and why refined values were used in Table 1.

Flows at the pond outfalls were gauged quite regularly during both the 1986-89 and 1996-1999 period. Samples of raw water were taken at the pond inlets during the earlier sampling period with less reliable or consistent flow readings. Some ponds had more than one inlet or source, and in this case, the inlet flows were subject to mass-balance equations such that a cumulative flow equal to the pond outfall was derived with acidity and iron concentrations relating to the contribution of each inlet's flow and chemistry. For example, the Cuttright outfall receives three influent flows of untreated water. The flows of each seep constitute 20%, 44%, and 36% of the outfall volume. Multiplying the acidity of each inlet by its flow gives a weighted average of the total inlet acidity and iron concentrations. Multiplying this by the total outlet flow returns the inlet acid and iron loads. For the 1986-89 period, 40 samples of each inlet and outlet were analyzed. Individual seeps or inlets and outlets were sampled 35 times in the 1996-99 period. This allows a high level of confidence in the data in Table 1.

The total average flow for all sites is within 5% between the two study periods, yet the total average acid load has decreased dramatically (-44%) at the raw (untreated) locations. The change in iron loads is even more remarkable (-71%). Three of the twelve sites exhibited an increase in acid load (Cuttright, Woody DO, and MA-1) and these increases occurred due to increased flows and decreased acidity concentrations but for Woody DO, which is apparently influenced by subsurface flow from the nearby stream.

Treatment expenses have been an apparent function of rainfall at the project. (Figure 2). As chemical consumption decreased due to acid load reduction, total expenses were influenced by rises in chemical cost and other expenses subject to inflation.



	JAN DEC 1989	JAN DEC 1990	JAN DEC 1991	JAN DEC 1992	JAN DEC 1993	JAN DEC 1994	JAN DEC 1995	JAN DEC 1996	JAN DEC 1997	JAN DEC 1998	JAN-DEC 1999
TOTAL EXPENSE	$347,64	$286,52	$396,08	$324,66	$293,59	$393,71	$431,61	$558,37	$428,00	$356,20	$315,44
RAINFALL	74	71	60	50	47	57	47	73	51	52	46

Figure 2. Treatment expense and rainfall at Alton.

Rainfall data is presented so that the primary variable in acid production may be compared between the two study periods. The flow of the Buckhannon River at Hall, WV (further downstream from Alton) is also shown for the period to supplement the absence of rainfall data at Alton (Figure 3). It appears the 1986-89 period encompassed a serious drought (1988) followed by an unusually rainy year in

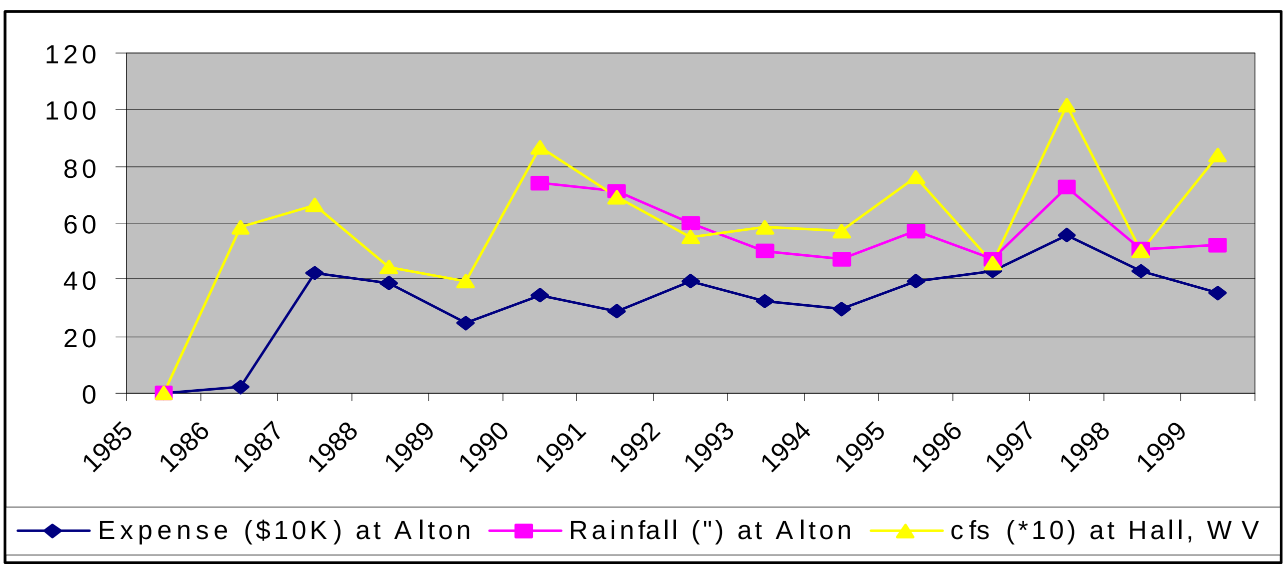


Figure 3. Rainfall, river flow downstream and treatment expense at Alton.

1989. The later study occurred during a wet 1996 and normal to light rainfall in 1997-99. By averaging the flows over the two three-year periods, comparable flows were attained.

The cause of the decreased acid loads can best be explained by comparing the techniques employed at each site against the change in water quantity and quality.

	% change					Technique employed		Comments
	#/day	#/day	gpm	mg/l	mg/l			
site	acid load	iron load	flow	acid	iron	by 1986	since 1986	
Plant	-42%	-43%	39%	-58%	-59%	Alkaline trenches, post holes	limited sludge disposal, lime injection	
Cuttright	11%	-79%	37%	-19%	-85%	Limited alkaline trenches	sludge disposal	acid ld. influeced by Q
Alton	-70%	-92%	-23%	-60%	-89%	PVC liner, post hole array		
Woody	-42%	-28%	3%	-44%	-30%			
Woody DO	293%	909%	-20%	394%	1167%			not direct spoil drainage
HR 2	-41%	49%	2%	-42%	46%			Fe 0.7 to 1.0 insignificant
HR 3	-39%	-78%	-17%	-26%	-73%			
Mercer	-48%	-58%	0%	-48%	-58%	Alkaline trenches, spread lime		
Douglas DO	-68%	-91%	75%	-82%	-95%			Gpm 5 to 8 insignificant
Douglas	-88%	-77%	-56%	-73%	-48%			
Streets	-79%	-65%	-13%	-76%	-60%			
MA-1	22%	-84%	194%	-58%	-95%	Limited alkaline trenches	sludge disposal	influenced by deep mine
Total	**-44%**	**-71%**	**5%**					

Table 2. Techniques employed at The Alton Project.

Certainly the return of highly alkaline pond sludge to the recharge area of the Plant, Cuttright, and MA-1 drainages has had an effect on the seepage measured from the regraded spoil in these areas. It is remarkable that only these three watersheds indicated an appreciable increase in average flow from the earlier to the later period. For the first many years, pond cleanings were hauled by vacuum truck to disposal areas that would recharge these seeps draining to these three discharges. For the past few years, ponds have been pumped directly to these sludge disposal sites. Plant Hollow receives less influence from the sludge disposal than Cuttright or MA-1, because of the prevailing dip of the strata to the NW, and it dominates the acid load of the three drainages (82%) influenced by sludge disposal. Despite its flow increase (39%), the reduced acidity concentrations (-58%) produced a net reduction in acid load from 1500 #/day to 877 #/day (-42%). The other sites influenced (more directly) by sludge disposal demonstrated an increase in flow (37% at Cuttright and 194% at MA-1) but a decrease in acid concentrations (-19% for Cuttright and -58% for MA-1) resulting in increased acid loads. The decreasing iron concentrations indicate the sludge is likely not re-dissolving within the regraded spoil.

Beginning in early 1998, researchers at the NMLRC began introducing lime products into the spoil through excavated trenches in the Plant Hollow drainage. This work followed a focused data collection of baseline seep and well information at the Cuttright, Plant, and MA-1 watersheds. Although a rapid and dramatic change in quality at some Plant seeps ensued, this did not appreciably affect the Plant Hollow raw water quality or skew the later dataset where acid loads actually increased at Plant Hollow over the earlier (1986-89) period.

Eleven of the twelve drainages at Alton are clearly dominated by surface manifestations of groundwater from the regraded spoil. Woody Dugout (DO) is an outlier in all trends. This dugout pond is fed by a subsurface spring likely not directly related to drainage from the regraded areas. Each of the eleven drainages from the regraded surface mine spoil exhibited substantial reductions in acid loads over the last decade with the exception of those two sites strongly influenced by alkaline pond sludge disposal. Although the flows at these two sludge disposal sites increased, the acidity concentrations decreased, and the iron concentrations decreased dramatically (85% to 95%), resulting in increased acid loads and decreased iron loads.

A major portion of the regraded spoil influencing the Alton Hollow site was covered with a 20-mil PVC liner in 1981. This resulted in an almost immediate reduction (of -84%) in acid load at the pond inlet. Since that time, flows have continued to diminish (-23%) and acid and iron concentrations and loads have decreased substantially. A portion of the spoil regraded too steeply to allow the placement of the PVC liner is responsible for the remaining acid production in this watershed. Future work proposed by the National Mine Land Reclamation Center will focus on transporting alkaline material into these areas.

The Mercer site was the scene of early work by Caruccio and Geidel in the area of alkaline recharge zones. After almost twenty years, this technique appears to continue to strongly influence the character of the seepage at the toe of the regraded slope. Gauged flows were nearly identical between the two sampling periods, yet the acidity concentrations decreased from 113 mg/l to 59 mg/l. Iron concentrations were reduced by over 50% as well.

Because of the dramatic success seen using limestone sand in streams affected by acidic precipitation and acidic drainage, limestone sand was introduced to Swamp Run in 1999. Preliminary data during the drought of 1999 are inconclusive.

Obviously, the pyritic material closely connected with the established watercourses through the backfill must be exhausting its potential to produce acidity as time since its disturbance increases. Vegetative success with concomitant increased evapotranspiration rates and water management practices directing surface water from the recharge areas have further reduced infiltration and flow from the problem drainage sites. Loading recharge waters with alkalinity through induced recharge zones has been successful over an extended period of study. Further improvement in water quality can be expected in coming years at the Alton Project.

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