TECHNOLOGY DEMONSTRATION PROJECT: ACID ROCK DRAINAGE TREATMENT WETLANDS, BASIN AND TENMILE CREEK WATERSHEDS, MONTANA

FINAL REPORT

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TECHNOLOGY DEMONSTRATION PROJECT: ACID MINE DRAINAGE TREATMENT WETLANDS, BASIN CREEK AND 10-MILE WATERSHEDS, MONTANA

INTRODUCTION

In 2003 BRI pursued two parallel approaches to assist treatment wetland creating in the Basin Creek and 10-Mile Watersheds, Montana (also known as the Lower Marsh of the Peerless/Jenny/King site):

1. The use of prevegetated coir buffer strips; and
2. Direct planting of wetland plants.

The entire site encompasses approximately 0.2 acres (9,258 square feet), with wetland cells and coir composing half of that zone. Wetland cells were created by excavating four parallel “trenches” with a backhoe along the contour. The trenches were backfilled with a bottom layer (four inches thick) of clean gravel, covered by an 18 to 24 inch layer of soil/wood chips/cow manure mixture. Wetland cell construction was conducted by Envirocon for the EPA in the fall of 2003 (Figure 1).

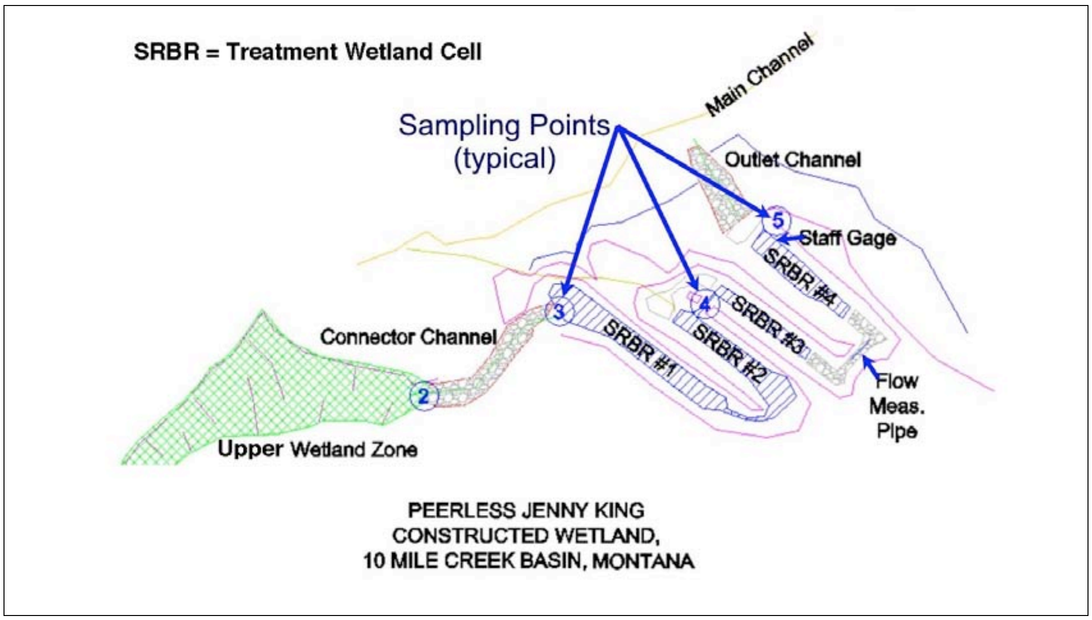

Figure 1. Plan view of Project showing layout of wetland cells
(Source: EPA 2004)

Following construction, BRI’s coir and containerized plants were installed on top of (or in) the organic mixture, and on the soil berms between the trenches. Thirty-eight prevegetated coir mats (approximately 2,000 square feet) were used to line the edges of the wetland cells. The native wetland plants listed in Table 1 were directly planted at approximately one foot spacing in the wetland cells, installed as three cubic inch (3T) and four cubic inch (4T) containerized seedlings (Figure 2). These species were chosen on the basis of their adaptation to these site conditions and their utility in treatment wetlands for metals loading.

Figure 2. Spacing of containerized wetland cell plants

Table 1. Technology Demonstration Project planting palette

Scientific Name	Common Name	Count for 0.17 acres of wetland
Carex utriculata	Beaked sedge	2,200
Deschampsia cespitosa	Tufted hairgrass	1,000
Glyceria striata	Fowl mannagrass	1,000
Juncus balticus	Baltic rush	1,000
Scirpus microcarpus	Panicled bulrush	1,000
Scirpus validus	Soft-stem bulrush	1,000
Typha latifolia	Common cattail	200
		Total: 7,400

The prevegetated coir buffer strips utilized the same species listed in Table 1 installed in Wetland Rollsods^{TM}. Thirty-eight Rollsods^{TM} were made using 3.2 ft by 16.5 ft felt blankets (approximately 2.5 inches thick) of tough, natural coir fibers (coir = processed coconut husk firer) encased in coir netting. The plants were installed at one foot spacing into the coir blankets and pre-grown in hydroponic ponds. The direct planting and installation of the prevegetated Rollsods^{TM} at the site were completed September 22-25, 2003.

OBJECTIVE

The objective of BRI's participation in this project was to test the implementation and success of techniques and practices for establishing particular species of wetland vegetation in constructed wetland cells having typically harsh acid mine drainage conditions of water laden with heavy metals. This was to be accomplished by implementing the design, then analyzing data from observations at three intervals of plant survival, diversity, canopy cover, as well as structural performance of the coir material.

HYPOTHESES

$H1_o$: Plant survival does not significantly differ between the three monitoring periods at alpha < 0.05
$H1_a$: Not $H1_o$

$H2_o$: Plant cover does not significantly differ between the three monitoring periods at alpha < 0.05
$H2_a$: Not $H2_o$

$H3_o$: Species diversity does not significantly differ between the three monitoring periods at alpha < 0.05
$H3_a$: Not $H3_o$

$H4_o$: Coir stability does not significantly differ between initial installation and any of the three monitoring periods at alpha < 0.05
$H4_a$: Not $H4_o$

MATERIALS AND METHODS

Sampling Design

Monitoring visits were made to the project site by a wetland ecologist in June, August, and at the end of September.

***Wetland cells*—**Plant survival, diversity, and canopy cover were monitored in 24 plots (six plots within each of the four wetland cells). Five of the plots for each cell, averaging approximately 10 feet long by one foot wide, were located at non-overlapping, random positions along the length of each cell. One wetland plot was located at the inlet area of each cell. This location is chosen subjectively, as it is the position of potentially greatest shear stress, and therefore greatest disturbance as water pours from one cell to the next.

The sampling plan is designed to survey a minimum of three percent (222 plants) of the total 7,400 wetland seedlings installed. This figure excludes the 2,000 plants in the prevegetated coir mats. During the first monitoring visit, plot boundaries were flagged, and a map of plot locations was created. These actions are taken to ensure that the same plot locations are surveyed in successive monitoring visits.

***Prevegetated coir mats*—**A similar sampling design was used to monitor plant survival, diversity, and canopy cover on the coir mats. Two plots were established on the mats adjacent to each of the five randomly located wetland cell plots described above (10 total). Two additional plots were surveyed within the inlet and outlet areas that separate the wetland cells. Plot size was two feet by two feet (four square feet).

***Plant survival monitoring*—**After the plot locations were established, the number of plants was counted by species surviving in each plot. Survival rates were calculated by dividing the number of living plants by the number of plants installed in each plot. Survival counts are presented separately for the wetland cells and the coir mats.

***Diversity monitoring*—**Plant species diversity, calculated using Simpson's index, is reported for the overall site and for each wetland cell. Classically, the formula used for Simpson's index is:

$$D = 1 - \text{the sum of } (p)^2 \text{ for all of "S" different species, where:}$$

p = the proportion of individuals in the sample belonging to each single species.

D (Simpson's index) can range from zero to one, with higher values representing greater diversity. This index gives little weight to rare species, and is most sensitive to abundant species (Barbour and others 1980). Nonetheless, because the plant species used in this project propagate rhizomatously to rapidly send up additional individual shoots, BRI will utilize the proportion of plot area covered by the canopy of each species as a surrogate for individual plant counts in the calculation of diversity for the pre-vegetated coir material

$$D = 1 - \text{the sum of } (p_s)^2 \text{ for all of "S" different species, where:}$$

p_s = the fraction of the plot area covered by the canopy of each individual species "s."

***Plant canopy cover*—**Plant canopy cover (recorded as the percent area of the plot occupied by the above ground living plant material) was occularly estimated for each species observed in each plot. Estimates of plant canopy cover is reported by species and by total plant cover are calculated for each wetland cell and as an average for the entire project.

Plant cover is also documented by photographic record. Photo points were established during the first monitoring visit at a minimum of two plots per wetland cell, and subsequent photos were taken at each monitoring visit.

***Coir material stability*—**Coir material stability was assessed quantitatively by 1) measuring the entire length of coir along each wetland cell and in the adjacent inlet/outlet areas, 2) measuring areas where the coir was not firmly attached to the ground (wooden stakes pulled out), and 3) by assigning a numeric percent value of instability observed to each strip of coir. Coir instability was calculated by dividing the measured length of loose coir by the total length of coir in each wetland cell, each inlet/outlet area, and for the entire project.

***Statistical analyses*—**The Shapiro-Wilk W test (1953) was utilized to analyze all data sets for normality. Due to the predominance of non-normal data, whose details are presented below in the Results and Discussion section, a non-parametric statistical procedure, particularly the Kruskal-Wallis one-way analysis of variance by ranks and the Mann-Whitney U-tests, were chosen as the primary methods of data analysis. Where statistical significance was indicated in the Kruskal-Wallis test, the Bonferroni-Dunn post hoc test was utilized to help uncover which pairs of categories show significant differences. All statistical analyses were performed at alpha = 0.05 level (Cochran and Cox 1992), using JMP Version 3.2.2 (SAS Institute, Inc. 1989-97) and Statview Version 4.51 (Abacus Concepts, Inc. 1992-95).

RESULTS AND DISCUSSION

In the original sampling plan, survival, diversity, and plant cover counts were to be done by species within the wetland cells and prevegetated coir mats. However, a late and cold spring in the area restricted early growth of the plants. This limited the living cover of the vegetation compared to expected results, thus rendering definitive identification at the species level impossible. Therefore, for the initial monitoring visit in June, diversity could not be calculated; and plant data was limited to survival and cover in the wetland plots, and to cover in the coir plots. Further, all analyses are based only upon the data collected for the species planted; volunteer species data were collected (see Appendices A and B), but are not used as the volunteers comprise a small minority of overall plant presence in the experiment.

Wetland Cell Comparisons.

Wetland cell plant survival data are presented in Table 2, while cover data are presented in Table 3 and diversity data in Table 4. All wetland cells contained six plots. Survival ranged from counts of 0 to 34 plants per cell plot, but averaged 9 plants. Cover ranged from 0 percent to 70 percent per cell plot, but averaged 11 percent. Diversity ranged from 0 to 1, but average 0.38.

Table 2. Wetland cell plant survival (count per plot in cell)

Data Set	Average Count	Standard Deviation	Min	Max
June_Cell 1	6.2	2.1	3	8
June_Cell 2	8.3	6.4	0	19
June_Cell 3	7.8	6.9	1	21
June_Cell 4	6.8	4.9	0	15
June_Overall	5.3	5.1	0	19
August_Cell 1	7.7	2.8	3	11
August_Cell 2	12.3	11.0	5	34
August_Cell 3	13.3	10.1	2	29
August_Cell 4	0.2	0.4	0	1
August_Overall	10.7	7.9	1	34
September_Cell 1	6.3	2.9	2	10
September_Cell 2	13.3	8.5	5	29
September_Cell 3	15.8	9.4	5	28
September_Cell 4	6.8	1.9	4	10
September_Overall	10.6	7.4	2	29
Combined Data	8.9	7.3	0	34

Table 3. Wetland cell plant cover

Data Set	Average	Standard Deviation	Min	Max
June_Cell 1	0.1	0.0	0.1	0.05
June_Cell 1	0.9	1.3	0.1	2.5
June_Cell 1	2.5	3.9	0.1	10.0
June_Cell 1	0.0	0.0	0.0	0.05
June_Overall	0.9	2.2	0	10.0
August_Cell 1	2.6	1.0	0.5	3.0
August_Cell 1	17.2	13.0	3.0	40.0
August_Cell 1	38.3	25.6	10.0	70.0
August_Cell 1	10.0	6.3	0.0	20.0
August_Overall	17.0	19.3	0.0	70.0
September_Cell 1	2.6	1.0	0.5	3.0
September_Cell 1	20.5	9.9	3.0	30.0
September_Cell 1	26.7	12.1	10.0	40.0
September_Cell 1	6.5	3.8	3.0	10.0
September_Overall	14.1	12.6	0.5	40.0
Combined Data	10.6	15.0	0.0	70.0

Table 4. Wetland cell diversity (Simpson's Index)

Data Set	Average	Standard Deviation	Min	Max
August_Cell 1	0.22	0.25	0.00	0.50
August_Cell 2	0.42	0.36	0.00	1.00
August_Cell 3	0.62	0.15	0.45	0.84
August_Cell 4	0.35	0.21	0.00	0.61
August_Overall	0.40	0.28	0.00	1.00
September_Cell 1	0.17	0.21	0.00	0.44
September_Cell 2	0.37	0.24	0.00	0.67
September_Cell 3	0.49	0.20	0.26	0.72
September_Cell 4	0.40	0.26	0.00	0.65
September_Overall	0.35	0.21	0.00	0.61
Combined Data	0.38	0.26	0.00	1.00

Analysis of wetland cell data normality— Wetland cell plant survival, cover and diversity were analyzed for normality via the Shapiro-Wilk W test. As shown in Table 5, 38 percent of the wetland cell plant count classes were non-normal at alpha = 0.05. As shown in Table 6, 69 percent of the wetland cell cover classes were non-normal at alpha = 0.05. As shown in Table 7, 27 percent of the wetland cell diversity classes were non-normal at alpha = 0.05. Due to the considerable lack of normality, non-parametric statistical procedures were applied for data analysis of the wetland cell data.

Table 5. Normality of wetland cell plant count percentages

Data Set	Shapiro-Wilk W Value	n	p-Value
June_Cell 1	0.97	6	0.81
June_Cell 2	0.89	6	0.30
June_Cell 3	0.91	6	0.45
June_Cell 4	0.50	6	0.0000*
June_Overall	0.89	24	0.0015*
August_Cell 1	0.93	6	0.66
August_Cell 2	0.72	6	0.0092*
August_Cell 3	0.87	6	0.21
August_Cell 4	0.90	6	0.36
August_Overall	0.79	24	0.0001*
September_Cell 1	0.95	6	0.76
September_Cell 2	0.86	6	0.19
September_Cell 3	0.93	6	0.56
September_Cell 4	0.91	6	0.42
September_Overall	0.82	24	0.0004*
Combined Data_Overall	0.85	72	<0.0001*

*Non-normal at alpha = 0.05

Table 6. Normality of wetland cell cover percentages

Data Set	Shapiro-Wilk W Value	n	p-Value
June_Cell 1**	-	6	-
June_Cell 2	0.64	6	0.0002*
June_Cell 3	0.72	6	0.0095*
June_Cell 4	0.5	6	0.0000*
June_Overall	0.44	24	<0.0001*
August_Cell 1	0.50	6	0.0000*
August_Cell 2	0.90	6	0.35
August_Cell 3	0.84	6	0.13
August_Cell 4	0.83	6	0.09
August_Overall	0.75	24	<0.0001*
September_Cell 1	0.50	6	0.0000*
September_Cell 2	0.83	6	0.11
September_Cell 3	0.91	6	0.40
September_Cell 4	0.68	6	0.0028*
September_Overall	0.84	24	0.0012*
Combined Data_Overall	0.32	24	<0.0001*

*Non-normal at alpha = 0.05; **All plot cover values equaled 0.05 percent

Table 7. Normality of wetland cell diversity scores

Data Set	Shapiro-Wilk W Value	n	p-Value
August_Cell 1	0.77	6	0.0299*
August_Cell 2	0.90	6	0.4935
August_Cell 3	0.84	6	0.7363
August_Cell 4	0.83	6	0.8894
August_Overall	0.75	24	0.3054
September_Cell 1	0.50	6	0.0453*
September_Cell 2	0.83	6	0.8736
September_Cell 3	0.91	6	0.2468
September_Cell 4	0.68	6	0.3631
September_Overall	0.84	24	0.0653
Combined Data_Overall	0.32	48	<0.0224*

*Non-normal at alpha = 0.05; **All plot cover values equaled 0.05 percent

Comparison of survival between monitoring visits— The results of the Kruskal-Wallis test showed that there were highly significant differences in wetland cell plant survival counts between at least two monitoring trips (H corrected for ties = 11.1 with a p-value of 0.039). Thus for the wetland cells, $H1_o$ can be rejected and $H1_a$ accepted - there is a significant difference in wetland cell plant survival counts between monitoring trips at an alpha = 0.05. The Bonferroni-Dunn post hoc test of categorical differences, whose significant results are shown in Table 8 and Figure 3, showed that plant survival counts in August and September were significantly higher than in June. This is probably due to the late spring at the project site, which retarded plant growth in the early summer.

Table 8. Bonferroni/Dunn for Percent Survival between monitoring visits

Cell Comparisons	Mean Difference	Critical Diff	p-Value
June versus August	-5.33	4.9	0.0093*
June versus September	-5.25	4.9	0.0104*
August versus September	0.08	4.9	0.9668

*Significant difference at alpha = 0.05; Comparisons in the table are not significant unless the corresponding p-value is less than .0167.

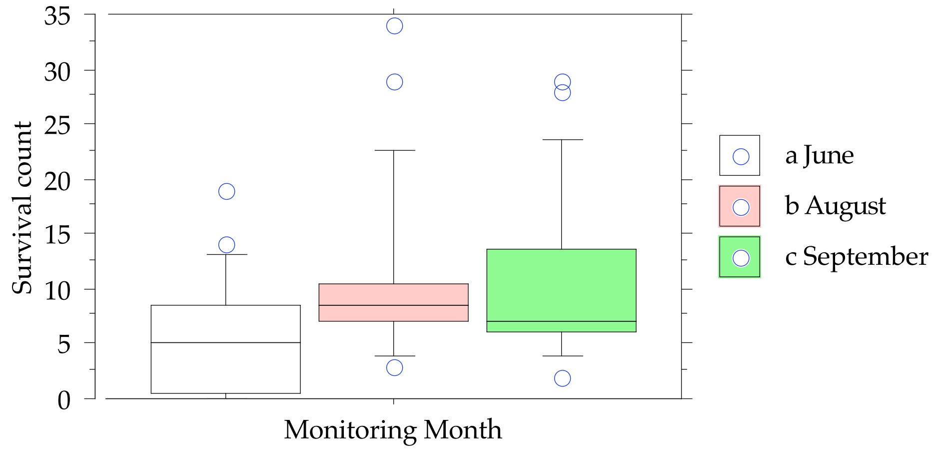

Figure 3: Plant Survival Count by Wetland Cell

More critical, however, is an assessment of the difference between the numbers found and the numbers planted. The sampling plan was designed to capture a minimum of 222 plants within the wetland cells or 3 percent of the area. Given the actual construction design of the wetland, however, the cells should have captured 602 plants. Instead, in June plot counts equaled 128 plants; in August and September, respectively, counts equalled 255 and 254 plants. This represents a 57 percent die-off of wetland plants from the fall planting until the height of the next growing season – an enormous decline.

Comparison of percent plant canopy cover between wetland cells— The results of the Kruskal-Wallis test showed that there were highly significant differences in wetland cell plant cover between at least two monitoring trips (H corrected for ties = 40.2 with a p-value of <0.001). Thus for the wetland cells, $H2_o$ can be rejected and $H2_a$ accepted - there is a significant difference in wetland cell plant survival counts between monitoring trips at an alpha = 0.05. The Bonferroni-Dunn post hoc test of categorical differences, whose significant results are shown in Table 9 and Figure 4, showed that plant cover counts in August and September were significantly higher than in June. Again, this is probably due to the late spring at the project site, which retarded plant growth in the early summer.

Table 9. Bonferroni/Dunn for plant cover between monitoring visits

Cell Comparisons	Mean Difference	Critical Diff	p-Value
June versus August	-16.2	9.5	<0.0001*
June versus September	-13.2	9.5	0.0011*
August versus September	3.0	9.5	0.4462

*Significant difference at alpha = 0.05; Comparisons in the table are not significant unless the corresponding p-value is less than .0167.

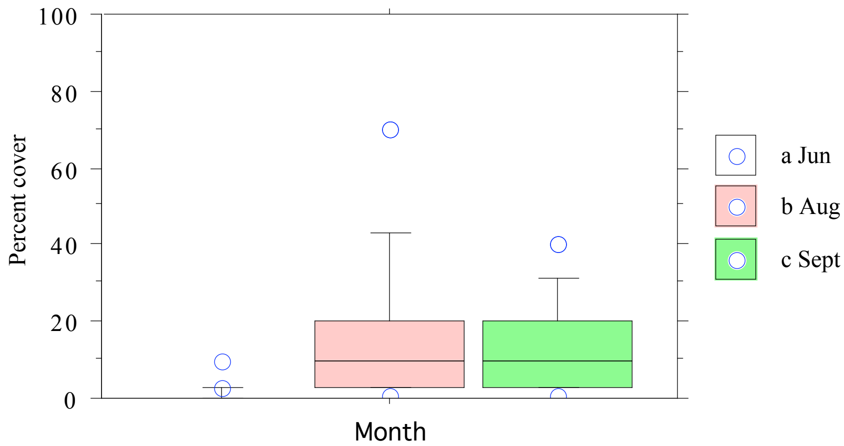

Figure 4: Plant Cover by Wetland Cell

Comparison of plant species diversity between wetland cells— The results of the Mann-Whitney U Test showed that there were no significant differences in wetland cell plant diversity between the August and September monitoring trips (Z-value corrected for ties = -0.45 with a p-value of 0.66) Figure 5). Thus for the wetland cells, $H3_o$ cannot be rejected and $H3_a$ accepted - there is no significant difference in wetland cell species between monitoring trips at an alpha = 0.05. This is probably due to the relative closeness of the two monitoring trips, although this data is also an indication that species consistency does not change significantly during the height of the growing season.

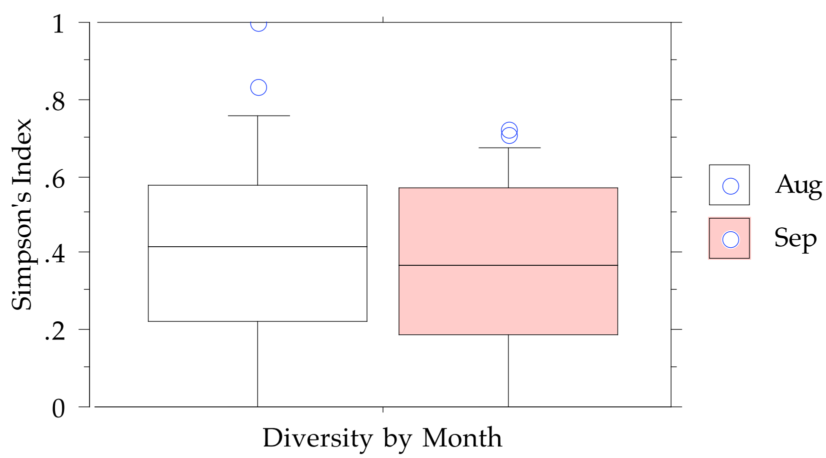

Figure 5: Species Diversity by Wetland Cell

Prevegetated Coir Comparisons.

Coir cover and diversity data are presented in Tables 10-11. Coir plant survival data was not measured due to the density of vegetation in the coir plots, which thwarted efforts to count individual plants. Plot data for coir from cells 1-3 are derived from 12 plots each with plots in the outflow channel lumped with data from the plots in the cells above. Plot data for coir in Cell 4 are derived from 6 plots only due to a lack of outflow plots as well as incomplete zones of coir coverage in this cell. Regardless, coir cover ranged from 10 percent to 100 percent per coir plot, but averaged 61 percent coverage.

Table 10. Coir cell plant cover

Data Set	Average	Standard Deviation	Min	Max
June_Cell 1	32	17	10	60
June_Cell 2	39	31	10	100
June_Cell 3	35	21	10	70
June_Cell 4	27	5	20	30
June_Overall	34	22	10	100
August_Cell 1	89	17	40	98
August_Cell 2	83	17	50	98
August_Cell 3	78	21	30	98
August_Cell 4	72	18	50	90
August_Overall	82	19	30	98
September_Cell 1	73	16	40	98
September_Cell 2	68	30	20	98
September_Cell 3	67	25	20	98
September_Cell 4	52	25	30	80
September_Overall	67	24	20	98
Combined Data	61	29	10	100

Table 11. Coir diversity

Data Set	Average	Standard Deviation	Min	Max
August_Cell 1	0.41	0.10	0.26	0.59
August_Cell 2	0.47	0.17	0.26	0.83
August_Cell 3	0.38	0.14	0.26	0.73
August_Cell 4	0.56	0.22	0.33	0.84
August_Overall	0.44	0.16	0.26	0.84
September_Cell 1	0.37	0.06	0.30	0.51
September_Cell 2	0.46	0.12	0.32	0.71
September_Cell 3	0.36	0.10	0.22	0.60
September_Cell 4	0.63	0.23	0.40	0.96
September_Overall	0.43	0.15	0.22	0.96
Combined Data	0.44	0.15	0.22	0.96

Analysis of coir data normality—Coir cover data were analyzed for normality via the Shapiro-Wilk W test. As shown in Table 12, 69 percent of the coir cover classes were non-normal at alpha = 0.05. As shown in Table 13, 36 percent of the coir diversity classes were non-normal at alpha = 0.05. Due to the considerable lack of normality, non-parametric statistical procedures were applied for data analysis of the coir cover data.

Table 12. Normality of coir cover data

Data Set	Shapiro-Wilk W Value	n	p-Value
June_Cell 1	0.91	12	0.2275
June_Cell 2	0.82	12	0.0137*
June_Cell 3	0.92	12	0.3229
June_Cell 4	0.64	6	0.0002*
June_Overall	0.86	42	0.0001*
August_Cell 1	0.61	12	<0.0001*
August_Cell 2	0.79	12	0.0064*
August_Cell 3	0.85	12	0.0383*
August_Cell 4	0.85	6	0.1484
August_Overall	0.81	42	<0.0001*
September_Cell 1	0.91	12	0.1944
September_Cell 2	0.86	12	0.0437*
September_Cell 3	0.90	12	0.1943
September_Cell 4	0.77	6	0.0322*
September_Overall	0.90	42	0.0014*
Combined Data_Overall	0.88	126	<0.0001*

*Non-normal at alpha = 0.05

Table 13. Normality of coir diversity scores

Data Set	Shapiro-Wilk W Value	n	p-Value
August_Cell 1	0.95	12	0.63
August_Cell 2	0.88	12	0.07
August_Cell 3	0.78	12	0.01*
August_Cell 4	0.85	6	0.14
August_Overall	0.83	42	<0.0001*
September_Cell 1	0.90	12	0.13
September_Cell 2	0.92	12	0.25
September_Cell 3	0.90	12	0.20
September_Cell 4	0.89	6	0.30
September_Overall	0.83	42	<0.0001*
Combined Data_Overall	0.86	84	<0.0001*

*Non-normal at alpha = 0.05; **All plot cover values equaled 0.05 percent

Comparison of coir cover**—**The results of the Kruskal-Wallis test showed that there were highly significant differences in coir cover between at least two monitoring trips (H corrected for ties = 53.2 with a p-value of <0.001). Thus for the coir, $H2_o$ can be rejected and $H2_a$ accepted - there is a significant difference in coir cover values between monitoring trips at an alpha = 0.05. The Bonferroni-Dunn post hoc test of categorical differences, whose significant results are shown in Table 14 and Figure 6, showed that coir cover was significantly different between each trip. Cover values were lowest in early spring, then peaked in mid-summer and then began to decline in the early fall. This may be due to both a change in seasons, as well to the drawdown in water levels in the wetland cells as the summer progressed.

Table 14. Bonferroni/Dunn for coir cover

Cell Comparisons	Mean Difference	Critical Diff	p-Value
June versus August	-47.4	11.7	<0.0001*
June versus September	-32.4	11.7	<0.0001*
August versus September	15.0	11.7	0.0022*

*Significant difference at alpha = 0.05; Comparisons in the table are not significant unless the corresponding p-value is less than .0167.

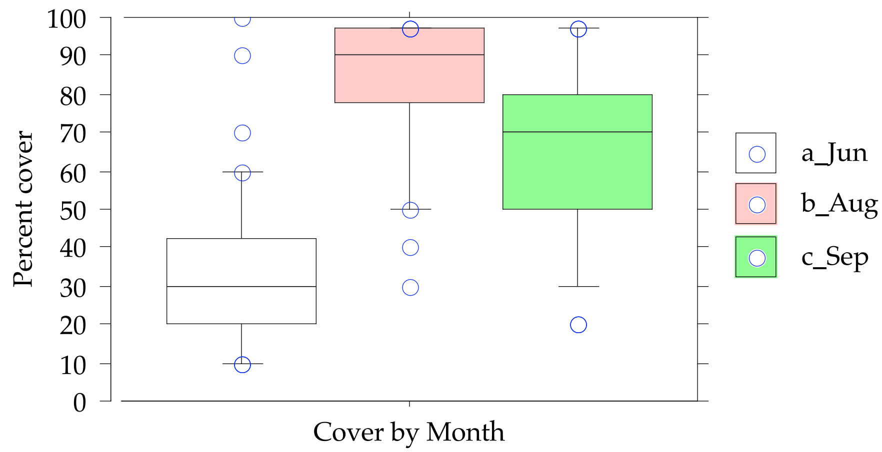

Figure 6: Coir cover by month

More critical, however, is a comparison of cover when planted versus found cover. While no measurements were taken when planted, BRI's pre-vegetated coir generally must 90 percent cover to meet shipping standards. During the August visit, the coir exhibited a total cover of 82 percent. This represents only a moderate die-back of 8 percent at the height of the growing season, as compared to the 57 percent die-off exhibited by the wetland plugs.

Comparison of coir plant species diversity— The results of the Mann-Whitney U Test showed that there were no significant differences in coir plant diversity between the August and September monitoring trips (Z-value corrected for ties = -0.26 with a p-value of 0.80). Thus for the coir, $H3_o$ cannot be rejected and $H3_a$ accepted - there is no significant difference in coir diversity between the monitoring trips at an alpha = 0.05.

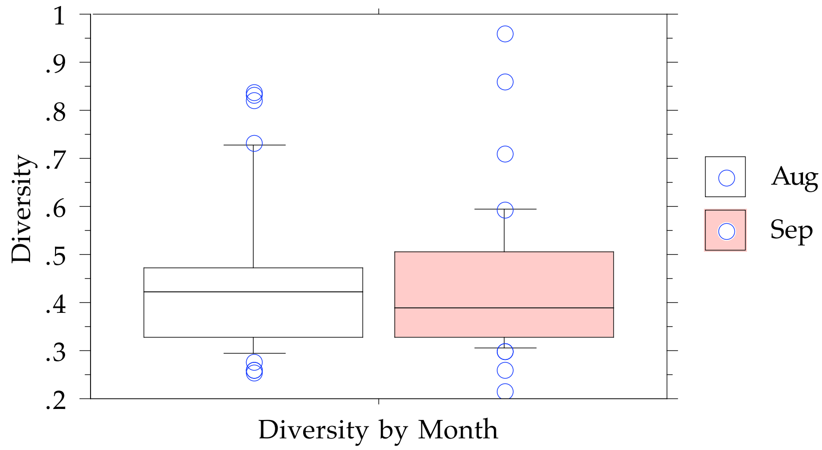

Figure 7: Coir species diversity

Coir stability— The project utilized 627 linear feet of 3.2 foot-wide coir. During the first monitoring visit, only 6 linear feet (1 percent) of coir was found to be disturbed. All 6 feet of material was in Cell 4, in which all coir and all wetland plant material was inundated with 1 to 1.5 feet of water. Due to the inundation, the berm banks to which the coir is attached were extremely softened, leading to the observed disturbance. Coir stability did not change from this first visit through the September monitoring visit. While some trampling of the coir mats by wildlife had occurred, the coir remained stably attached to the wetland banks, even if cover declined. Since there was no change in the length of disturbance, no statistical analyses were needed; there is no significant difference in coir stability values between monitoring trips at an alpha = 0.05. This strongly supports the utility of prevegetated coir as a bank protection tool.

Observations and Recommendations

Observations at the initial monitoring visit in mid June were indeed bleak. There was still snow and ice on the site. Furthermore, the wetland cells held deep water that was inhibiting growth of several of the more mesic of the planted species. However, by the second and third monitoring visits in mid August and late September, the vegetation in both the wetland cells and in the prevegetated coir mats had begun to express dramatically (Figure 8).

Figure 8. Vegetation expression in Cell 3 (Sept. 30, 2004)

The main problem that is evident from very uneven hydrologic and vegetation performance stems form poor grading of the wetland cell bottoms. There are deepwater spots (Figure 9) and dry spots (Figure 10), in some cases amounting to 3 to 6 inches difference in water depth within a single cell.

Figure 9. Deep water in Cell 2 (Sept. 30, 2004)

Figure 10. Dry bottom in Cell 4 (Sept. 30, 2004)

At the upper end of Cell 1 just below the inlet to the system, there is a lot of fine sediment that has killed about half the vegetation in Cell 1 (Figure 11).

Figure 11. Accumulating sediment in Cell 1 (Sept. 30, 2004)

There are a few spots in the prevegetated coir that has lost the vegetation that was growing in them initially (Figure 12). The reasons for this are unclear, although this may be related to the placement of the prevegetated coir relative to the wetland cell hydrology.

Figure 12. Coir mat that has lost its vegetation in Cell 2 (Sept. 30, 2004)

While an analysis of the influence of water quality on plant survival awaits the arrival of data from the EPA, the basic implications of these observations underscore the importance of appropriate hydrology on plant establishment and growth in treatment wetlands. Given the compressed timeframe in which this project was, as well as the unknowns of constructing wetlands at a remote location in rugged country, a significant number of on-the-ground engineering decisions are expected. These realities suggest, however, that one should first construct the wetland and let the hydrology settle prior to installation of the wetland plants or coir. One plausible scenario would be to build the wetland in the summer, let the hydrology equilibrate and then install the coir in the fall for erosion protection over the winter. Then, the wetland cells themselves could be planted during the following spring/summer, permitting them a full growing season prior winter stress.

Alternatively, the entire site could be planted in the fall with pre-vegetated coir. An analysis of the budget indicates that the time and materials costs for installing coir versus installing wetland plugs are about equal for a similar area (approximately $8.55 per square foot). Nonetheless, during the August visit, the coir exhibited a total cover of 82 percent. This compares very favorably to the 17 percent cover and 57 percent mortality exhibited at the same time in the wetland cell areas. While this equation could be altered by increasing the area in which the wetland plugs are planted, for small areas of intensive planting, such as treatment wetlands, pre-vegetated coir provides a very cost-effective solution.

LITERATURE CITED

Abacus Concepts, Inc. 1992-95. Statview version 4.51. Berkley, CA USA. Software package.

Barbour, M.G., J.H. Burk, and W.D. Pitts. 1980. Terrestrial Plant Ecology. Menlo Park: Benjamin/Cummings Publishing Co. pp 139-140.

Shapiro, S.S. and M.B. Wilk. 1965. An analysis of variance test for normality (complete samples) Biometrika. 52:591-611.

SAS Institute, Inc. 1989-97. JMP version 3.2.2. Cary, NC. Software package.

APPENDIX A

Wetland Cell Data

Plant Survival Count and Canopy Cover

August 18, 2004 data

Wetland Cells Planted Species

Plot	CARUTR/S CIMIC		DESCES		GLYSTR		JUNBAL		SCIVAL		TYPLAT		**Total**	
	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	**Count**	**Cover**
1.1	4	0.005	0	0	0	0	0	0	4	0.005	0	0	**8**	**0.005**
1.2	8	0.03	0	0	0	0	2	0.005	0	0	0	0	**10**	**0.03**
1.3	8	0.03	0	0	0	0	3	0.005	0	0	0	0	**11**	**0.03**
1.4	7	0.03	0	0	0	0	0	0	0	0	0	0	**7**	**0.03**
1.5	7	0.03	0	0	0	0	0	0	0	0	0	0	**7**	**0.03**
1.6	3	0.03	0	0	0	0	0	0	0	0	0	0	**3**	**0.03**
2.1	19	0.3	0	0	0	0	15	0.1	0	0	0	0	**34**	**0.4**
2.2	0	0	0	0	0	0	5	0.1	0	0	0	0	**5**	**0.1**
2.3	11	0.1	0	0	0	0	2	0.03	0	0	0	0	**13**	**0.2**
2.4	7	0.1	0	0	0	0	0	0	0	0	0	0	**7**	**0.1**
2.5	5	0.03	0	0	0	0	1	0.005	0	0	0	0	**6**	**0.03**
2.6	8	0.1	0	0	0	0	1	0.005	0	0	0	0	**9**	**0.2**
3.1	7	0.2	0	0	0	0	3	0.1	0	0	0	0	**10**	**0.3**
3.2	1	0.005	0	0	0	0	1	0.03	0	0	0	0	**4**	**0.1**
3.3	8	0.4	0	0	0	0	10	0.2	4	0.03	0	0	**22**	**0.7**
3.4	21	0.6	0	0	3	0.1	5	0.03	0	0	0	0	**29**	**0.7**
3.5	5	0.2	0	0	0	0	2	0.03	2	0.005	0	0	**9**	**0.3**
3.6	5	0.2	0	0	0	0	1	0.03	2	0.005	0	0	**8**	**0.2**
4.1	0	0	1	0.005	0	0	0	0	0	0	0	0	**0**	**0**
4.2	8	0.1	0	0	0	0	1	0.005	1	0.005	0	0	**10**	**0.1**
4.3	6	0.1	0	0	0	0	1	0.005	0	0	2	0.005	**9**	**0.1**
4.4	15	0.1	0	0	0	0	4	0.005	0	0	0	0	**19**	**0.1**
4.5	7	0.2	0	0	0	0	1	0.005	0	0	0	0	**8**	**0.2**
4.6	5	0.1	0	0	0	0	3	0.03	0	0	0	0	**8**	**0.1**

August 18, 2004 data
Wetland Cells Volunteer Species (not counted in total count or cover)

EPICIL		EQUISE		TRIFOL		MOSS		GRASS		CAREX		AGRSTO		POAXXX		FORBX		POLAVI		JUNBUF	
Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover
0	0	8	0.005	0	0	0	0	9	0.005	3	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	3	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	6	0.005	NA	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.005	0	0	0	0	0	0	1	0.005	0	0	0	0	0	0	0	0	0	0	0	0
1	0.005	0	0	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0	0	0	0	0
2	0.005	0	0	0	0	NA	0.005	2	0.005	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	2	0.005	NA	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0.005	0	0	3	0.03	NA	0.005	0	0	0	0	3	0.005	3	0.005	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0.005	0	0	0	0	0	0	0	0	0	0	1	0.005	0	0	0	0
0	0	0	0	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	8	0.03	0	0	6	0.03	0	0	1	0.005	0	0	1	0.005	1	0.005	0	0
0	0	0	0	3	0.005	0	0	1	0.005	0	0	1	0.005	0	0	3	0.005	0	0	0	0
0	0	1	0.005	6	0.005	0	0	20	0.03	0	0	15	0.03	0	0	0	0	0	0	0	0
0	0	0	0	1	0.005	0	0	10	0.005	0	0	9	0.005	0	0	0	0	0	0	1	0.005
0	0	0	0	1	0.005	0	0	1	0.005	0	0	2	0.005	0	0	1	0.005	0	0	0	0
0	0	0	0	5	0.005	0	0	0	0	0	0	1	0.005	0	0	4	0.005	0	0	0	0

September 30, 2004 data

Wetland Cells

Plot	CARUTR/S CIMIC		DESCES		GLYSTR		JUNBAL		SCIVAL		TYPLAT		Total	
	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover
1.1	5	0.005	0	0	0	0	0	0	2	0.005	0	0	7	0.005
1.2	9	0.03	0	0	0	0	1	0.005	0	0	0	0	10	0.03
1.3	6	0.03	0	0	0	0	2	0.005	0	0	0	0	8	0.03
1.4	7	0.03	0	0	0	0	0	0	0	0	0	0	7	0.03
1.5	4	0.03	0	0	0	0	0	0	0	0	0	0	4	0.03
1.6	2	0.03	0	0	0	0	0	0	0	0	0	0	2	0.03
2.1	19	0.2	0	0	0	0	10	0.1	0	0	0	0	29	0.3
2.2	2	0.03	0	0	0	0	3	0.03	0	0	6	0.1	11	0.2
2.3	11	0.2	0	0	0	0	3	0.03	0	0	0	0	14	0.2
2.4	7	0.2	0	0	0	0	0	0	0	0	0	0	7	0.2
2.5	4	0.03	0	0	0	0	1	0.005	0	0	0	0	5	0.03
2.6	12	0.3	0	0	0	0	1	0.005	1	0.005	0	0	14	0.3
3.1	19	0.2	0	0	0	0	4	0.03	0	0	0	0	23	0.3
3.2	7	0.1	5	0.1	0	0	1	0.005	0	0	0	0	13	0.2
3.3	15	0.2	0	0	0	0	11	0.2	2	0.005	0	0	28	0.4
3.4	17	0.3	0	0	2	0.03	1	0.03	0	0	0	0	20	0.4
3.5	3	0.1	0	0	0	0	2	0.03	1	0.005	0	0	6	0.2
3.6	4	0.1	0	0	0	0	1	0.005	0	0	0	0	5	0.1
4.1	4	0.03	0	0	0	0	2	0.03	0	0	1	0.005	7	0.1
4.2	3	0.03	0	0	0	0	1	0.005	0	0	0	0	4	0.03
4.3	4	0.03	0	0	0	0	2	0.005	0	0	1	0.005	7	0.1
4.4	9	0.03	0	0	0	0	1	0.005	0	0	0	0	10	0.03
4.5	6	0.1	0	0	0	0	0	0	0	0	0	0	6	0.1
4.6	5	0.03	0	0	0	0	2	0.005	0	0	0	0	7	0.03

September 30, 2004 data

Volunteer Species (not counted in total count or cover)

Plot	EPICIL		EQUISE		TRIFOL		MOSS		GRASS		CAREX		AGRSTO		POA sp		FORB		POLAVI		JUNBUF	
	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover	Count	Cover
1.1	0	0	0	0	0	0	0	0	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0
1.2	0	0	0	0	1	0.005	0	0	0	0	0	0	1	0.005	0	0	0	0	0	0	0	0
1.3	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.4	0	0	0	0	0	0	0	0	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6	0	0	0	0	0	0	0	0	0	0	0	0	1	0.005	0	0	0	0	0	0	0	0
2.1	0	0	0	0	0	0	2	0.005	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0
2.2	1	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.3	1	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.6	1	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.4	0	0	0	0	0	0	0	0	0	0	0	0	1	0.005	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0.005	0	0	0	0	0	0	0	0
3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1	0	0	0	0	3	0.005	0	0	0	0	0	0	1	0.005	2	0.005	0	0	0	0	0	0
4.2	0	0	0	0	1	0.005	0	0	0	0	0	0	0	0	1	0.005	0	0	0	0	0	0
4.3	0	0	0	0	7	0.005	0	0	0	0	0	0	20	0.03	4	0.005	0	0	0	0	0	0
4.4	0	0	0	0	2	0.005	0	0	0	0	0	0	7	0.03	2	0.005	0	0	0	0	1	0.005
4.5	0	0	0	0	3	0.005	0	0	0	0	0	0	2	0.005	0	0	0	0	0	0	0	0
4.6	0	0	0	0	8	0.005	0	0	0	0	0	0	4	0.005	0	0	0	0	0	0	0	0

APPENDIX B

Prevegetated Coir Mat Data

Plant Species Canopy Cover

August 18 Coir Left (canopy cover)

NOTE 1: CARUTR & SCIMIC lumped as CARUTR

NOTE 2: Blank rows = voided plots

Volunteer Species (not counted in total cover)

Plot	CARUTR/S CIMIC	DESCES	GLYSTR	JUNBAL	SCIVAL	TYPLAT	Total	EPICIL	EQUISE	TRIFOL	MOSS	GRASSX	POAPRA	AGRSTO
1.2L	0.6	0.1	0.1	0.1	0.1	0.2	0.975	0.03	0	0.005	0	0	0	0
1.3L	0.6	0	0.1	0.1	0	0	0.8	0.03	0	0	0	0	0	0
1.4L	0.3	0.1	0.6	0.005	0	0	0.975	0.1	0	0	0	0.005	0	0
1.5L	0.8	0.03	0.1	0.1	0	0.3	0.975	0.3	0	0	0	0.03	0	0
1.6L	0.6	0.1	0	0.2	0	0.3	0.975	0.03	0	0	0	0	0	0
2.2L	0.5	0	0.005	0.1	0	0.2	0.8	0.005	0	0	0	0	0.03	0
2.3L	0.1	0.005	0.1	0.3	0.1	0.3	0.9	0.1	0	0	0	0.005	0	0
2.4L	0.6	0	0	0.1	0.005	0.005	0.8	0.03	0	0.005	0	0.005	0	0.03
2.5L	0.9	0.1	0.2	0.3	0	0.03	0.975	0.005	0	0	0	0	0	0
2.6L	0.4	0.1	0.1	0.3	0	0.03	0.9	0.005	0	0	0	0	0	0.005
3.2L	0.03	0.2	0.005	0.1	0	0	0.3	0	0	0	0	0	0	0
3.3L	0.7	0	0.03	0.2	0.005	0.2	0.9	0.2	0	0	0.005	0	0	0
3.4L	0.3	0	0.1	0.4	0	0.1	0.9	0.03	0	0	0.005	0	0	0
3.5L	0.4	0.1	0.2	0.1	0	0.2	0.9	0.1	0	0	0	0	0	0
3.6L	0.6	0.1	0.2	0.2	0.03	0.2	0.975	0.2	0	0	0	0	0	0
3.8L	0.5	0.03	0.1	0.1	0	0.03	0.7	0	0	0	0	0	0	0
4.2L	0.6	0	0.2	0.1	0	0.1	0.9	0.005	0	0	0	0	0	0
4.3L														
4.4L														
4.5L	0.9	0	0.1	0	0	0	0.9	0.005	0	0	0	0	0	0
4.6L	0.7	0.03	0	0.005	0.03	0	0.8	0	0	0	0	0	0	0.005

August 18 Coir Left (canopy cover)

NOTE: Blank rows = voided plots

Volunteer Species (not counted in total cover)

POAPAL	FORBXX	ELEPAL	LUPINE	LACSER	CARNEB	SISALT	ACHMIL	ELYGLA	CHEALB	ELEACI	TAROFF
0	0	0	0	0	0	0	0	0	0	0	0.005
0.005	0	0	0	0	0	0	0	0	0	0	0
0.1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0.03	0	0	0	0	0	0	0
0	0	0	0.005	0.03	0	0	0	0	0	0	0
0	0.005	0	0	0.0054	0	0	0	0	0	0	0
0	0.005	0	0	0	0	0.1	0	0	0	0	0
0	0.005	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0.005	0	0	0	0.03	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0.005
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0.005	0	0	0	0	0	0	0	0	0

August 18 Coir Right (canopy cover)

NOTE 1: CARUTR & SCIMIC lumped as CARUTR

NOTE 2: Blank rows = voided plots

Volunteer Species (not counted in total cover)

Plot	CARUTR	DESCES	GLYSTR	JUNBAL	SCIVAL	TYPLAT	Total	EPICIL	EQUISE	TRIFOL	MOSS	GRASSX	POAPRA	AGRSTO
1.2R	0.6	0	0.03	0.3	0	0.3	0.975	3	0	0	0	0	0	0
1.3R	0.8	0	0	0.2	0	0.3	0.975	2	0	0	0.005	0	0	0
1.4R	0.3	0	0.3	0.2	0	0.2	0.9	1	0	0	0.005	0	0	0.005
1.5R	0.6	0.2	0.03	0.03	0	0.1	0.975	5	0	0	0.005	0	0	0.005
1.6R	0.1	0.005	0.03	0.3	0	0.2	0.8	2	0	0	0	0	0	0.005
1.7R	0.1	0.1	0.03	0.2	0	0	0.4	0	0	0.005	0	0	0	0
1.8R	0.8	0.1	0	0.1	0	0.1	0.9	0.005	0	0	0	0	0.1	0
2.2R	0.9	0.03	0.005	0.03	0	0.4	0.975	0.1	0	0	0	0	0	0
2.3R	0.9	0.03	0	0.2	0	0.3	0.975	0.2	0	0	0	0	0	0
2.4R	0.8	0	0.03	0.2	0.005	0.4	0.975	0.1	0	0	0	0	0.03	0
2.5R	0.3	0	0	0.3	0.005	0.3	0.8	0.1	0	0	0	0	0	0.005
2.6R	0.5	0	0.1	0.03	0.03	0.1	0.8	0.03	0	0	0	0	0	0
2.7R	0.4	0.03	0	0.005	0	0.005	0.5	0.005	0	0	0	0	0.03	0.005
2.8R	0.3	0.1	0	0.005	0	0.1	0.5	0.005	0	0	0	0.005	0	0
3.2R														
3.3R	0.3	0.03	0.1	0.1	0	0.1	0.6	0	0	0	0	0	0	0.005
3.4R	0.1	0.1	0	0.1	0.005	0.3	0.6	0.1	0	0	0	0	0	0.005
3.5R	0.7	0.2	0	0.3	0.005	0.3	0.975	0.005	0	0	0	0	0	0
3.6R	0.5	0.2	0	0.2	0	0.2	0.975	0.005	0	0	0	0	0	0.2
3.7R	0.7	0	0.1	0	0.03	0	0.8	0.005	0	0	0	0	0	0
4.2R	0.3	0	0.005	0.03	0	0.1	0.5	0	0.005	0	0	0	0	0
4.3R														
4.4R														
4.5R	0.1	0.1	0.005	0	0.005	0.3	0.5	0	0	0	0	0	0.005	0.005
4.6R	0.3	0.03	0.03	0.1	0	0.3	0.7	0	0	0.005	0	0	0.005	0.005

August 18 Coir Right (canopy cover)

NOTE: Blank rows = voided plots

Volunteer Species (not counted in total cover)

POAPAL	FORBXX	ELEPAL	LUPINE	LACSER	CARNEB	SISALT	ACHMIL	ELYGLA	CHEALB	ELEACI	TAROFF
0	0	0	0.005	0.005	0.03	0	0	0	0	0	0
0	0	0	0	0	0	0.005	0	0	0	0	0
0	0	0	0	0.005	0	0	0	0	0	0	0
0	0	0	0	0.005	0	0	0	0	0	0	0
0	0	0	0	0.005	0	0	0	0	0	0	0
0.1	0.005	0	0	0	0	0	0	0	0	0	0
0	0.005	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0.005	0	0	0	0
0	0	0	0	0	0.005	0	0	0.03	0	0	0
									0	0	0
0	0	0	0	0	0	0.1	0	0	0	0	0
0	0	0	0	0.005	0	0.005	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.005	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0.005	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0.005	0

September 30 Coir Left (canopy cover)

NOTE 1: CARUTR & SCIMIC lumped as CARUTR

NOTE 2: Blank rows = voided plots

Plot	CARUTR/ SCIMIC	DESCES	GLYSTR	JUNBAL	SCIVAL	TYPLAT	Total
1.2L	0.4	0.1	0.03	0.1	0.03	0.2	0.8
1.3L	0.5	0	0.1	0.1	0	0.03	0.7
1.4L	0.3	0.1	0.3	0	0	0	0.7
1.5L	0.4	0.03	0.03	0.1	0.005	0.3	0.8
1.6L	0.4	0.1	0	0.2	0	0.2	0.9
2.2L	0.1	0	0	0.1	0	0.1	0.2
2.3L	0.1	0.03	0	0.2	0.005	0.2	0.6
2.4L	0.4	0	0	0.1	0.005	0.03	0.6
2.5L	0.6	0.1	0.1	0.1	0.005	0.1	0.975
2.6L	0.3	0.1	0.03	0.2	0	0.03	0.7
3.2L	0.1	0.1	0.005	0.005	0	0	0.2
3.3L	0.4	0.03	0	0.1	0.005	0.2	0.7
3.4L	0.3	0	0.005	0.4	0	0.1	0.8
3.5L	0.3	0.005	0.1	0.1	0.005	0.2	0.7
3.6L	0.3	0.1	0.2	0.2	0.005	0.2	0.975
3.8L	0.3	0.005	0	0.1	0	0.005	0.5
4.2L	0.6	0	0.005	0.1	0	0.1	0.8
4.3L							
4.4L							
4.5L	0.8	0	0.005	0.005	0.005	0	0.8
4.6L	0.5	0.03	0	0.005	0.005	0	0.6

Volunteer Species (not counted in total cover)

Plot	EPICIL	EQUISE	TRIFOL	MOSS	GRASSX	POAPRA	AGRSTO	POAPAL
1.2L	0.1	0	0	0.03	0	0	0	0
1.3L	0.03	0	0	0	0	0.005	0	0
1.4L	0.1	0	0	0	0	0.1	0	0
1.5L	0.1	0	0	0.03	0	0.005	0	0.03
1.6L	0.03	0	0	0.005	0	0	0	0
2.2L	0.005	0	0	0	0	0	0	0.03
2.3L	0.1	0	0	0.03	0	0.005	0	0
2.4L	0.005	0	0	0	0	0	0	0
2.5L	0.03	0	0	0	0	0	0	0
2.6L	0.005	0	0	0.03	0	0	0	0
3.2L	0	0	0	0	0	0	0	0.2
3.3L	0.2	0	0	0.005	0	0	0	0
3.4L	0.03	0	0	0.005	0	0	0	0
3.5L	0.1	0	0	0.005	0	0	0	0
3.6L	0.1	0	0	0	0	0	0	0
3.8L	0.03	0	0		0	0	0	0.03
4.2L	0.005	0	0	0.03	0	0.1	0	0
4.3L								
4.4L								
4.5L	0.005	0	0	0	0	0.03	0	0
4.6L	0.005	0	0	0	0	0.03	0.03	0

September 30 Coir Left (canopy cover)

NOTE: Blank rows = voided plots

Volunteer Species (not counted in total cover)

All Plants

Plot	FORBXX	ELEPAL	LUPINE	LACSER	CARNEB	SISALT	ACHMIL	ELYGLA	CHEALB	ELEACI	TAROFF	Total-2
1.2L	0	0	0	0	0	0	0	0	0	0	0	0.9
1.3L	0	0	0	0	0	0	0	0	0	0	0	0.7
1.4L	0	0	0	0	0	0	0	0	0	0	0	0.9
1.5L	0	0	0	0	0	0	0	0	0	0	0	0.9
1.6L	0	0	0	0.005	0	0	0	0	0	0	0	0.9
2.2L	0	0	0	0	0	0	0	0	0	0	0	0.2
2.3L	0	0	0	0	0	0	0	0	0	0	0	0.7
2.4L	0	0	0	0	0	0.2	0	0	0	0	0	0.7
2.5L	0	0	0	0	0	0	0	0	0	0	0	0.975
2.6L	0	0	0	0	0	0	0	0	0	0	0	0.8
3.2L	0	0	0	0	0	0	0	0	0	0	0	0.4
3.3L	0	0	0	0	0	0	0	0	0	0	0	0.9
3.4L	0	0	0	0	0	0	0	0	0	0	0	0.8
3.5L	0	0	0	0	0	0	0	0	0	0	0	0.9
3.6L	0	0	0	0	0	0	0	0	0	0	0	0.975
3.8L	0	0	0	0	0	0	0	0	0	0	0	0.6
4.2L	0	0	0	0	0	0	0	0	0	0	0	0.9
4.3L												
4.4L												
4.5L	0	0.03	0	0	0	0	0	0	0	0	0	0.9
4.6L	0	0	0	0	0	0	0	0	0	0	0	0.7

September 30 Coir Right (canopy cover)

NOTE 1: CARUTR & SCIMIC lumped as CARUTR

NOTE 2: Blank rows = voided plots

Volunteer Species (not counted in total cover)

Plot	CARUTR/ SCIMIC	DESCES	GLYSTR	JUNBAL	SCIVAL	TYPLAT	Total	EPICIL	EQUISE	TRIFOL	MOSS	GRASSX	POAPRA	AGRSTO	POAPAL
1.2R	0.3	0	0	0.3	0	0.1	0.7	0.2	0	0	0.005	0	0	0	0
1.3R	0.5	0	0	0.2	0	0.3	0.975	0.1	0	0	0.005	0	0.005	0	0
1.4R	0.3	0	0.1	0.1	0	0.2	0.7	0.1	0	0	0.005	0	0	0	0
1.5R	0.4	0.3	0.03	0	0.005	0.1	0.8	0.2	0	0.005	0.03	0	0.005	0.005	0
1.6R	0.2	0	0.03	0.1	0	0.1	0.5	0.1	0	0	0	0	0.1	0	0
1.7R	0.2	0.1	0	0.1	0	0	0.4	0	0	0	0	0	0.2	0	0
1.8R	0.5	0.1	0.03	0.1	0	0.03	0.8	0.03	0	0	0	0	0.1	0	0
2.2R	0.7	0	0.03	0.03	0	0.3	0.975	0.1	0	0	0.03	0	0.1	0	0
2.3R	0.7	0.03	0	0.1	0.005	0.3	0.975	0.1	0	0	0	0	0.005	0	0
2.4R	0.7	0.03	0	0.2	0	0.3	0.975	0.1	0	0	0	0	0	0	0
2.5R	0.3	0	0	0.2	0	0.3	0.8	0.1	0	0	0	0	0	0	0
2.6R	0.6	0	0.1	0.1	0.03	0.03	0.8	0	0	0	0	0	0	0	0
2.7R	0.2	0	0	0.1	0	0.005	0.3	0	0	0	0	0	0.1	0	0
2.8R	0.2	0.03	0	0.005	0	0.005	0.2	0.03	0	0	0	0	0.1	0	0
3.2R															
3.3R	0.3	0.03	0.05	0.1	0	0.1	0.5	0	0	0	0.03	0	0.005	0	0
3.4R	0.2	0.03	0	0.1	0	0.2	0.5	0.1	0	0	0.005	0	0.005	0	0
3.5R	0.4	0.03	0	0.3	0.03	0.2	0.975	0.03	0	0	0	0	0	0	0
3.6R	0.2	0.3	0	0.2	0	0.3	0.975	0	0	0	0	0	0.005	0	0
3.7R	0.2	0.03	0.1	0.1	0	0	0.5	0.005	0	0	0	0	0	0	0
4.2R	0.2	0	0	0.03	0	0.1	0.3	0	0.005	0	0	0	0.005	0	0
4.3R															
4.4R															
4.5R	0.03	0.03	0	0.03	0	0.2	0.3	0	0	0	0	0	0.03	0.005	0
4.6R	0.2	0.03	0	0.03	0	0.1	0.3	0	0	0	0	0	0	0.005	0

September 30 Coir Right (canopy cover)

NOTE: Blank rows = voided plots

Volunteer Species (not counted in total cover)

All Plants

Plot	FORBXX	ELEPAL	LUPINE	LACSER	CARNEB	SISALT	ACHMIL	ELYGLA	CHEALB	ELEACI	TAROFF	Total
1.2R	0	0	0.03	0.03	0.005	0	0	0	0	0	0	0.9
1.3R	0	0	0	0	0	0	0	0	0	0	0	0.975
1.4R	0	0	0	0.005	0	0	0	0	0	0	0	0.8
1.5R	0	0	0	0	0	0	0.005	0	0	0	0	0.975
1.6R	0	0	0	0.005	0	0	0	0	0	0	0	0.7
1.7R	0	0	0	0	0	0	0	0	0	0	0	0.5
1.8R	0	0	0	0.005	0	0	0	0	0	0	0	0.9
2.2R	0	0	0	0	0	0	0	0	0	0	0	0.975
2.3R	0	0	0	0	0	0	0	0	0	0	0	0.975
2.4R	0	0	0	0	0	0	0	0	0	0	0	0.975
2.5R	0	0	0	0	0	0	0	0	0	0	0	0.9
2.6R	0	0	0	0	0	0	0	0	0	0	0	0.8
2.7R	0	0	0	0	0	0	0	0	0	0	0	0.4
2.8R	0.005	0	0	0	0	0	0.005	0.03	0	0	0	0.3
3.2R												
3.3R	0	0	0	0	0	0	0	0	0	0	0	0.5
3.4R	0	0	0	0	0	0	0	0	0	0	0	0.6
3.5R	0	0	0	0	0	0	0	0	0	0	0	0.975
3.6R	0.005	0	0	0	0	0	0	0	0	0	0	0.975
3.7R	0	0	0	0	0	0	0	0	0	0	0	0.5
4.2R	0	0	0	0	0	0	0	0	0	0	0	0.3
4.3R												
4.4R												
4.5R	0	0	0	0	0	0	0	0	0	0	0	0.3
4.6R	0	0	0	0	0	0	0	0	0	0	0	0.3

APPENDIX C

Monitoring Site Visit Notes

Monitoring Site Visit Notes
June 19, 2004

The monitoring visit of June 19, 2004, took place in windy, cool conditions. The site experienced a slight snowfall during the morning hours, and small chunks of ice were observed floating in Wetland Cell 4. The ice melted by the close of the day, but thunder and light rain threatened all day.

The project site was physically sound. No leaks or signs of erosion were evident, save in the outflow/inflow zone between Wetland Cells 3 and 4. In this area, a plastic pipe had been installed above small boulders, both to decrease erosion and to facilitate water flow between the two cells. The erosion had equilibrated and no head-cutting was observed.

The surface of all wetland cells were stained with a rust-colored scum approximately 1/2 inch in thickness. Surface water was observed flowing in all four wetland cells, and initial signs of channelization of the surface flow was evident as well. All four cells were inundated with water, with Cells 2 and 3 having only partial coverage with water to a maximum depth of 1/2 inch. Cell 1 was completed inundated, with water levels ranging from 1 to 2 inches; Cell 4 was completely inundated with 1 to 1.5 feet of water. Despite the high water levels, the wetland cells were solid and could support the weight of a human without significant sinking.

Some Interim Lessons

1. The initial design envisioned water being forced sub-surficially at the upstream end of each wetland plot. Instead, much of the water is flowing across the surface of the wetland plots, potentially limiting the amount of water quality treatment.
2. The level of inundation in the wetland cells seemed to have a significant impact on plant survival. Survival and cover were highest in Cells 2 and 3, which had the least amount of standing water. In Cell 4, which was completely inundated, only one surviving wetland plug was observed.
3. This suggests that one should first construct the wetland and let the hydrology settle prior to installation of the wetland plants or coir. One plausible scenario could be to build the wetland in the summer, let the hydrology equilibrate and then install the coir in the fall for erosion protection over the winter. Then, the wetland cells themselves could be planted during the following spring/summer, permitting them a full growing season prior winter stress.

BASIN CREEK PEERLESS TREATMENT WETLAND MONITORING VISIT 8/18/2004

On August 18, 2004 Gant Massey and Bill Thompson of BRI visited the Basin Creek Peerless Mine Treatment Wetland Test Site to conduct scheduled vegetation monitoring according to plan.

Upon arrival in the area, we checked in at the Envirocon trailer and notified the staff person on duty that we were in the area. Dave Torgerson, who was present, informed us that there was construction work in the area was completed, and that Envirocon would be vacating the site in the near future. Later in the day Dave arrived at the Treatment Wetland Site to collect water chemistry samples.

The weather on site that day was cool and drizzling until mid afternoon, when it cleared to partial cloud cover.

We noted that in the time since the previous monitoring visit in June of this year, the planted vegetation had significantly, even dramatically, grown. The uneven appearance of the vegetation in the wetland cell bottoms seemed to correspond to the uneven water level and micro topography. There was indication of extended periods of very deep water in the upstream cells, while cell 4 at the downstream end was entirely dry. Free water was encountered 1.7 feet below the surface in a pit dug near the lower (south) end of the cell.

Cell 1: There was surface water on 100% of the area varying in depth from about 1 to 5 inches. Orange color, like iron oxide, on sediment surface. It appears that significant fine sediment has collected in this cell from erosion above. Vegetation in cell appears sparse and of low vigor.

Cell2; Surface water was on about 90% of the area varying in depth from about 1 to 5 inches. Bottom materials in this cell are gray-black color. Plants reduced vigor and yellowish color.

Cell 3: There was surface water with a visible flow current on about 2/3 of the width on about the upper 2/3 of the length of this cell. On about the lower 1/3 of the cell water is ponded with no surface flow exiting to Cell 4. Obviously, the water is percolating into the cell bottom at this point. Of note also in this ponded water was a profuse variety of invertebrate fauna, including water skippers, mosquito larvae, and strange looking white worms.

Cell 4: There was no surface water in Cell 4. A pit dug in the downstream end encountered free water at a depth of 1.7 feet.

In general the coir reinforced vegetation along the banks of all wetland cells was dense and in excellent condition. There were tracks of deer and moose throughout the project site. There had been some utilization of planted material by grazers (probably moose and/or elk), especially on the SCIVAL.

BASIN CREEK PEERLESS TREATMENT WETLAND MONITORING VISIT
9/30/2004

On September 29 and 30, 2004 Bill Thompson of BRI visited the Basin Creek Peerless Mine Treatment Wetland Test Site to conduct the final vegetation monitoring for the year. Upon entry along the Rimini Road, it was noted that the ENVIROCON trailers were still in place, but there was no one present. Later I spoke with two ENVIROCON employees who visited the Peerless site for a short time.

The weather on site those two days was clear and mild with freezing temperatures at night warming to about 55 F during the day. The wetland cells had a covering of ice until nearly noon each day. Workers at the Basin Creek mine site only a few hundred feet higher reported about six inches of snow the previous week.

The vegetation in and around the wetland cells has continued to grow since the last visit about 6 weeks ago. It is attracting a host of herbivores. The entire site is pugged by moose and elk which have cropped much of the herbage of selected species (mostly the DESCES, SCIVAL, and CARUTR). Also small rodents are heavily utilizing the dense vegetation along the coir banks of the cells.

Cell 1: Good flow at the inlet, appearing slightly more than in August. The coir vegetation along cell 1 is dense and robust, whereas the vegetation in the cell bottom is very sparse. There is almost none in the upper 20 ft, where there is a lot of fine sediment. Surface water varies from 1 to 4 inches deep over the entire cell. There is some gray-black coloration on the bottom surface at the lower end. There are water skipper on the water at the lower end where the water is deepest. The outlet ditch has whitish/cream coloration on the bottom gravels.

Cell2; There is surface water over the entire cell bottom about 1 to 4 inches deep. There is an oily sheen on about 20 to 30 percent of the surface. The coir edge vegetation is robust and dense. The cell bottom vegetation is better than in cell 1, but not very dense. Over all the cell bottom has about 20 percent vegetation canopy cover. Bottom materials are gray-black color near the outlet end. There are lots of insect larvae (resembling larvae of mosquitoes, but about 1 cm long).

Cell 3: Flow entering cell 3 is about equal to that entering cell 1. The coir vegetation along the sides is very dense and robust. The cell bottom vegetation is the best of all four cells with about 30 to 40 percent canopy cover. The entire cell bottom is covered with water about 1 to 6 inches deep, deepest near the lower end. Outlet flow to cell 4 seems slightly reduced from inlet flow from cell 2. No discoloration is noticeable in cell 3, however there is a slight whiteish coloration of gravels in the outlet ditch.

Cell 4: The cell bottom is moist throughout its length, but free surface water all goes underground and ends about mid cell at the lowest point. Coir vegetation (where coir exists) along the sides is less robust than around other cells. Cell bottom vegetation is sparse, but evenly distributed. Someone has dug four test pits in the cell bottom, spaced about evenly along the cell length, to find the level of ground water. Reflecting the general contour of the cell bottom, the water is down about 12 inches at both ends, and about 6 inches in the two middle pits.

The pre-vegetated coir along the banks of wetland cells, although well anchored by the dense vegetation, is being disturbed by the trampling of elk and moose throughout the project site.