

PHASE III  
SUCCESS STANDARDS FOR INDUSTRIAL/COMMERCIAL  
AND RESIDENTIAL REVEGETATION

Arkansas Department of Environmental Quality  
Surface Mining and Reclamation Division  
P. O. Box 8913  
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Effective Date:

## INDUSTRIAL/COMMERCIAL/RESIDENTIAL

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## **I. Introduction**

This policy describes the criteria and procedures for determining Phase III success standards for areas being restored to an industrial/commercial or residential land use.

For areas which are part of an industrial/commercial or residential land use and are not intended to be vegetated, such as building sites, parking lots, and roads, these revegetation standards obviously do not apply. The revegetation standards described here only apply to those parts of the industrial/commercial or residential land use which will require vegetative erosion control.

Pursuant to the Arkansas Surface Coal Mining and Reclamation Code (ASCMRC) Section 816.116, revegetation success on industrial/commercial or residential land use areas must be determined on the basis of the following conditions:

general revegetation requirements of the approved permit; and ground cover density.

The permittee is responsible for measuring the vegetation and for submitting the data to the Director for analysis. Measurements of the vegetation must be made in accordance with the procedures outlined in this document.

## **II. General Revegetation Requirements**

The general requirements for revegetation, as stated under ASCMRC 816.111, shall be considered satisfied upon the determination by the Director that:

- A. The permittee has established on regraded areas and all other disturbed areas, except water areas, and surface areas of roads and areas around buildings that are approved as part of the postmining land use, a vegetative cover that is in accordance with the reclamation plan in the approved permit and that is:
  1. diverse, effective, and permanent;
  2. comprised of species native to the area, or of introduced species which are allowable under ASCMRC 816.112 and necessary to achieve the postmining land use and approved by the regulatory authority;
  3. at least equal in extent of cover to the natural vegetation of the area; and
  4. capable of stabilizing the soil surface from erosion.

- B. The Director must also make the determination that the reestablished plant species are:
1. compatible with the approved postmining land use;
  2. of the same seasonal characteristics of growth as the original vegetation;
  3. capable of self-regeneration and plant succession;
  4. compatible with the plant and animal species of the area; and
  5. allowed for planting under applicable State and Federal laws and regulations which control the growth of poisonous and noxious plants and introduced species.

### **III. Success Standards and Measurement Frequency**

#### **A. Ground Cover**

1. In areas developed for industrial/commercial or residential land use within two (2) years of regrading, ground cover shall not be less than that required to control erosion. If bond release is requested for industrial/commercial or residential use prior to the end of the two year period, the standard for determining if ground cover density is sufficient shall be the same as that which is described further in this guideline.
2. If the area is not developed for industrial/commercial or residential use within two (2) years of regrading, the land use designation must be changed, and the success standard for ground cover density shall be seventy percent (70%) at a ninety percent (90%) statistical confidence level for the last year of the five (5) year responsibility period, and not be less than that required to control erosion.
3. The aggregate of areas with less than seventy percent (70%) ground cover must not exceed five percent (5%) of the release area. These areas must not be larger than 1 acre and must be completely surrounded by desirable vegetation which has a ground cover of seventy percent (70%). Areas void of desirable vegetation may not be larger than 1/4 acre and must be surrounded by desirable vegetation which has a ground cover of seventy percent (70%).

4. No more than thirty percent (30%) of the stand can be approved species not listed in the permit.
5. There should be no more than forty percent (40%) deviation from the approved seeding mixture in the stand.

B. Sampling Period and Frequency

1. Ground cover shall be sampled once during the last year of the five-year responsibility period.
2. The permittee shall notify the Director ten (10) days prior to conducting sampling or other harvesting operations to allow a representative from the state an opportunity to monitor the sampling procedures.

#### IV. Sampling Procedures

A. Random Sampling

1. To assure that the samples truly represent the vegetative characteristics of the whole release area, the permittee must use methods that will provide 1) a random selection of sampling sites, 2) a sampling technique unaffected by the sampler's preference, and 3) sufficient samples to represent the true mean of the vegetation characteristics.
2. Sampling points shall be randomly located by using a grid overlay on a map of the release area and by choosing horizontal and vertical coordinates as described in Appendix A. Each sample point must fall within the release area boundaries and be within an area having the vegetative cover type being measured. Additionally, at least one sample point must be measured in each noncontiguous unit, if the release area does not consist of a single unit.

B. Sampling Techniques

1. Ground cover shall be measured as the area covered by the combined aerial parts of the accepted plant species approved in the permit, and the leaf litter that is produced naturally onsite, expressed as a percentage of the total area of measurement.
2. A line-point transect shall be a series of 100 points spaced 1 foot apart along a straight line. The permittee shall establish a transect at each of the randomly selected sampling points. The direction of

the transect shall also be determined randomly. This can be done as easily as spinning a pencil on a clipboard, or throwing it up in the air and using the direction where it points.

3. The permittee shall identify the species or type of ground cover at each 1-foot interval along the entire length of the transect (starting at 1 foot from the random point). The area of measurement shall be a line projected downward and perpendicular to the ground at each 1-foot interval (100 in total).
4. Each transect must be entirely within a homogeneous area that accurately represents the vegetative cover type being measured. Samples must be taken in pure vegetation types and not in transition zones between adjacent types. Also, the sample sites must be located so they avoid the effects of neighboring vegetation types, roads, stream courses, ponds, etc.
5. At each point along the transect, ground cover shall be classified by species as acceptable or unacceptable as follows:

<u>Acceptable</u>	<u>Unacceptable</u>
Vegetation approved in permit	Vegetation not approved in permit
Dead vegetation or litter from acceptable species	Rock or bare ground
Acceptable-not approved in permit	

6. All data gathered from the line-point transects shall be recorded in the format shown in Appendix B.

#### C. Sample Adequacy

1. The permittee shall collect samples using a two-staged sampling procedure. During the first stage, the permittee shall take an initial group of samples (minimum of ten). By using these initial samples and by applying the formula below, the permittee shall determine the actual number of samples needed:

$$N = \frac{(t^2)(s^2)}{(0.1x)^2}$$

N = minimum number of samples needed.

t<sup>2</sup> = squared t-value from the table in Appendix C.

$s^2$  = initial estimate of the variance of the release  
(or reference) area

$(0.1x)^2$  = the level of accuracy ( $\pm 10\%$ ) expressed as  
10% of the mean. Note that this term is squared.

(Example use of the formula is presented in Appendix D)

2. If the formula reveals that the required number of samples is equal to or less than ten, the initial sampling will satisfy the sampling requirements. If the number of samples needed is greater than ten, the permittee must take the balance of additional samples (Stage Two Sampling) as specified by the formula. This process shall be repeated until sample adequacy shall be met.

## V. Data Analysis

- A. If the data shows that revegetation success has been met, the permittee shall submit the data to the Director for review in the format shown in Appendix B within thirty (30) days of collection.
- B. When the data indicates that the average ground cover density was insufficient, but close to the standards, the permittee may submit the data to the Director to determine if the vegetation is acceptable when statistically compared to the standards using a 90-percent statistical confidence interval. Appendix E explains how the statistical analysis shall be performed.

## VI. Maps

- A. Whenever a new Phase III plan is submitted to the Director, it must be accompanied by maps showing the location of the area covered by the plan (i.e., the area proposed for release).
- B. Whenever data from a previously approved plan is submitted to the Director, it must be accompanied by maps showing:
  1. the location of each transect;
  2. the area covered by the sampling; and
  3. all permit boundaries.

**VII. Mitigation Plan**

Ground cover must be greater than or equal to 70% coverage the fifth year following completion of the last augmented seeding. If it is not, the permittee must submit a Mitigation Plan to the Director which includes the following:

- A. a statement outlining the problem;
- B. a discussion of what practices, beyond normal agronomic practices, the operator intends to use to enable the area to finally meet the release standards; and
- C. a new Phase III liability release plan.

If renovation, soil substitution or any other practice which constitutes augmentation is employed, the five-year responsibility period shall restart when the mitigation plan is approved and the practices are completed.



APPENDIX A

## Selection of Random Sampling Sites

The permittee shall use X and Y grid coordinates in establishing the location of sampling sites on the reclaimed area.

A grid shall be placed or drawn on the map containing the areas to be sampled. The grid must be large enough so that all of the release area is covered by the grid (see drawing in Figure 1). Also, the grid pattern shall be such that the axes are 200 feet apart or closer.

The X and Y axes shall be numbered in consecutive order beginning at the extreme lower left point of the grid (this point being 1).

The permittee shall generate random number pairs for each X and Y axis combination needed. For example, if five (5) sampling locations are to be established, the permittee must generate five (5) random number pairs.

The random numbers table shown in Table 1 may be used to choose the numbers needed. The table is used as follows:

- Step 1) Choose an axis to work on (X or Y).
- Step 2) Flip a coin twice to determine a column on which to start (refer to coin flip combinations at the head of each column).
- Step 3) By beginning at the top of the column selected, begin reviewing the numbers until a number that falls within the range of those on the chosen grid axis is found. If the range of numbers on the axis is less than 10, then you will only review the last digit of the numbers in the column. If the range of numbers is more than 10 but less than 100, then the last two digits will be reviewed.
- Step 4) Record the first number found.
- Step 5) Beginning after the last number found, continue down the column until another number is located within the given range. Record this number and continue following the above procedure until the required amount of numbers is found and recorded. If you reach the bottom of the column before you locate enough numbers, proceed to one of the adjacent columns, starting again at the top. When all columns have been used, begin again with the first column used, except review only the first (instead of the last) one or two digits of the numbers in the column.

## APPENDIX A

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Step 6) After enough numbers are generated for the first axis chosen, restart the process at Step 1 for the other axis.

After enough random number pairs have been generated for each axis, locate the sample points on the grid. If a point(s) falls outside the release area, a new point(s) must be chosen as explained above.

APPENDIX A

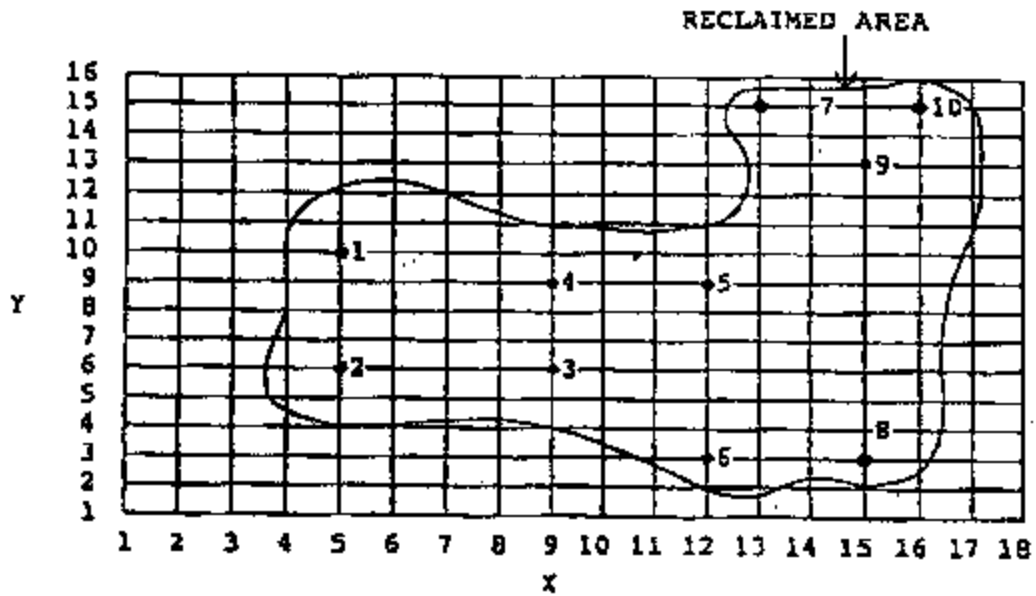
Table 1  
A Set of Random Numbers

<u>Heads/Heads</u> <u>Column 1</u>	<u>Tails/Tails</u> <u>Column 2</u>	<u>Heads/Tails</u> <u>Column 3</u>	<u>Tails/Heads</u> <u>Column 4</u>
6327	0983	3798	4679
2167	6484	9467	9058
3939	0407	1804	8827
4672	3865	5689	9878
8071	5185	5514	5008
9509	0603	7461	8550
6615	2588	3558	3349
4833	2422	9790	1183
5594	1809	6931	6571
9441	1699	3947	7702
7922	9812	7229	5252
9419	6494	8179	8065
6178	3556	2466	2495
2647	3961	7546	4799
0474	1839	6926	6534
9814	1577	8293	0301
0104	4579	0627	8667
1608	9470	4131	5345
9722	1557	0471	5498
4189	3582	3675	9461
9855	8088	9006	6897
5791	8234	1472	3421
0872	3310	0510	9046
8953	9809	8037	8376
2895	4319	6544	8953
0609	5248	8734	2498
0795	2464	6170	1063
1572	7371	7936	2841
4307	0294	6060	5194
4857	0197	2401	7005
1632	7189	6463	9830
0745	8034	7882	7152
0736	5110	5165	6571
8168	7924	5876	1407
7468	5313	2736	9010
6044	5420	3077	9070
6716	0059	3001	8871
9342	0169	6880	7986
5809	6048	9051	1151
1532	9715	7081	0109
5506	5812	5917	4415
4045	1751	2817	9958
5966	9930	6437	7279
6062	3296	5093	2503
4097	8379	5670	0614
6793	3999	4645	5143
7960	4853	0583	1920
1321	4067	8503	1604

APPENDIX A  
FIGURE 1

RANDOM PLOT LOCATIONS GRID OVERLAY

Random Plot	Random Numbers	
	X	Y
1	5	10
2	5	6
3	9	6
4	9	9
5	12	9
6	12	3
7	13	15
8	15	3
9	15	13
10	16	15



APPENDIX B, PART 1

(Example of Format for Summarizing Line Point Transect Date)

LINE POINT TRANSECT SUMMARY SHEET

Page \_\_\_\_ of \_\_\_\_

Company Name \_\_\_\_\_

Permit No. \_\_\_\_\_

Land Use \_\_\_\_\_

Acres in Release Area \_\_\_\_\_

No. of Transects Used (n) = \_\_\_\_\_

Date of Sampling \_\_\_\_\_

Acceptable  
Points Found  
(Out of 100)

Transect No.(n)                      \_\_\_\_\_ (X) \_\_\_\_\_

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18 (Extend as needed)

n = \_\_\_\_\_                      ' X = \_\_\_\_\_

Mean  $\bar{x}$  = ' X/n = \_\_\_\_\_

APPENDIX B, PART 2

Example of Format for Recording Line Point Transect Information:

LINE POINT TRANSECT SHEET

Page \_\_\_\_\_ of \_\_\_\_\_  
 Company Name \_\_\_\_\_  
 Permit No. \_\_\_\_\_  
 Land Use \_\_\_\_\_  
 Date of Sampling \_\_\_\_\_  
 Line Point Transect # \_\_\_\_\_

Point #	Accept or Unaccept	Point #	Accept or Unaccept	Point #	Accept or Unaccept	Point #	Accept or Unaccept
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	

Species \_\_\_\_\_ % Stand \_\_\_\_\_ % Cover =  $\frac{\text{Accept}}{100} =$  \_\_\_\_\_  
 % Accept/not approved =  $\frac{\text{ANA}}{100} =$  \_\_\_\_\_

APPENDIX C

<u>d.f.</u>	<u>t.100</u>
1	3.078
2	1.886
3	1.638
4	1.533
5	1.476
6	1.440
7	1.415
8	1.397
9	1.383
10	1.372
11	1.363
12	1.356
13	1.350
14	1.345
15	1.341
16	1.337
17	1.333
18	1.330
19	1.328
20	1.325
21	1.323
22	1.321
23	1.319
24	1.318
25	1.316
26	1.315
27	1.314
28	1.313
29	1.311
inf.	1.282

Note: for the sample adequacy calculations and 1 tail productivity comparisons, use column t.100.

APPENDIX D

## Example Use of Sample Adequacy Formula for Ground Cover Measurements

In this example, the permittee has taken an initial group of samples from ten (10) randomly located line-point transects. The results of his sampling are as follows:

1) Calculating the variance:

<u>Transect No. (n)</u>	Acceptable Points (Out of 100)	<u>x<sup>2</sup></u>
	<u>x</u>	
1	86	7,396
2	90	8,100
3	76	5,776
4	82	6,724
5	40	1,600
6	76	5,776
7	40	1,600
8	82	6,724
9	86	7,396
10	<u>90</u>	<u>8,100</u>
	' x = 748	' x <sup>2</sup> = 59,192

Now we need to calculate the variance, S<sup>2</sup>:  
Number of transects (n) = 10

$$S^2 = \frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}$$

or, put into words:

$$S^2 = \frac{\frac{\text{Sum of Squared Values Added}}{\text{Number of Values}} - \frac{\text{Square of Sum of All Values}}{\# \text{ of Values}}}{(\text{Number of Values} - 1)}$$

From the data in the above example, we calculate:

$$S^2 = \frac{59,192 - \frac{(748)^2}{10}}{9} = \frac{59,192 - 55,950.4}{9} = \frac{3241.6}{9} = 360.18$$



## Appendix D

## Page 2

## 2) Determining sample adequacy:

From the t table, we find t for a sample size of 10.

$n-1$  = degrees of freedom

$10-1$  = 9 degrees of freedom for our example

From the t table, locate the t statistic for 9 degrees of freedom = 1.383

The sample adequacy formula is:

$$N = \frac{(t^2)(S^2)}{(0.1x)^2}$$

Where:

$\bar{O}$  = the sample mean

$N$  = the number of samples which will need to be taken.

$t^2$  = t table value, squared

$S^2$  = variance

Plugging these values into the sample adequacy formula, we get:

$$N = \frac{(1.383^2)(360.18)}{(7.48)} = \frac{688.91}{55.95} = 12.31 \text{ or } 13$$

Since we already have taken 10 samples and the sample adequacy formula tells us we need only 13, we need to take an additional 3 transects ( $13 - 10 = 3$ ).

Now, when those 3 additional transects have been taken, a new variance must be calculated and the sample adequacy formula recalculated. This is to ascertain that the 3 additional transects didn't somehow increase the variance and therefore, require still more transects. If this happens, the additional transects must be taken and the variance recalculated to determine sample adequacy.

The sample adequacy requirements must be fulfilled before a comparison to the standard can be made.

APPENDIX E

## Statistical Analysis on Ground Cover Measurements

In performing statistical comparisons for ground cover, results of randomly assigned line-point transects will be compared to the success standard (i.e., ninety percent (90%) ground cover at a ninety percent (90%) confidence statistical interval), as illustrated in the following example:

Null hypothesis: Ground cover on release area  $\geq$  70% ground cover.

Alternate hypothesis: Ground cover on release area  $<$  70% ground cover.

	Release Area <u>Sample Results (X)</u>	<u>Ground Cover Standard</u>
Assume that it	41%	70%
took 10 samples (n)	72%	
to achieve sample	89%	
adequacy	42%	
	69%	
	80%	
	42%	
	57%	
	77%	
	<u>89%</u>	
	658%	

$$\text{Ground Cover Mean } (\bar{X}) = \frac{\sum X}{n} = \frac{658}{10} = 65.8$$

$$\text{Standard Deviation } (s) = \sqrt{\frac{\sum X^2 - \frac{(\sum X)^2}{n}}{n-1}} = \sqrt{\frac{46574 - \frac{432,964}{10}}{9}}$$

$$\frac{46574 - 43296.4}{9} = \frac{3277.6}{9} = 364.178 = 19.08$$

Number of Samples (n) = 10.

t table 0.10 a df (10-1) = 1.38.

$$t \text{ calculated} = \frac{|\text{Ground Cover Mean of Release Area} - \text{Target Ground Cover}|}{s/\sqrt{n}}$$

$$= \frac{|65.8 - 90|}{19.08/\sqrt{10}} = \frac{24.2}{6.03} = 4.01$$

Since 4.01 > 1.38, the null hypothesis is rejected; and it cannot be accepted that the ground cover on the release area is greater than or equal to the target ground cover.

Appendix F

Grasses of acceptable plant species\* for permanent cover on non-agricultural areas.

Warm Season Grasses		Cool Season Grasses		Legumes	
Bahiagrass	Paspalum notatum	Bluegrass	Poa pratensis Poa compressa	Bristly Locust	Lotus corniculatus
Bermudagrass	Cynodon dactylon	Redtop	Agrostis gigantea	Clovers	Trifolium pratense Trifolium repens Trifolium hybridum
Bluestems	Andropogon L. Schizachyrium scoparium	Orchardgrass	Dactylis glomerata	Lespedezas	Lespedeza cuneata
Buffalograss	Buchloe dactyloides	Fescues	Festuca arundinacea Festuca pratensis	Vetch	Coronilla varia Astragalus cice
Dallisgrass	Paspalum dilatatum	Ryegrass	Lolium perenne	<b>Forbes</b>	
Gramagrass	Bouteloua gracilis Bouteloua curtipenula	Wheatgrass	Agropyron smithii	Yarrow	Achillea lanulosa Achillea millefolium
Indiangrass	Sorghastrum nutans	<b>Aquatic/Semi-Aquatic</b>		Sunflower	Helianthus maximiliani Helianthus mollis
Lovegrass	Eragrostis curvula	Mudplantain	Heteranthera reniformis	Partridge pea	Cassia fasciculata
Switchgrass	Panicum virgatum	Ducksalad	Heteranthera limos	Sesbania	Sesbania exaltata
Deertongue	Panicum clandestinum	Arrowhead	Sagittaria latifolia		
Eastern Gamagrass	Tripsacum dactyloides	Bulrush	Scirpus acutus		

\*At any time during the planning, reclamation and sampling phases, the permittee may make a written request that the Surface Mining and Reclamation Division accept plant species not listed here.

APPENDIX GReferences

Bonham, Charles D., 1989. Measurements for Terrestrial Vegetation. Wiley, New York, 338 pages.

Chambers, Jeanne C., and Ray W. Brown. 1983. Methods for Vegetation Sampling and Analysis on Revegetated Mined Lands. U. S. Forest Service, Intermountain Forest and Range Experiment Station, Odgen, Utah. General Technical Report INT-151.