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Reference: Examples of Methods of Controlling Wind Erosion (Soil Blowing) Under Center Pivot Irrigation Systems With and Without Windbreaks

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NOTE:

Technical Notes MNTC Ecological Sciences 190-LI-2, "Determining the Effect of Field Windbreaks and Wind Barriers on Wind Erosion (Soil Blowing) on a Given Field," January 1983, and MNTC Ecological Sciences 190-LI-3, Examples of Methods of Controlling Wind Erosion on a Given Field With and Without Windbreaks and Wind Barriers," January 1983, should be reviewed prior to reading this technical note.

Author wishes to thank M. Scott Argabright, MNTC agronomist, SCS, and Keith Ticknor, state staff forester, SCS, Lincoln, Nebraska, for assistance in preparing the "Quick Reference Chart for the Design of Windbreaks, Vegetative Barriers, or Buffer Strips for Southcentral Kansas."

Examples of Methods of Controlling Wind Erosion (Soil Blowing) Under Center Pivot Irrigation Systems With And Without Windbreaks

Wind erosion (soil blowing) can be a serious problem under center pivot and other types of overhead irrigation systems. In those situations where crops do not produce adequate crop residues to keep soil losses to wind and water erosion within soil loss tolerances (T)[1/] or where the residues are inadequate to protect young seedlings or sensitive crops, opportunities exist to design unique wind erosion control systems. This technical note was developed to present ideas and to stimulate the user into using a systems approach to solving wind erosion (soil blowing) problems on wind erosion prone soils under overhead irrigation systems. Although many examples are given, they do not represent all the alternatives that could be developed.

It is of the utmost importance in the design of wind erosion control systems to consider all the practices that can be used to control wind erosion. Different crops and different farming practices dictate the need to tailor wind erosion control systems to the specific needs of the individual land user.

Each soil has some degree of inherent resistance to erosion. This built-in erosion retardance is further enhanced by management variables which affect conditions at the ground surface-surface residue and tillage induced surface roughness. The interaction of these three retarding effects is referred to in this paper as surface resistance.

[1/] (T)--Soil loss tolerance is defined as the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely.

Surface resistance inhibits saltation and the resulting avalanching effect of soil movement along the ground surface. Soil movement is reduced, and the distance over which soil movement is contained within selected tolerances is extended. Thus, some distance is adequately protected by surface resistance without need for additional conservation measures.

Other practices add support to the effect of surface resistance in one of two ways:

1. Barrier effects which reduce wind velocity near the ground surface downwind of the barrier. Barriers may be trees, shrubs, perennial grasses, annual crops, or combinations of these. Tree or shrub windbreaks protect relatively wide field areas at mature height. Perennial grass barriers become effective more quickly but protect less distance downwind. Annual crop barriers are temporary requiring reestablishment each year and are generally less effective.

2. Field layouts which reduce the erosion-susceptible distance downwind from a stable point. Conventional stripcropping or narrow buffer strips are used to create strips protected by cover alternating with erosive strips. The protected strips interrupt saltation and create additional stable edges. The distance protected downwind is determined by the surface resistance interactions.

The following figures illustrate how a variety of wind erosion control practices can be used to control wind erosion problems under center pivot systems. In some cases the practices will be used alone and in other cases, they will be used with other practices. The following field information will apply to figures 1, 2, 3, and 4.

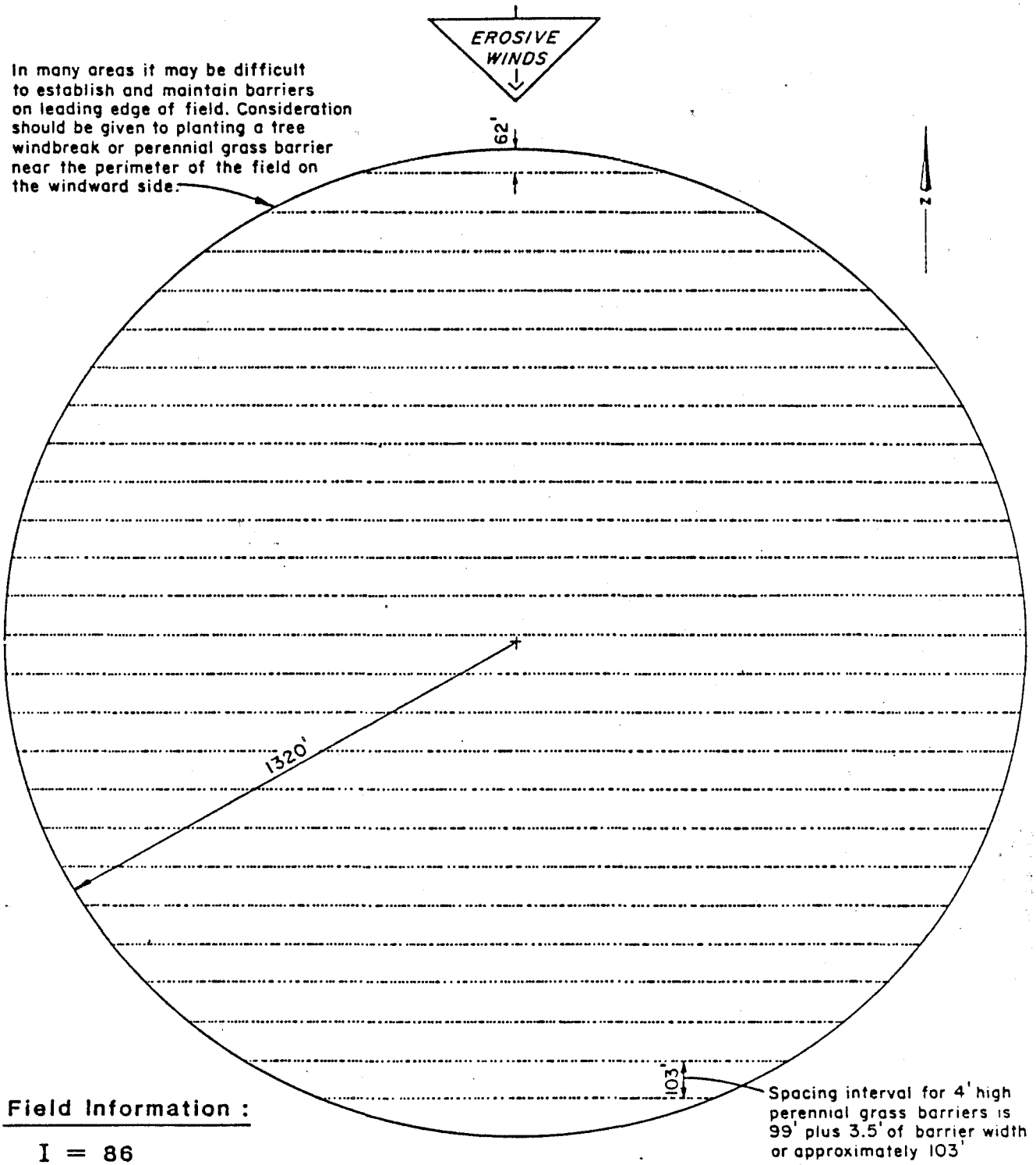
Field Size - 2,640 ft/diameter
- approx. 126 acres[1/]
I = 86 (sandy loam)
K = 0.8
C = 40
V = 0 lbs/Ac
Maximum Allowable Annual Losses to
Wind Erosion--4 T/Ac/Yr[2/]

The "Quick Reference Chart for the Design of Windbreaks, Vegetative Barriers, or Buffer Strips for south-central Kansas" attached to this technical note was used for determining spacing intervals for all figures.

Since adequate residues (approximately 1,250 lbs/Ac are needed) are not available to the landowner, it becomes obvious that something must be done or the potential losses to wind erosion (soil blowing) will exceed acceptable limits. In this case there is a 4 T/Ac/Yr limit. Without adequate residues, the best way to control wind erosion is to find some means to divide the field into smaller subfields.

[1/] No end gun.
[2/] T-Abbreviation for Ton or Tons. It should not be confused with soil loss tolerance (T) which represents the maximum annual level of soil erosion loss that is recommended for a given soil. Soil loss tolerance (T) is a combination of wind and water erosion losses.

One way, illustrated in figure 1, is to use 4-foot-high annual crop or perennial grass barriers spaced at intervals determined through the use of the wind erosion equation. The Quick Reference Chart for the Design of Windbreaks, Vegetative Barriers, or Buffer Strips attached to this technical note was developed by using the wind erosion equation. Using the Quick Reference Chart for an I = 86, K = 0.8, C = 40, we can determine the spacing interval required to keep soil losses below the 4 T/Ac/Yr maximum limit. The chart shows that for a V = 0 (crop residue during critical period) and barrier height of 4 feet, the spacing interval between barriers is 99 feet. The spacing interval including the width of the barrier is 99 feet + 3.5 feet or approximately 103 feet. Starting on the windward edge of the field, the first barrier should be placed approximately 62 feet from the edge. This distance is essentially the width of field that would be considered adequately protected (to within the maximum 4 T/Ac/Yr soil loss) by surface resistance. In this case no residues would be present to interact with the other factors that determine surface resistance. Using the chart with a barrier height of 0, V = 0 and a maximum soil loss of 4 T/Ac/Yr, we obtain the field width of 62 foot. After placing the first barrier at 62 feet, all other barriers should be placed at approximately 103 feet. Dividing 2,518 (2,640-62) by 103 indicates that 25 barriers would be needed to provide protection to the entire field.



Field Information :

I = 86

K = 0.8

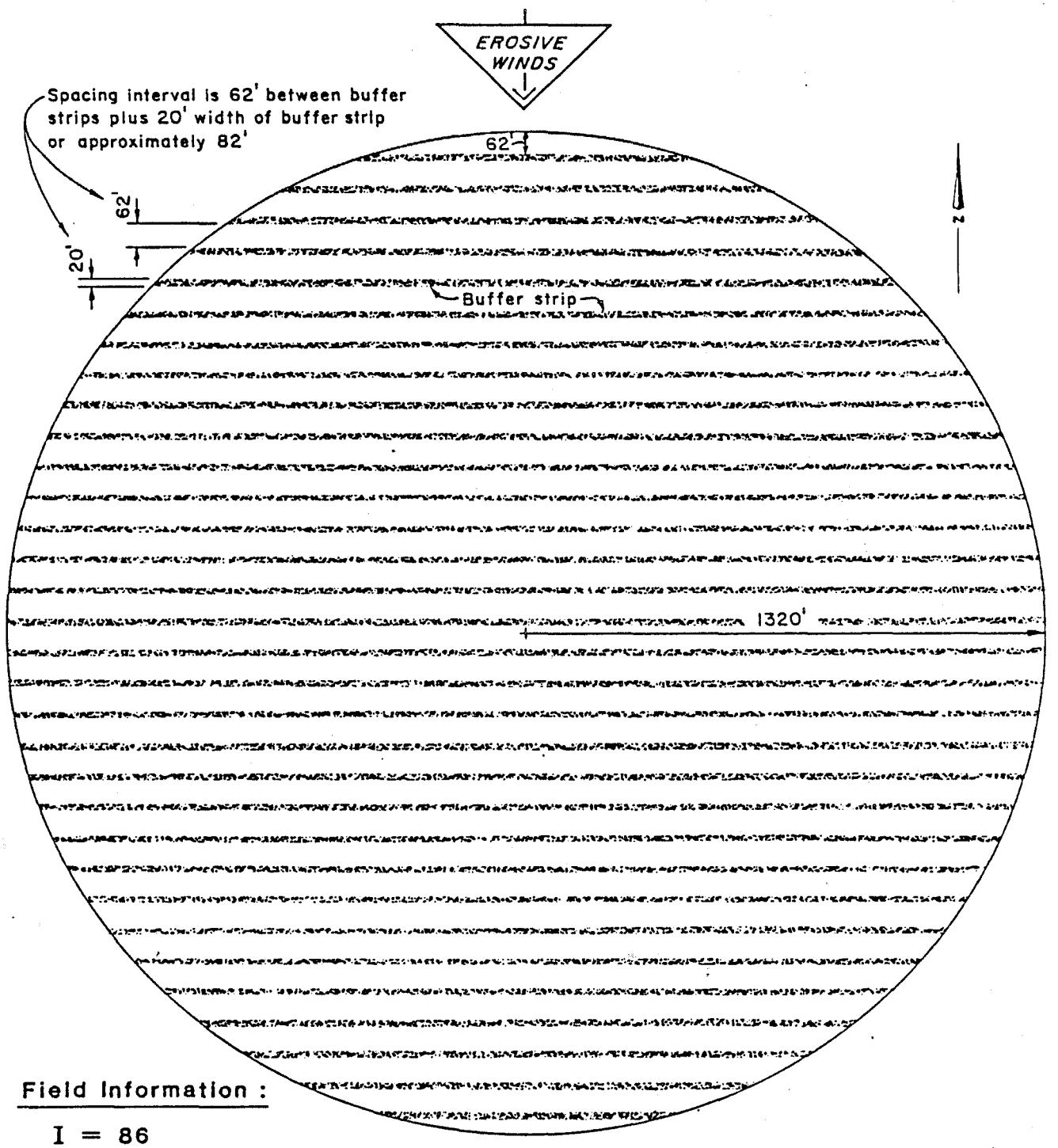
C = 40

V = 0 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 1. 4 ft. annual crop or perennial grass barriers.

There are many ways to divide a larger field into smaller subfields that are adequately protected. Figure 2 illustrates how buffer strips could be used to protect the field. Buffer strips are vegetative barriers, less than 2 feet in height, that can be used to stop the wind erosion process. Alfalfa, other hay crops, and grain sorghum stubble would be examples of buffer strips. To be effective, all hay crops must have enough regrowth (alive or dead) to stop the wind erosion process and all grain crops must have a substantial amount of stubble standing at the critical times of the year. The buffer strips should be a minimum of approximately 12 feet in width. Starting at the windward edge of the field, there would be a 62-feet width of field protected by surface resistance. Since no credit is taken for barrier height, this also becomes the spacing interval between strips. Using the Quick Reference Chart with a zero feet barrier height, zero pounds of crop residue, and a 4 T/Ac/Yr maximum annual potential soil loss to wind erosion, the spacing interval, including the buffer strip, can be determined. The total spacing interval is 62 feet (width of field protected by surface resistance) plus 20 feet (width of buffer strip) or 82 feet. A total of 32 buffer strips (2,578 ÷ 82) would be required to protect the entire field.



Field Information :

I = 86

K = 0.8

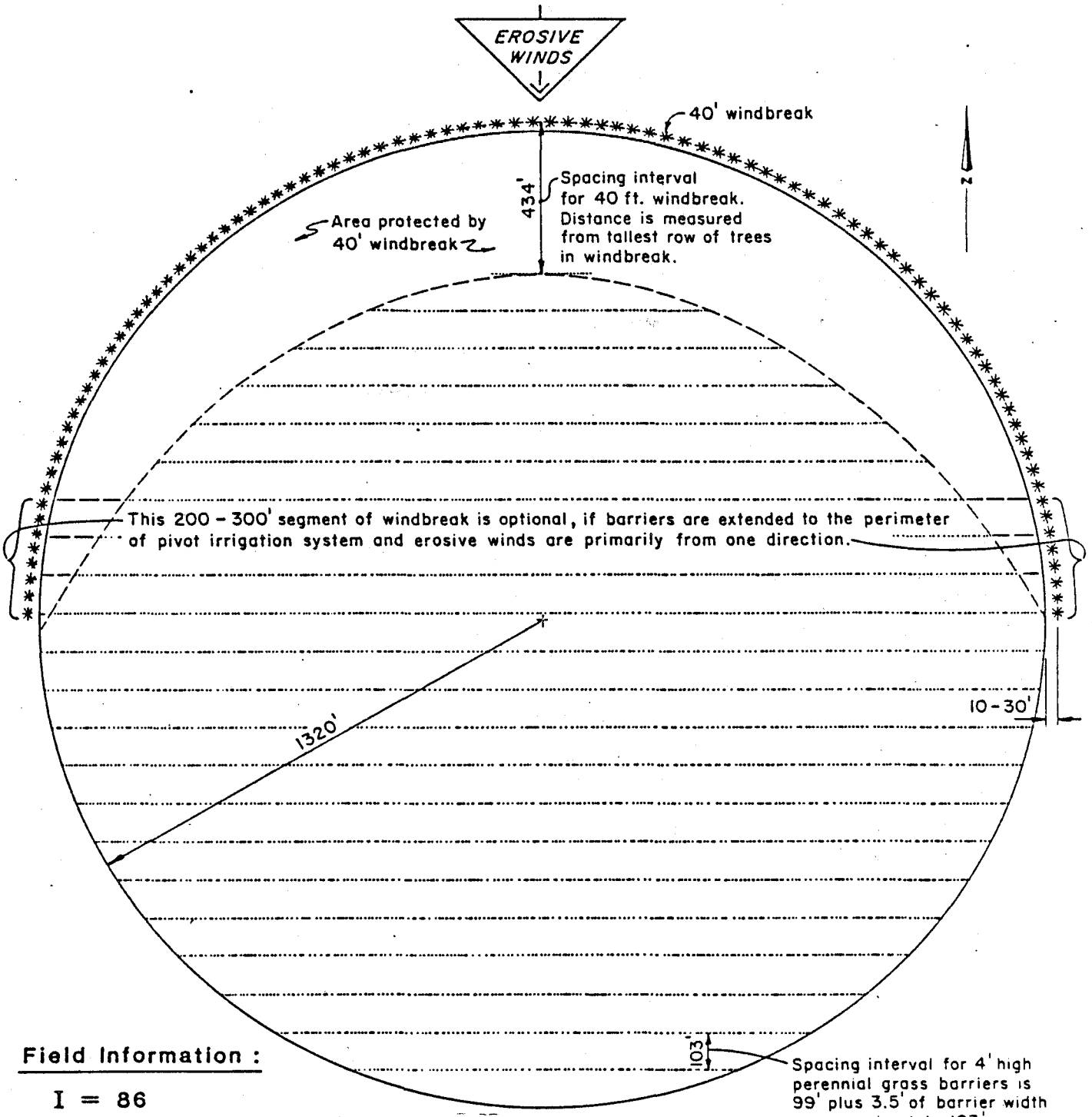
C = 40

V = 0 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 2. Buffer strips (less than 2 ft. in height) 20 ft. wide.

In many instances the windward edge of a field is subject to blowing soils from adjacent areas. The blowing soils can cause serious damage to vegetative barriers and crops before the wind erosion control practices in the field can be fully effective. Where this occurs and where high winds are common during the irrigation season, there are opportunities to use tree windbreaks on the leading edge of the field to control blowing soil and improve the distribution of irrigation water. Figure 3 illustrates the use of a 40-foot-high field windbreak on the windward edge of a field and 4-foot-high annual crop or perennial grass barriers on the remainder of the field. Since no residues are present, the windbreaks and the wind barriers are the essential components of the wind erosion control system. At the widest point, the windbreak and surface resistance will protect approximately 434 feet of field. See Quick Reference Chart for 40-foot-high windbreak (barrier), zero pounds of residue and maximum soil loss of 4 T/Ac/Yr. Since 4-foot barriers will be used on the remainder of the field, a spacing interval of 99 feet (width of field protected by surface resistance--62 feet plus width of field protected by barriers--37 feet) plus 3.5 feet (width of barrier) or 103 feet will be used (see Quick Reference Chart). Approximately 22 barriers (2,206 ÷ 103) will be needed to protect the remainder of the field.



Field Information :

I = 86

K = 0.8

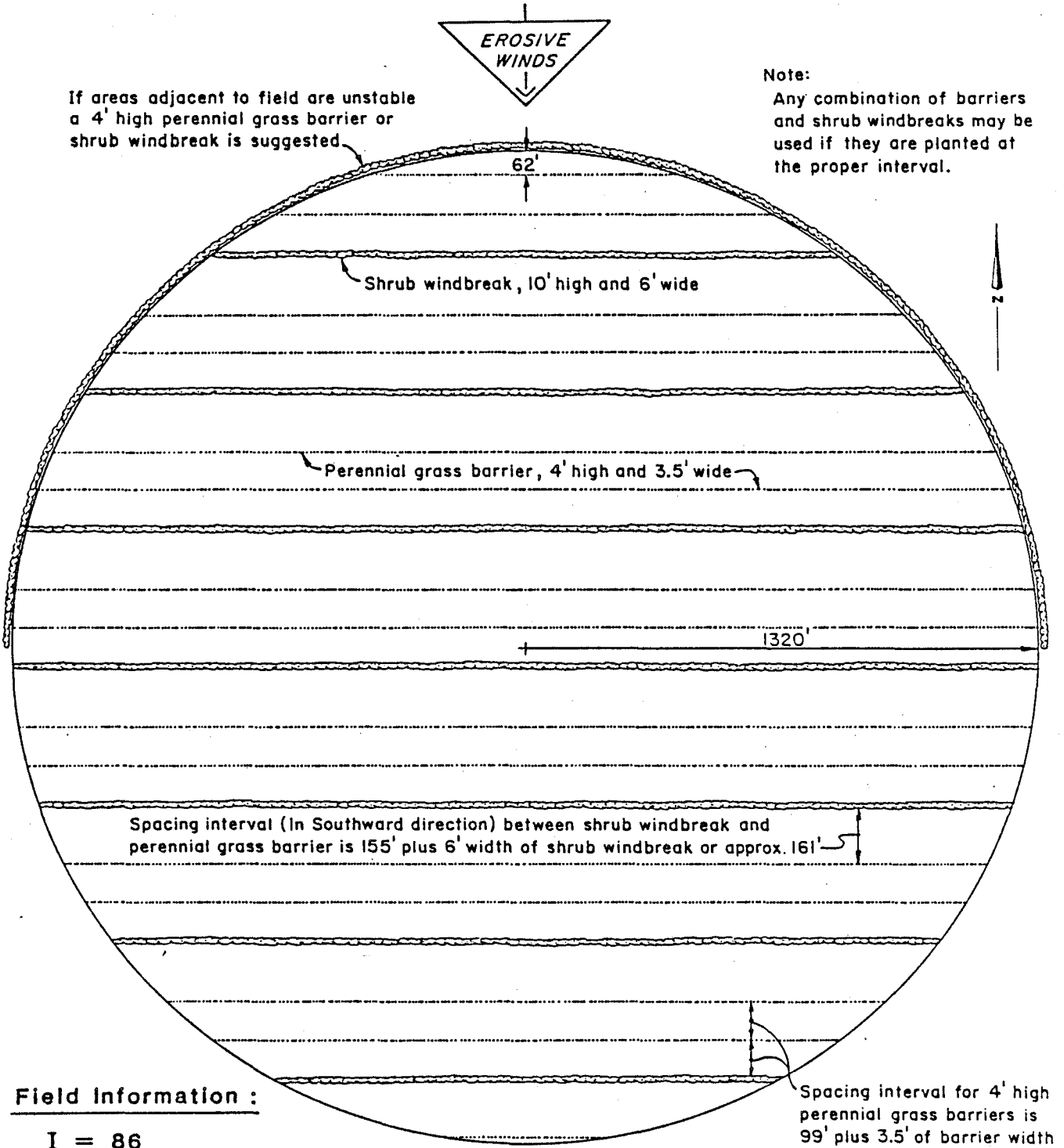
C = 40

V = 0 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 3. 40 ft. windbreak and 4 ft. annual crop or perennial grass barriers.

The use of woody plants beneath the overhead lateral pipe of the systems will be limited to those woody plants that will not significantly exceed the height to the pipe or those woody plants that can be maintained at an acceptable height through shearing. Generally, this will limit the height of woody plants to 9 to 13 feet in total height. Figure 4 illustrates a wind erosion control system which uses 10-foot-high shrub windbreaks and 4-foot-high perennial grass barriers to provide an adequate degree of protection to the field. Although it may not be needed, it is suggested that a strip of perennial grass in the form of a barrier or a shrub or tree windbreak be placed at the windward margin of the field to protect the field from soil blowing on adjacent areas. Although the arrangement of shrub rows and grass barriers can vary within the field, the spacing total interval for grass barriers will be approximately 103 feet (99 feet + 3.5 feet) apart and the spacing interval for the 10-foot-high, 6-foot-wide shrub windbreaks would be approximately 161 feet (155 feet + 6 foot). They can be used in any combination or sequence. In the illustration, beginning at the windward edge of the field, two perennial grass barriers are planted at 103 feet intervals. These are followed by a shrub windbreak, which protects 161 feet (includes distance of 62 feet protected by surface resistance.



Field Information :

I = 86

K = 0.8

C = 40

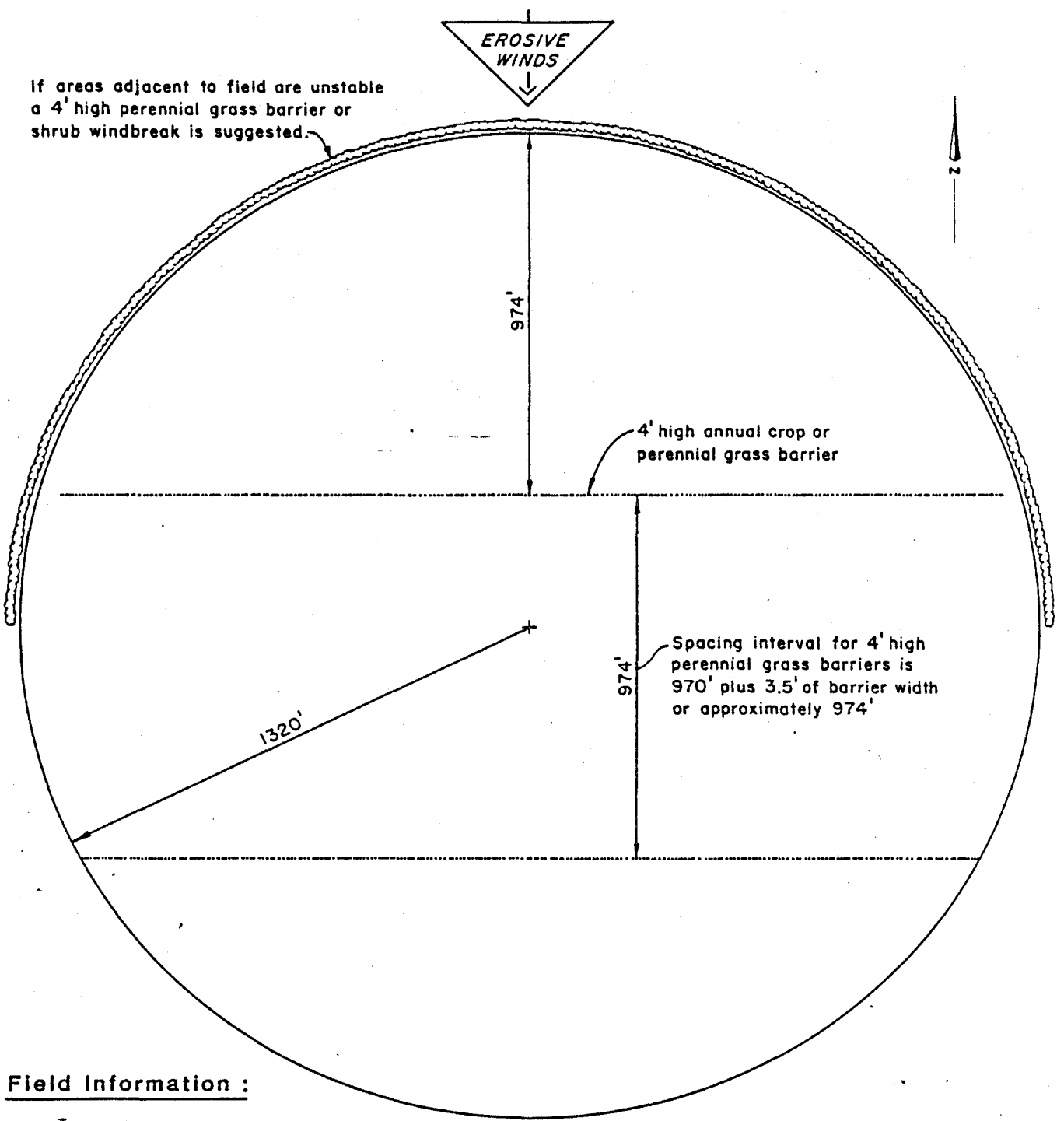
V = 0 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 4. 10 ft. shrub windbreaks and 4 ft. annual crop or perennial grass barriers.

By adding residues to a given wind erosion control system, we widen the portion of a given field that is protected by surface resistance. This, in turn, widens the spacing intervals between buffer strips, barriers, and windbreaks. Less area of a given field is devoted to these practices but the degree of protection is the same.

For figures 5, 6, 7, and 8, the following field information will apply: I = 86, K = 0.8, C = 40, and V = 1,000 lbs/Ac. The introduction of the 1,000 lbs of residue per acre dramatically changes the spacing intervals between buffer strips, barriers, and windbreaks. In figure 5, the availability of the 1,000 lbs of residue results in the need for only two 4-foot-high annual crop or perennial grass barriers to protect the entire field. However, consideration should be given to providing for a windbreak or perennial grass barrier on the windward edge of the field, if blowing soil could be a problem on areas adjacent to the center pivot area. Using the Quick Reference Chart, it is easy to determine that the spacing interval between the barriers should be approximately 974 feet (970 feet + 3.5 feet).



Field Information :

I = 86

K = 0.8

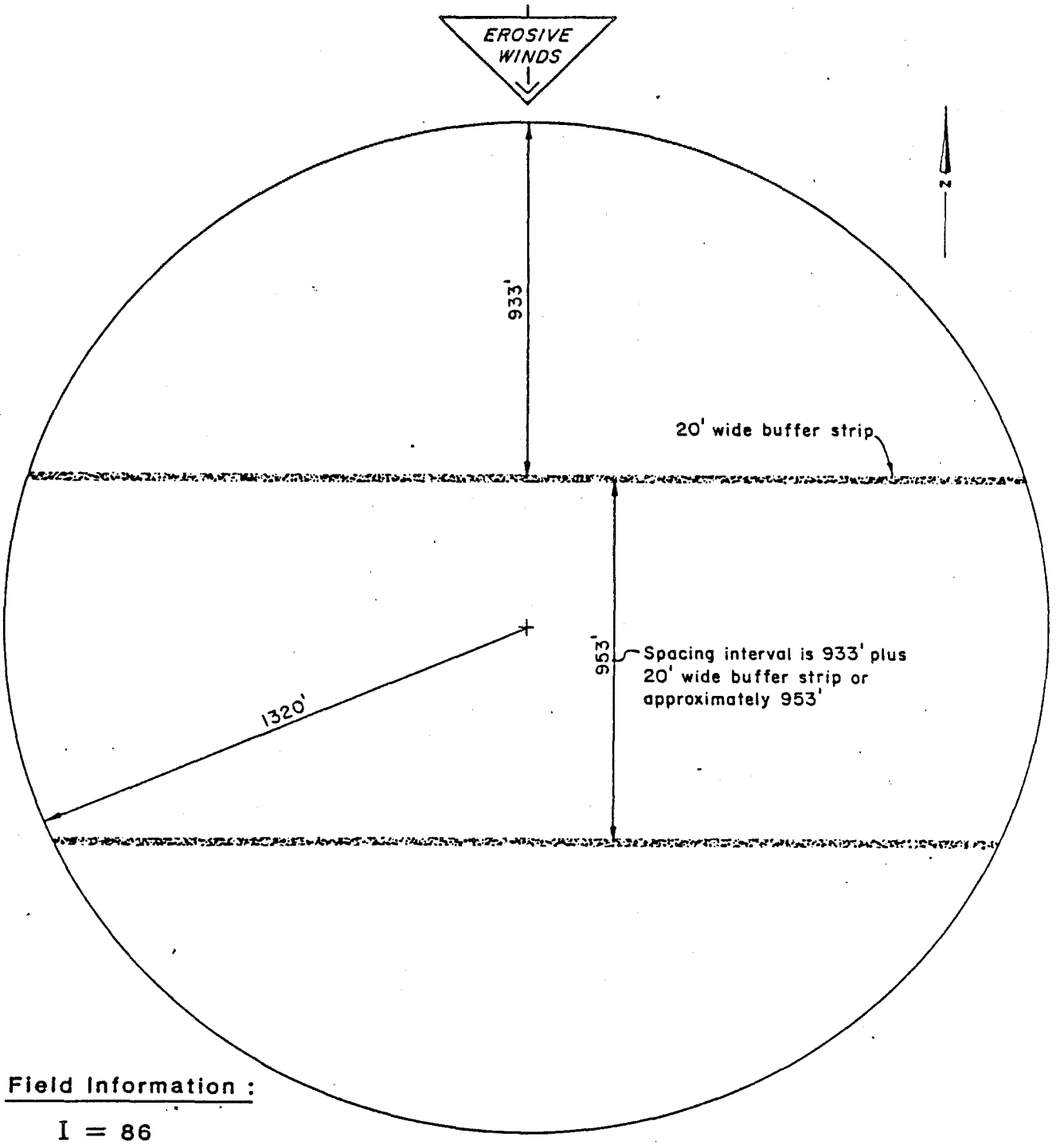
C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 5. 4 ft. annual crop or perennial grass barriers.

Buffer strips less than 2 feet in height are illustrated as providing adequate wind erosion control protection in figure 6. The field factors were the same as for figure 5. With the 1,000 lbs/Ac of residue, two buffer strips located at approximately 953 feet (933 feet + 20 feet) provide adequate protection.



Field Information :

I = 86

K = 0.8

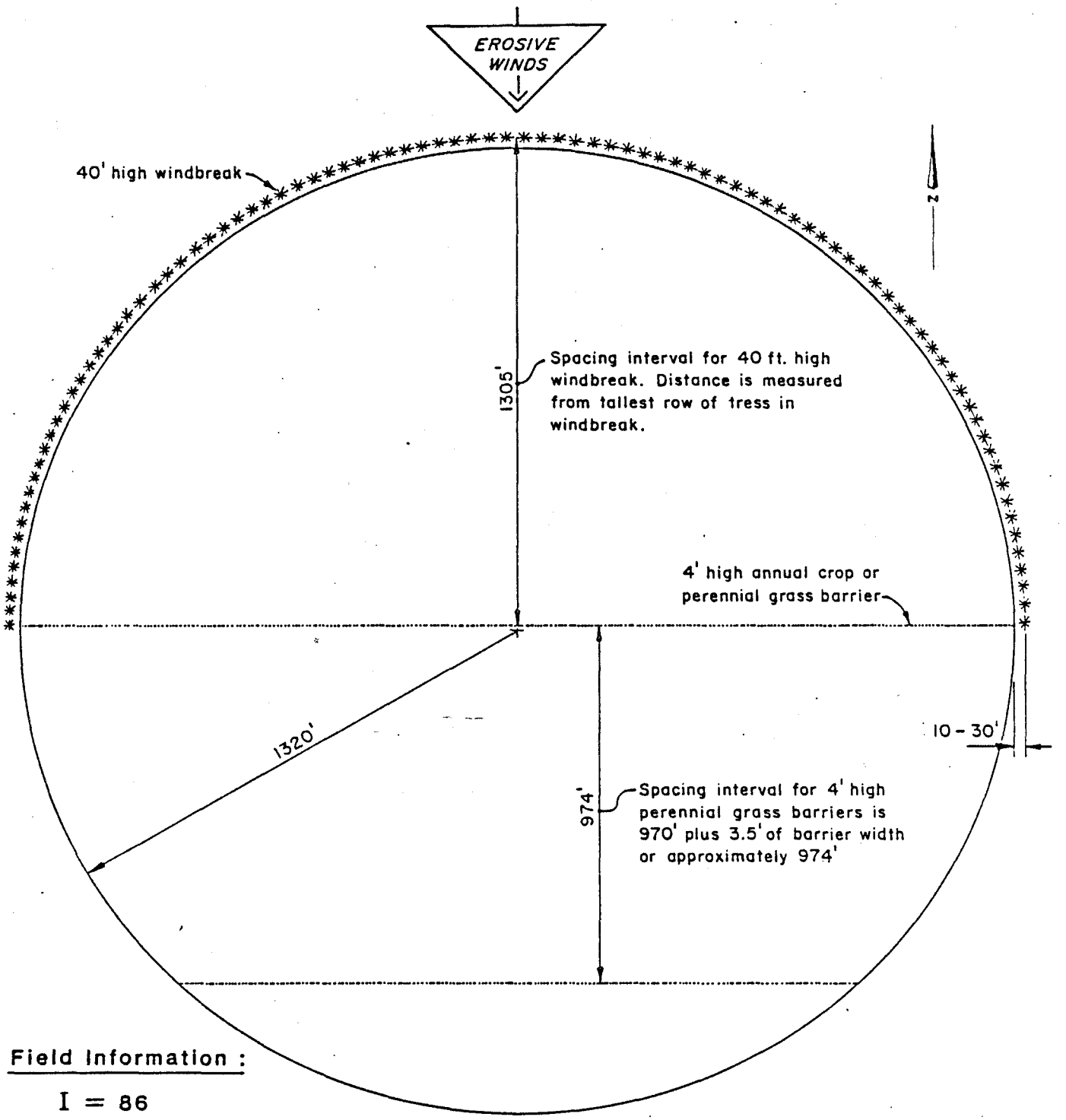
C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 6. Buffer strips (less than 2 ft. in height) 20 ft. wide.

For fields needing a high degree of protection, the wind erosion control system in figure 7, V = 1,000 lbs/Ac, K = 0.8, with a 40-foot-high windbreak on the windward edge and two 4-foot-high annual crop or perennial grass barriers, is a realistic solution to soil blowing problems. The maximum width of field protected by the 40-foot-high windbreak and 1,000 lbs of residue is 1,305 feet (372-feet windbreak, plus 933-feet surface resistance). This represents approximately one-half the field. Two 4-foot-high annual crop or perennial grass barriers spaced at approximately 974 feet (37-feet distance protected by barrier, plus 3.5 feet width of barrier, plus 933-feet distance protected by surface resistance) will adequately protect the remainder of the field.



Field Information :

I = 86

K = 0.8

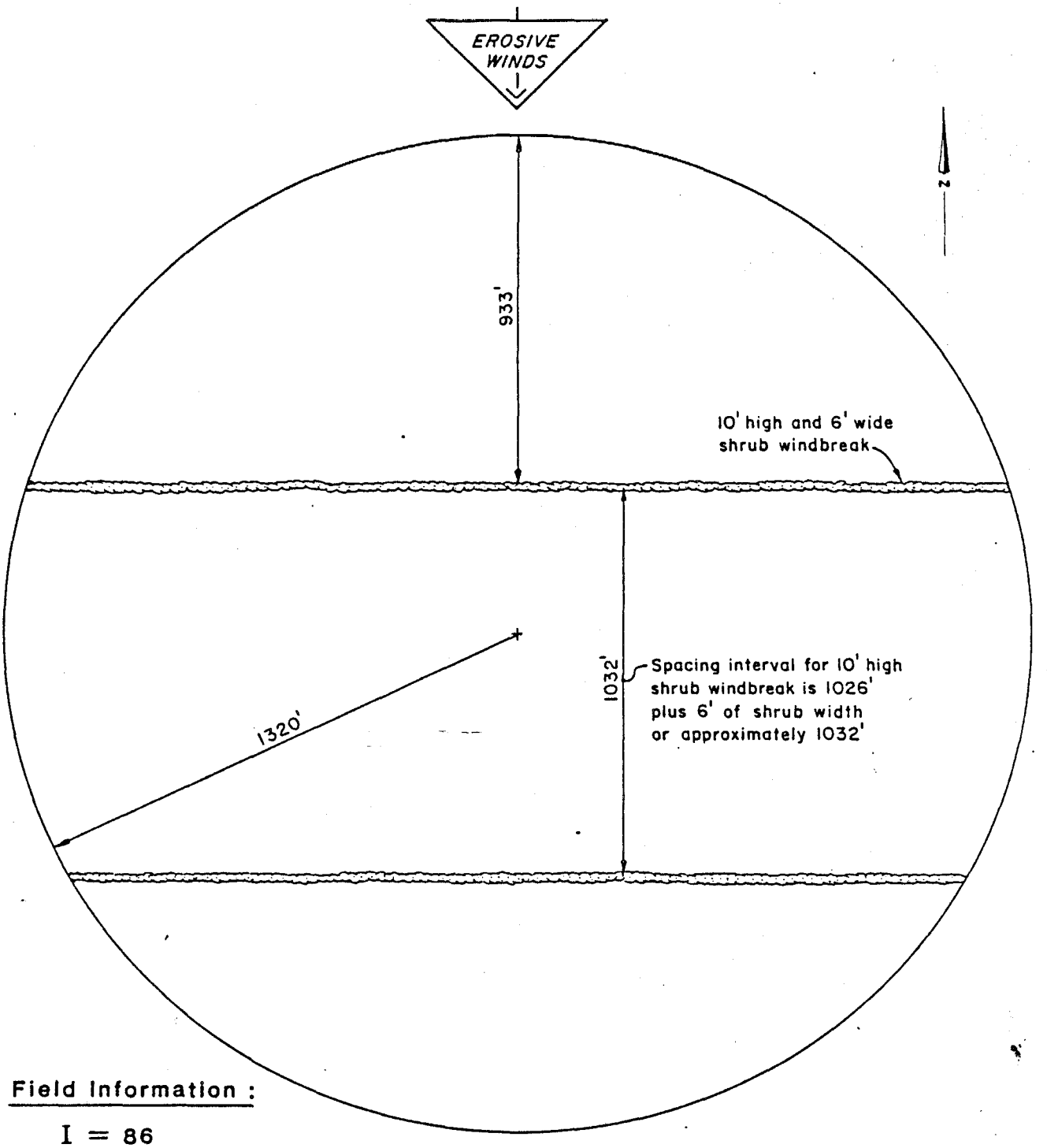
C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 7. 40 ft. windbreak and 4 ft. annual crop or perennial grass barriers.

The 1,000 lbs/Ac of residue also presents an excellent opportunity to use shrub windbreaks under the irrigation system. Figure 8 illustrates how two 10-foot-high shrub windbreaks can be utilized in a wind erosion control system. Since 1,000 lbs of residues and a K = 0.8 will provide enough surface resistance to protect 933 feet of the windward side of the field, the first windbreak will be planted downwind at approximately this distance. The spacing interval between the first and second windbreak is approximately 1,026 feet (93-feet distance protected by windbreak, plus 933-feet surface resistance). An additional 6 feet could be added to the spacing interval (bringing it to approximately 1,032 feet) to allow for the width of field devoted to the windbreak. However, since the width of field protected by the second windbreak and the width of field protected by surface resistance was more than enough to protect the field downwind from the second windbreak, the 6 feet was disregarded.



Field Information :

I = 86

K = 0.8

C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

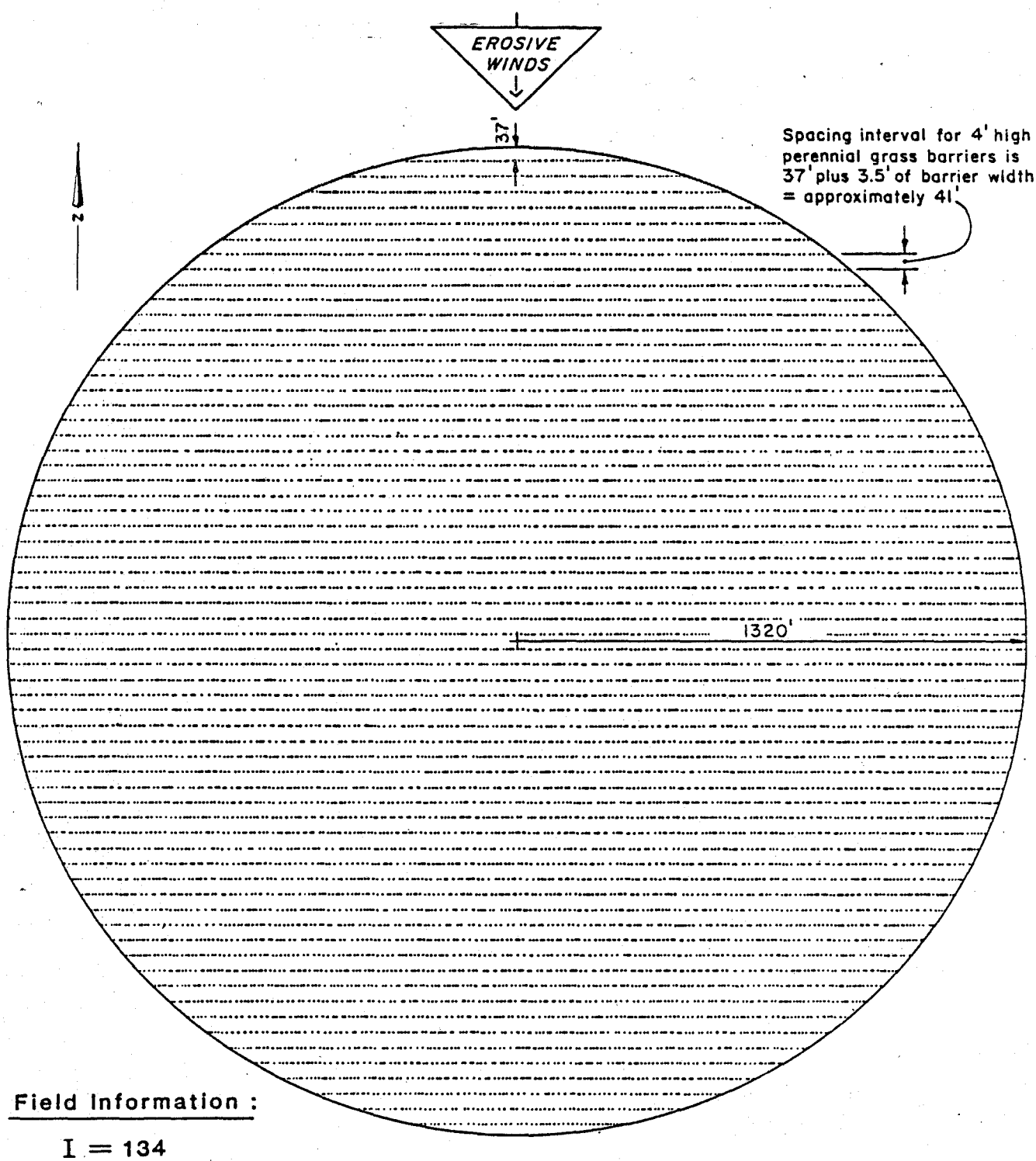
Figure 8. 10 ft. shrub windbreaks.

Soils with a loamy sand or sand texture in all areas of the United States can be subject to severe wind erosion (soil blowing) problems, if they are planted to annual crops. This is especially true, where the crops produce low amounts of crop residue, or if the residues of high residue producing crops are destroyed. Since these soils are commonly planted to vegetables, mellons, soybeans, dry beans, peanuts, cotton, and other low residue producing crops, there is also a severe hazard for plant damage or crop degrading due to blowing soils. Most of these plant species require the design of wind erosion control systems that allow for 1 T/Ac/Yr or less annual potential soil losses to wind erosion. Figures 9 through 15 illustrate what could be done to protect soils with a loamy sand texture.

For figures 9 and 10, the following field information will apply-I = 134, K = 1.0, C = 40, and V = 0 lbs/Ac. The maximum potential annual soil loss to wind erosion is 4 T/Ac/Yr.

Annual crop or perennial grass barriers can be used to effectively control the wind erosion on loamy sand soils. Figure 9 illustrates the use of 4-foot-high annual crop or perennial grass barriers. Using the Quick Reference Chart to determine spacing intervals, we can determine that the spacing interval between barriers should be approximately 41 feet (37-feet width of field protected by barrier, plus 3.5-feet width of barrier). Without adding residues into the wind erosion control system, surface resistance will not protect any width of field to within the 4 T/Ac/Yr allowable annual soil loss to wind erosion.

If the area adjacent to the irrigated field is stable, there would be a need to use approximately 64 annual crop or perennial grass barriers which are 4 foot in height.



Field Information :

I = 134

K = 1.0

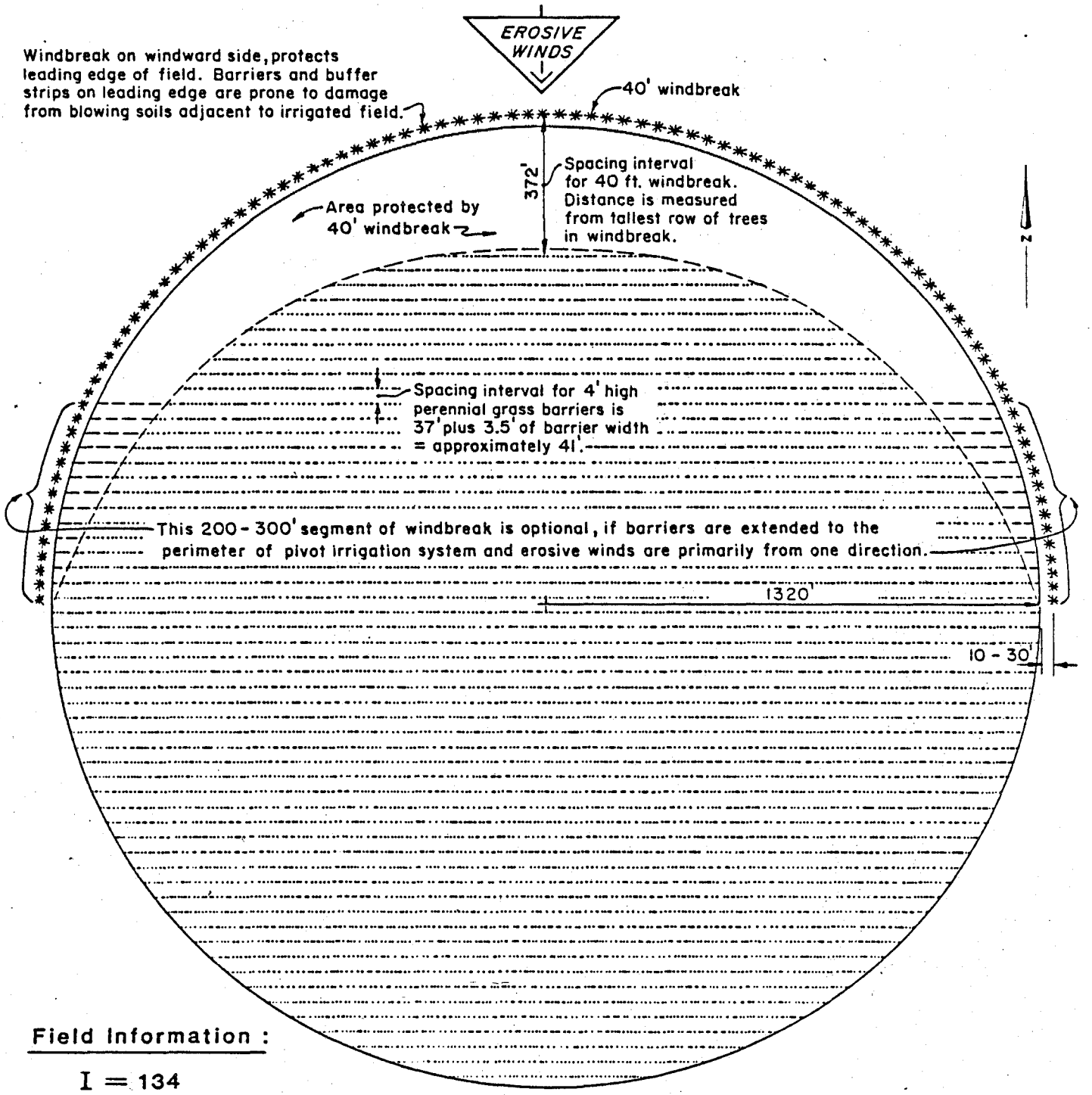
C = 40

V = 0 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 9. 4 ft. annual crop or perennial grass barriers.

The windward edges of fields with loamy sand soil textures can be subjected to soil blowing problems from adjacent areas. When this occurs, the vegetative barriers, crops, and residues on the windward side of the field can be severely damaged for some distance into the field. It is important to design wind erosion control systems which adequately protect adjacent areas or establish buffer strips, barriers or windbreaks which will stop the soil blowing at the field border. Figure 10 illustrates the use of a 40-foot-high field windbreak to stop all soil blowing before it reaches the field. In addition, it will provide adequate protection to approximately 372 feet of field (at its widest point). All of this protection is provided by the windbreak (see Quick Reference Chart). The remainder of the field would be protected by the 4-foot-high annual crop or perennial grass barriers at spacing intervals of approximately 41 feet (37 feet width of field protected by barrier, plus 3.5-feet width of barrier). Approximately 56 barriers would be needed. Shrub windbreaks could also be effectively used on loamy sands and sands in manner similar to those illustrated in figure 4. Buffer strips could not be effectively used without the addition of residues into the wind erosion control system.



Field Information :

I = 134

K = 1.0

C = 40

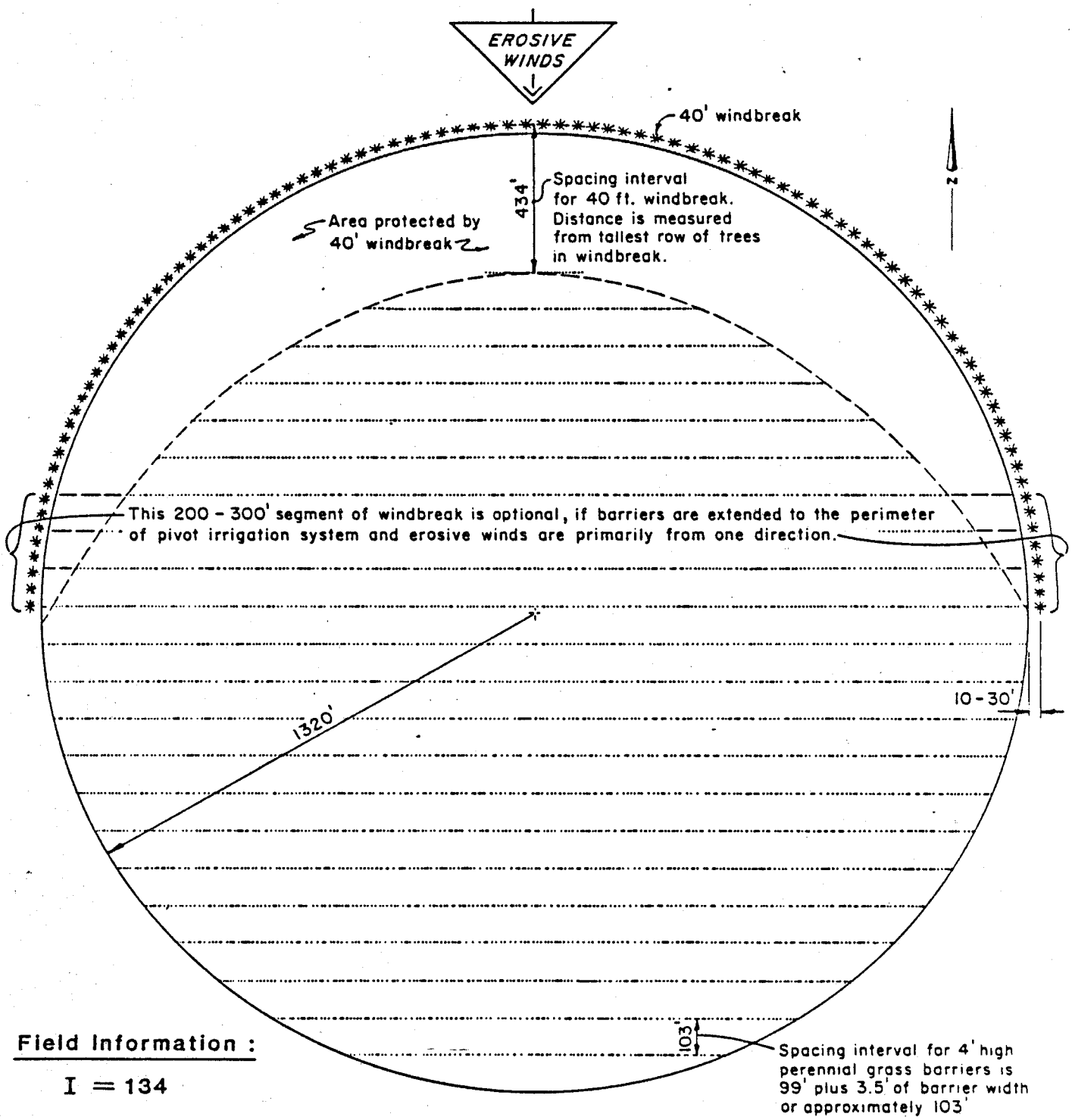
V = 0 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 10. 40 ft. windbreak and 4 ft. annual crop or perennial grass barriers.

On loamy sand and sandy soils, it is very important to utilize all residues in the most effective manner in the design of wind erosion control systems. Where high residue amounts are not produced, serious consideration should be given to utilizing cover crops. Both the residues from field crops and/or cover crops can be effective in controlling soil blowing. Their effective use can drastically reduce the amount and number of other practices needed. In figures 11 through 15, the following field information applies: I = 134, K = 1.0, C = 40, V = 1,000 lbs/Ac and the maximum potential annual soil loss to wind erosion is 4 T/Ac/Yr.

The wind erosion control system in figure 11 utilizes a 40-foot-high field windbreak on the windward edge, 4-foot-high annual crop or perennial grass barriers within the field and 1,000 lbs of residue on the surface. The width of field protected by the windbreak and width of field protected by surface resistance adequately protects approximately 434 feet (372 feet protected by windbreak, plus 62 feet protected by surface resistance) at the widest point on the windward edge of the field (see Quick Reference Chart). The remainder of the field is protected by approximately twenty-two 4-foot-high annual crop or perennial grass barriers planted at 103 feet intervals (99 feet + 3.5 feet).



Field Information :

I = 134

K = 1.0

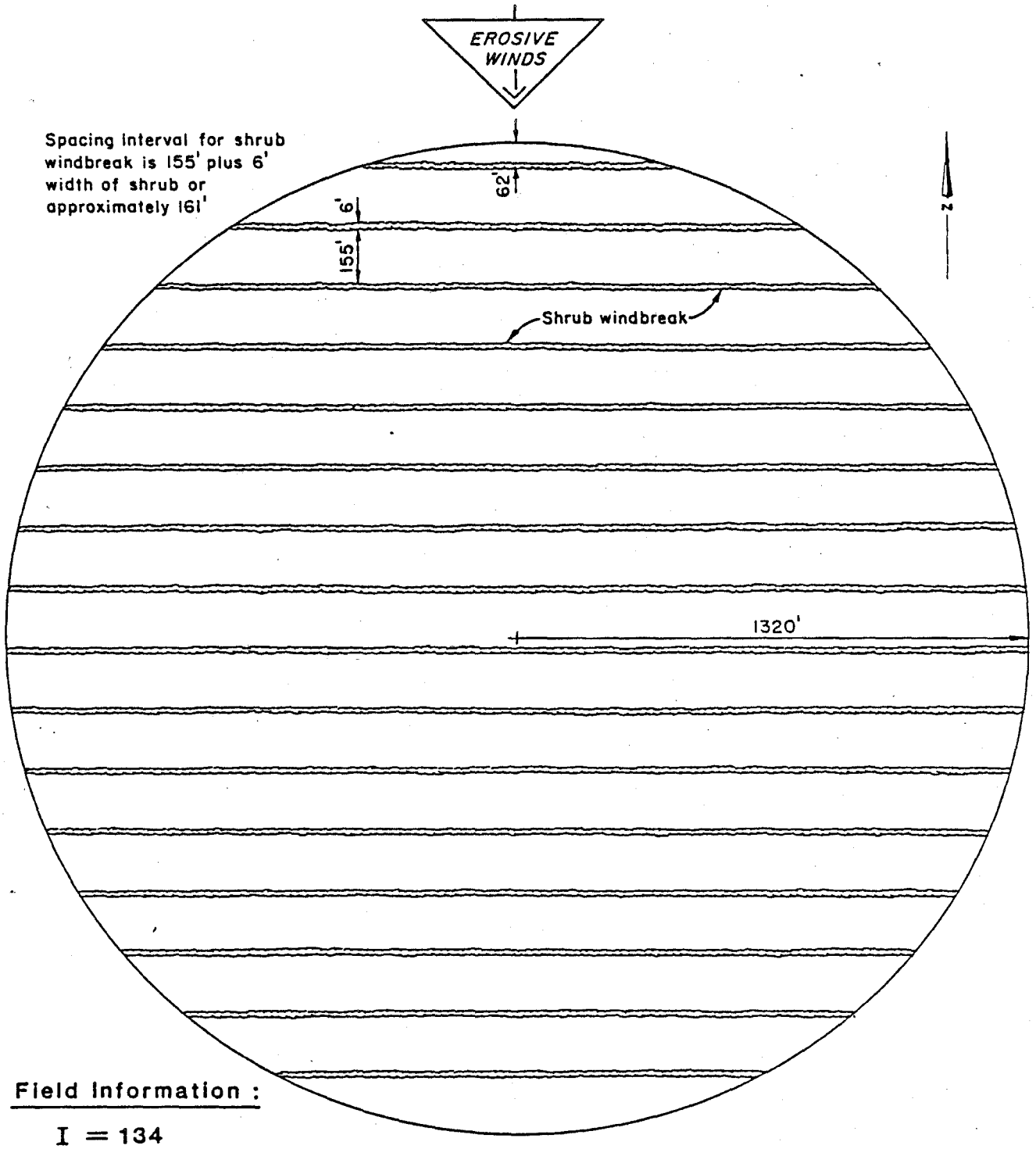
C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 11. 40 ft. windbreak and 4 ft. annual crop or perennial grass barriers.

Shrub windbreaks and the 1,000 lbs/Ac residue are the primary components of the wind erosion control system illustrated in figure 12. The shrub windbreaks have an effective height of 10 feet and are approximately 6 feet in width. Using the Quick Reference Chart, the width of field protected by the windbreak and surface resistance is 155 feet. The spacing interval between the windbreaks is approximately 161 feet (155 feet plus 6 feet). The first shrub windbreak will be located approximately 62 feet in from the windward side of the field. Sixteen 10-foot-high shrub windbreaks would be needed to protect the entire field. A design of this type would be excellent for growing vegetables or other high value crops.



Field Information :

I = 134

K = 1.0

C = 40

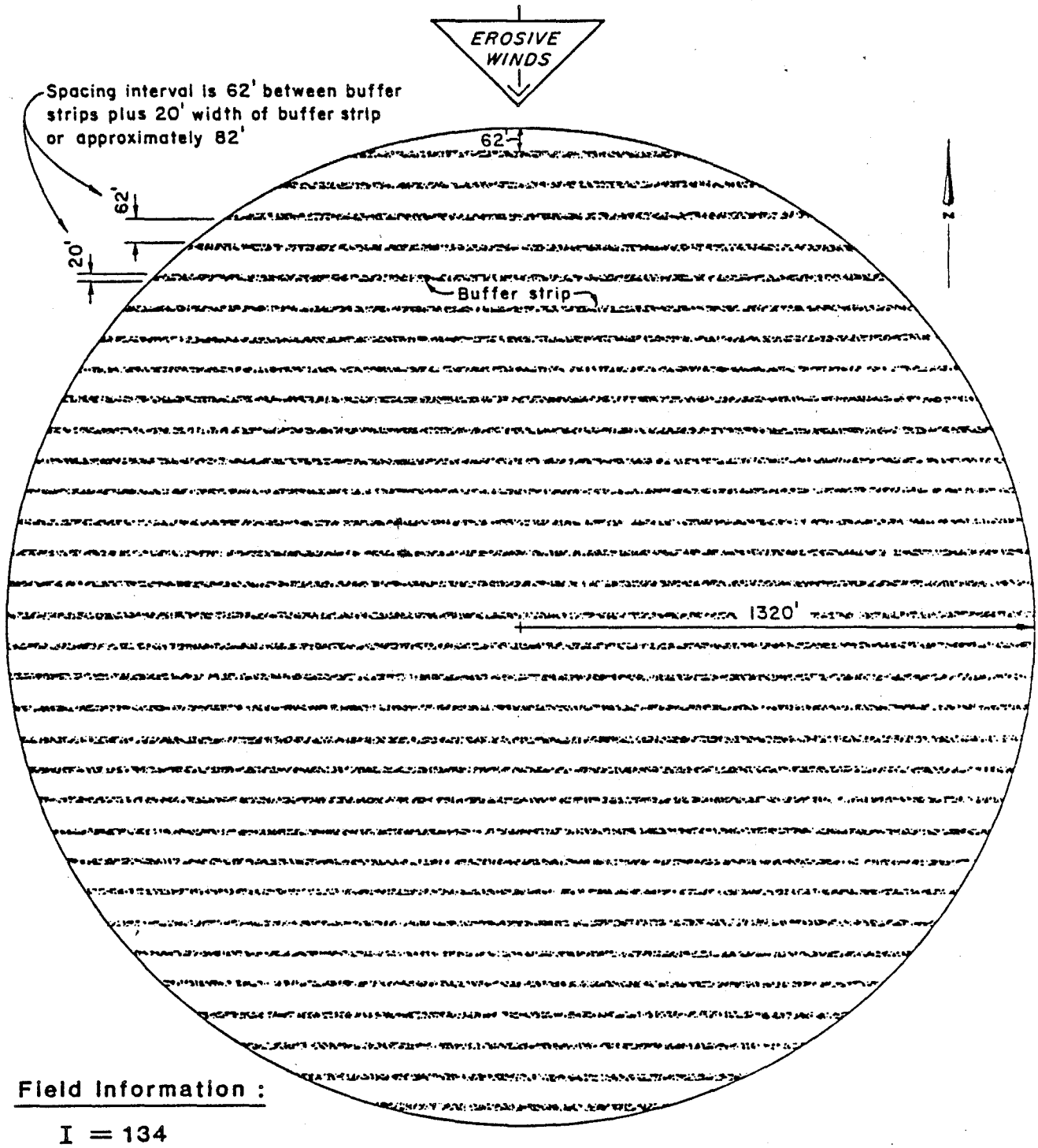
V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 12. 10 ft. shrub windbreaks.

The availability of the 1,000 lbs/Ac of residue makes it possible to utilize buffer strips on loamy sands. Figure 13 shows 32 buffer strips, which are 20 feet wide, being used to adequately protect the field. The Quick Reference Chart shows that surface resistance will protect a field width of 62 feet. The 62 feet added to the 20-feet width of the buffer strip is the total spacing interval (approximately 82 feet).

NOTE: Buffer strips can be less than 20 feet in width but should generally not be less than 12 feet in width.



Field Information :

I = 134

K = 1.0

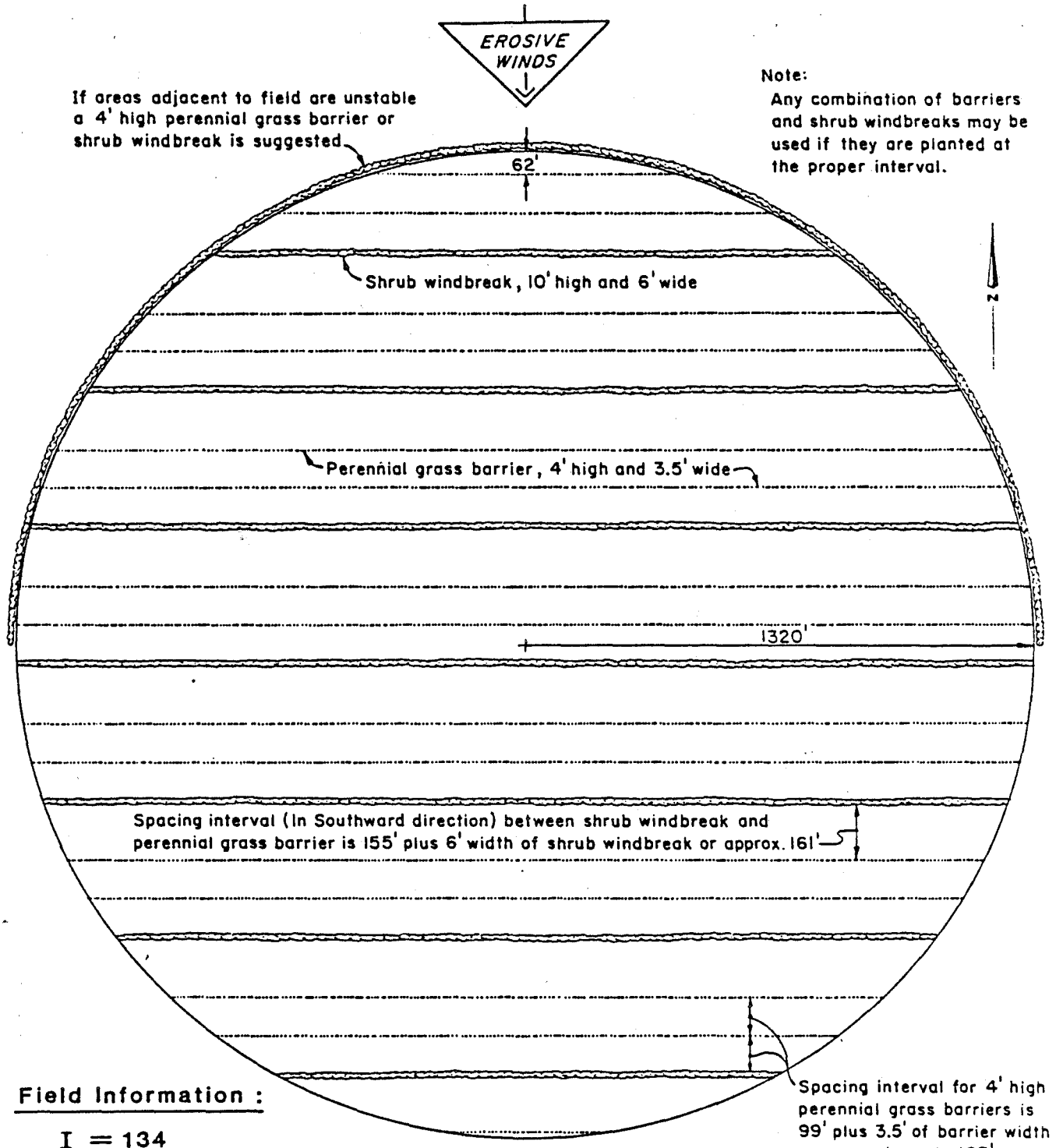
C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 13. Buffer strips (less than 2 ft. in height) 20 ft. wide.

By using several wind erosion control practices in the design of a wind erosion control system, a wide variety of systems can be developed. Figure 14 incorporates a field windbreak or perennial grass barrier on the windward side of the field, 10-foot-high shrub windbreaks, and 4 foot high perennial grass barriers within the field and 1,000 lbs/Ac of residue. The protection of the windward edge of the field by the windbreak or perennial grass barrier outside the field, allows for the placement of the first grass barrier at approximately 62 feet. The spacing interval between the first and second barrier is approximately 103 feet (99 feet + 3.5 feet). This is also the spacing distance between the second barrier and first shrub windbreak. Since the 10-foot-high shrub windbreak will protect 93 feet (width of field protected by windbreak) plus 6 feet (the width of field occupied by the windbreak) or 99 feet and since surface resistance protects an additional 62 feet of field, the distance to the third grass barrier (from the windward side) is approximately 161 feet. The perennial grass barriers and shrub windbreaks can be repeated in any sequence as long as it is remembered that the grass barriers and surface resistance will protect up to approximately 103 feet of field and the shrub windbreaks plus surface resistance will protect up to approximately 161 feet. This type of design would be highly practical for high value crops.



Field Information :

I = 134

K = 1.0

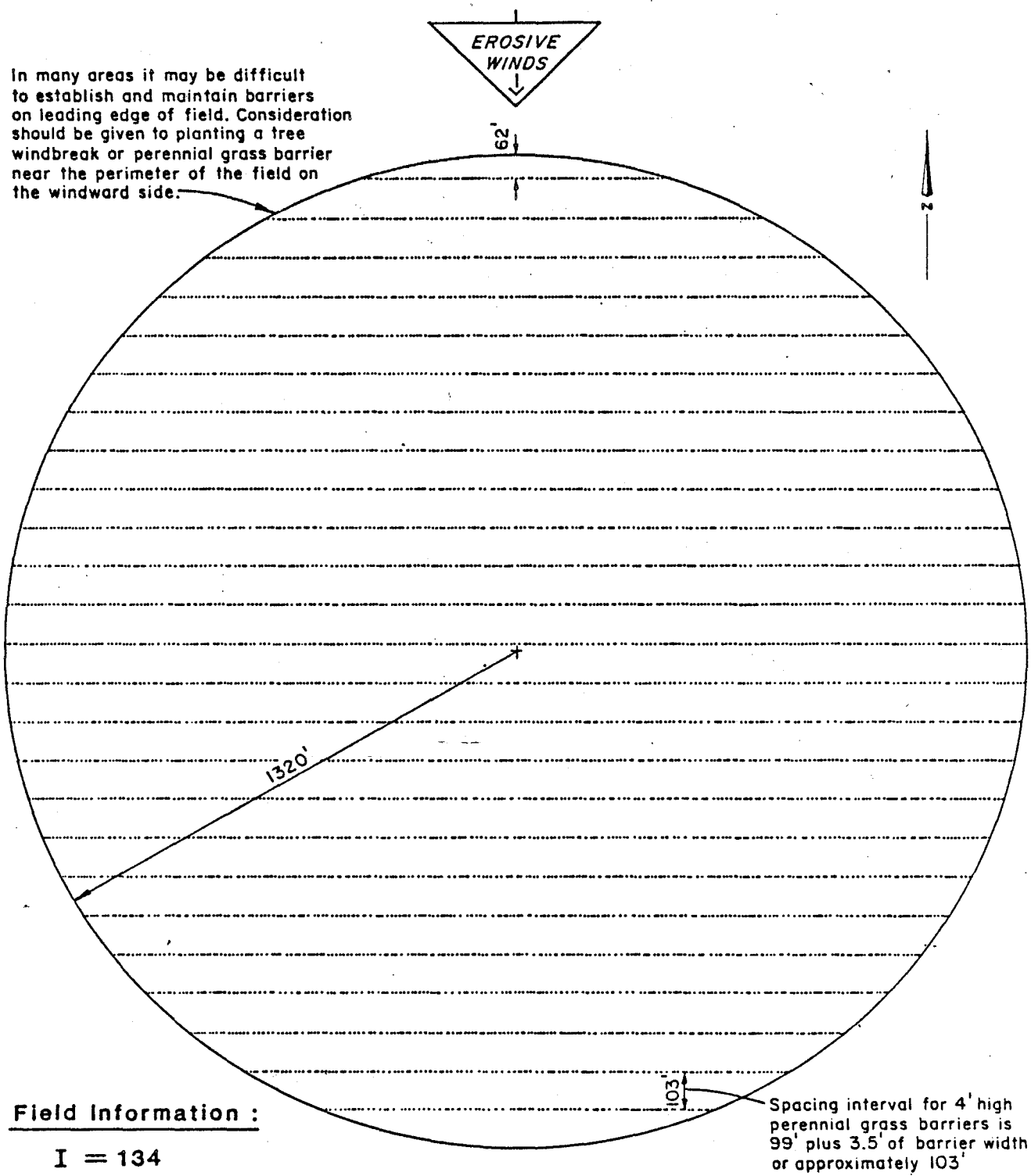
C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 14. 10 ft. shrub windbreaks and 4 ft. perennial grass barriers.

If the 1,000 lbs/Ac of residue is available, the simplest wind erosion control system that could be designed is illustrated in figure 15. In this illustration, 25 annual crop or perennial grass barriers are utilized to protect the field. These 4-foot-high barriers would be planted at intervals of approximately 103 feet.



Field Information :

I = 134

K = 1.0

C = 40

V = 1,000 lbs/ac

Maximum potential soil loss (Wind only) 4T/Ac/Yr

Figure 15. 4 ft. perennial grass barriers.

All of the practices in the wind erosion control systems described and illustrated in this technical note have desirable and undesirable features. For instance, the annual crop barriers and annual crop buffer strips are the easiest and quickest to establish but do not provide the degree of protection that the tree and shrub windbreaks do. The perennial buffer strips and perennial grass barriers take longer to establish but do not need to be established each year. The tree and shrub windbreaks take the longest to become established and effective. However, they generally are longer lived and provide a wider area of protection than herbaceous materials. Numerous other comparisons can be made which may be important. The important thing to remember is that they all can be useful in wind erosion control systems. It is also important to be familiar with all the practices and be able to discuss their use with landowners. The wide diversity of crops grown and the wide diversity of interests and farming methods of landowners offers opportunities to develop and utilize all of the wind erosion practices and wind erosion control systems described and illustrated in this technical note. In addition, with a little bit of ingenuity on the part of planners, many more alternative wind erosion control systems can be developed.

The Quick Reference Chart that has been used throughout this technical note eliminates many of the problems associated with determining potential soil losses, spacing intervals, etc. Since C factors and wind energy information can vary greatly from one area to another, the charts should be tailored to a given area. They are worth the time and effort to develop--them.

DAVID L. HINTZ
National Windbreak Forester
Ecological Sciences Staff

QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS,
VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 134

Ridge Roughness K = 1.0

Climate Factor C = 40 IKC = 53.6 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
0 (Buffer strips)	0	NA 1/	NA 1/	NA 1/	NA 1/	NA 1/	12
	250	NA 1/	NA 1/	NA 1/	NA 1/	12	14
	500	NA 1/	NA 1/	NA 1/	13	17	20
	750	NA 1/	NA 1/	15	21	28	35
	1000	NA 1/	17	30	45	62	82
	1250	NA 1/	45	85	183	256	400
	1500	NA 1/	117	333			
	1750	NA 1/	500		No buffer strips,		
	2000	NA 1/	windbreaks, or vegetative barriers needed.				
4	0	37	37	37	37	37	49
	250	37	37	37	37	49	51
	500	37	37	37	50	54	57
	750	37	37	52	58	65	72
	1000	37	54	67	82	99	119
	1250	37	82	122	220	293	437
	1500	37	154	370			
	1750	37	537		No buffer strips,		
	2000	37	windbreaks, or vegetative barriers needed.				
6	0	56	56	56	56	56	68
	250	56	56	56	56	68	70
	500	56	56	56	69	73	76
	750	56	56	71	77	84	91
	1000	56	73	86	101	118	138
	1250	56	101	141	239	312	456
	1500	56	173	389			
	1750	56	556		No buffer strips,		
	2000	56	windbreaks, or vegetative barriers needed.				
10	0	93	93	93	93	93	105
	250	93	93	93	93	105	107
	500	93	93	93	106	110	113
	750	93	93	108	114	121	128
	1000	93	110	123	138	155	175
	1250	93	138	178	276	349	493
	1500	93	210	426			
	1750	93	593		No buffer strips,		
	2000	93	windbreaks, or vegetative barriers needed.				

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QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS, VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 134

Ridge Roughness K = 1.0

Climate Factor C = 40 IKC = 53.6 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
15	0	140	140	140	140	140	152
	250	140	140	140	140	152	154
	500	140	140	140	153	157	160
	750	140	140	155	161	168	175
	1000	140	157	170	185	202	222
	1250	140	185	225	323	396	540
	1500	140	257	473			
	1750	140	640		No buffer strips,		
	2000	140	windbreaks, or vegetative barriers needed.				
20	0	186	186	186	186	186	198
	250	186	186	186	186	198	200
	500	186	186	186	199	203	206
	750	186	186	201	207	214	221
	1000	186	203	216	231	248	268
	1250	186	231	271	369	442	586
	1500	186	303	519			
	1750	186	686		No buffer strips,		
	2000	186	windbreaks, or vegetative barriers needed.				
30	0	279	279	279	279	279	291
	250	279	279	279	279	291	293
	500	279	279	279	292	296	299
	750	279	279	294	300	307	314
	1000	279	296	309	324	341	361
	1250	279	324	364	462	535	679
	1500	279	396	612			
	1750	279	779		No buffer strips,		
	2000	279	windbreaks, or vegetative barriers needed.				
40	0	372	372	372	372	372	384
	250	372	372	372	372	384	386
	500	372	372	372	385	389	392
	750	372	372	387	393	400	407
	1000	372	389	402	417	434	454
	1250	372	417	457	555	628	772
	1500	372	489	705			
	1750	372	872		No buffer strips,		
	2000	372	windbreaks, or vegetative barriers needed.				

1/ Not Applicable

*Maximum soil loss from wind erosion from a bare, smooth and wide field.

MNTC 10/83

QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS,
VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 86

Ridge Roughness K = 1.0

Climate Factor C = 40 IKC = 34.4 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
0 (Buffer strips)	0	NA 1/	12	22	29	38	51
	250	NA 1/	16	26	37	51	58
	500	NA 1/	24	38	56	68	80
	750	NA 1/	38	62	83	128	177
	1000	NA 1/	70	140	233	357	575
	1250	NA 1/	225	640	1667		
	1500	NA 1/	1000				
	1750	NA 1/	No buffer strips,				
	2000	NA 1/	windbreaks, or vegetative barriers needed.				
4	0	37	49	59	66	75	88
	250	37	53	63	74	88	95
	500	37	61	75	93	105	117
	750	37	75	99	120	165	214
	1000	37	107	177	270	394	612
	1250	37	262	677	1704		
	1500	37	1037				
	1750	37	No buffer strips,				
	2000	37	windbreaks, or vegetative barriers needed.				
6	0	56	68	78	85	94	107
	250	56	72	82	93	107	114
	500	56	80	94	112	124	136
	750	56	94	118	139	184	233
	1000	56	126	196	289	413	631
	1250	56	281	696	1723		
	1500	56	1056				
	1750	56	No buffer strips,				
	2000	56	windbreaks, or vegetative barriers needed.				
10	0	93	105	115	122	131	144
	250	93	109	119	130	144	151
	500	93	117	131	149	161	173
	750	93	131	155	176	221	270
	1000	93	163	233	326	450	668
	1250	93	318	733	1760		
	1500	93	1093				
	1750	93	No buffer strips,				
	2000	93	windbreaks, or vegetative barriers needed.				

MNTC 10/83

QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS, VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 86

Ridge Roughness K = 1.0

Climate Factor C = 40 IKC = 34.4 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
15	0	140	152	162	169	178	191
	250	140	156	166	177	191	198
	500	140	164	178	196	208	220
	750	140	178	202	223	268	317
	1000	140	210	280	373	497	715
	1250	140	365	780	1807		
	1500	140	1140				
	1750	140			No buffer strips,		
	2000	140	windbreaks, or vegetative barriers needed.				
20	0	186	198	208	215	224	237
	250	186	202	212	223	237	244
	500	186	210	224	242	254	266
	750	186	224	248	269	314	363
	1000	186	256	326	419	543	761
	1250	186	411	826	1853		
	1500	186	1186				
	1750	186			No buffer strips,		
	2000	186	windbreaks, or vegetative barriers needed.				
30	0	279	291	301	308	317	330
	250	279	295	305	316	330	337
	500	279	303	317	335	347	359
	750	279	317	341	362	407	456
	1000	279	349	419	512	636	854
	1250	279	504	919	1946		
	1500	279	1279				
	1750	279			No buffer strips,		
	2000	279	windbreaks, or vegetative barriers needed.				
40	0	372	384	394	401	410	423
	250	372	388	398	409	423	430
	500	372	396	410	428	440	452
	750	372	410	434	455	500	549
	1000	372	442	512	605	729	947
	1250	372	597	1012	2039		
	1500	372	1372				
	1750	372			No buffer strips,		
	2000	372	windbreaks, or vegetative barriers needed.				

1/ Not Applicable

*Maximum soil loss from wind erosion from a bare, smooth and wide field.

QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS,
VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 86

Ridge Roughness K = 0.8

Climate Factor C = 40 IKC = 27.5 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
0 (Buffer strips)	0	NA 1/	20	34	47	62	78
	250	NA 1/	26	42	58	78	93
	500	NA 1/	36	63	88	117	158
	750	NA 1/	64	100	163	236	343
	1000	NA 1/	120	250	500	933	1900
	1250	NA 1/	467	3000			
	1500	NA 1/			No buffer strips,		
	1750	NA 1/			windbreaks, or vegetative		
	2000	NA 1/			barriers needed.		
4	0	37	57	71	84	99	115
	250	37	63	79	95	115	130
	500	37	73	100	125	154	195
	750	37	101	137	200	273	380
	1000	37	157	287	537	970	1937
	1250	37	504	3037			
	1500	37			No buffer strips,		
	1750	37			windbreaks, or vegetative		
	2000	37			barriers needed.		
6	0	56	76	90	103	118	134
	250	56	82	98	114	134	149
	500	56	92	119	144	173	214
	750	56	120	156	219	292	399
	1000	56	176	306	556	989	1956
	1250	56	523	3056			
	1500	56			No buffer strips,		
	1750	56			windbreaks, or vegetative		
	2000	56			barriers needed.		
10	0	93	113	127	140	155	171
	250	93	119	135	151	171	186
	500	93	129	156	181	210	251
	750	93	157	193	256	329	436
	1000	93	213	343	593	1026	1993
	1250	93	560	3093			
	1500	93			No buffer strips,		
	1750	93			windbreaks, or vegetative		
	2000	93			barriers needed.		

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QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS, VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 86

Ridge Roughness K = 0.8

Climate Factor C = 40 IKC = 27.5 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
15	0	140	160	174	187	202	218
	250	140	166	182	198	218	233
	500	140	176	203	228	257	298
	750	140	204	240	303	376	483
	1000	140	260	390	640	1073	2040
	1250	140	607	3140			
	1500	140	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	140					
	2000	140					
20	0	186	206	220	233	248	264
	250	186	212	228	244	264	279
	500	186	222	249	274	303	344
	750	186	250	286	349	422	529
	1000	186	306	436	686	1119	2086
	1250	186	653	3186			
	1500	186	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	186					
	2000	186					
30	0	279	299	313	326	341	357
	250	279	305	321	337	357	372
	500	279	315	342	367	396	437
	750	279	343	379	442	515	622
	1000	279	399	529	779	1212	2179
	1250	279	746	3279			
	1500	279	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	279					
	2000	279					
40	0	372	392	406	419	434	450
	250	372	398	414	430	450	465
	500	372	408	435	460	489	530
	750	372	436	472	535	608	715
	1000	372	492	622	872	1305	2272
	1250	372	839	3372			
	1500	372	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	372					
	2000	372					

1/ Not Applicable

*Maximum soil loss from wind erosion from a bare, smooth and wide field.

MNTC 10/83

QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS,
VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 48

Ridge Roughness K = 1.0

Climate Factor C = 40 IKC = 19.2 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
0 (Buffer strips)	0	NA 1/	50	83	123	168	213
	250	NA 1/	60	106	161	216	268
	500	NA 1/	90	175	250	333	433
	750	NA 1/	175	300	500	800	1454
	1000	NA 1/	350	867	2750		
	1250	NA 1/	2500				
	1500	NA 1/	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	NA 1/					
	2000	NA 1/					
4	0	37	87	120	160	205	250
	250	37	97	143	198	253	305
	500	37	127	212	287	370	470
	750	37	212	337	537	837	1491
	1000	37	387	904	2787		
	1250	37	2537				
	1500	37	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	37					
	2000	37					
6	0	56	106	139	179	224	269
	250	56	116	162	217	272	324
	500	56	146	231	306	389	489
	750	56	231	356	556	856	1510
	1000	56	406	923	2806		
	1250	56	2556				
	1500	56	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	56					
	2000	56					
10	0	93	143	176	216	261	306
	250	93	153	199	254	309	361
	500	93	183	268	343	426	526
	750	93	268	393	593	893	1547
	1000	93	443	960	2843		
	1250	93	2593				
	1500	93	No buffer strips, windbreaks, or vegetative barriers needed.				
	1750	93					
	2000	93					

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QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS, VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 48

Ridge Roughness K = 1.0

Climate Factor C = 40 IKC = 19.2 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
15	0	140	190	223	263	308	353
	250	140	200	246	301	356	408
	500	140	230	315	390	473	573
	750	140	315	440	640	940	1594
	1000	140	490	1007	2890		
	1250	140	2640				
	1500	140	No buffer strips,				
	1750	140	windbreaks, or vegetative				
	2000	140	barriers needed.				
20	0	186	236	269	309	354	399
	250	186	246	292	347	402	454
	500	186	276	361	436	519	619
	750	186	361	486	686	986	1640
	1000	186	536	1053	2936		
	1250	186	2686				
	1500	186	No buffer strips,				
	1750	186	windbreaks, or vegetative				
	2000	186	barriers needed.				
30	0	279	329	362	402	447	492
	250	279	339	385	440	495	547
	500	279	369	454	529	612	712
	750	279	454	579	779	1079	1733
	1000	279	629	1146	3029		
	1250	279	2779				
	1500	279	No buffer strips,				
	1750	279	windbreaks, or vegetative				
	2000	279	barriers needed.				
40	0	372	422	455	495	540	585
	250	372	432	478	533	588	640
	500	372	462	547	622	705	805
	750	372	547	672	872	1172	1826
	1000	372	722	1239	3122		
	1250	372	2872				
	1500	372	No buffer strips,				
	1750	372	windbreaks, or vegetative				
	2000	372	barriers needed.				

1/ Not Applicable

*Maximum soil loss from wind erosion from a bare, smooth and wide field.

QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS,
VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 48

Ridge Roughness K = 0.7

Climate Factor C = 40 IKC = 13.4 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
0 (Buffer strips)	0	NA 1/	100	200	277	388	600
	250	NA 1/	142	245	367	615	769
	500	NA 1/	225	400	711	1000	1625
	750	NA 1/	400	867	1727	3750	
	1000	NA 1/	1167	5000			
	1250	NA 1/			No buffer strips,		
	1500	NA 1/			windbreaks, or vegetative		
	1750	NA 1/		barriers needed.			
	2000	NA 1/					
4	0	37	137	237	314	425	637
	250	37	179	282	404	652	806
	500	37	262	437	748	1037	1662
	750	37	437	904	1764	3787	
	1000	37	1204	5037			
	1250	37			No buffer strips,		
	1500	37			windbreaks, or vegetative		
	1750	37		barriers needed.			
	2000	37					
6	0	56	156	256	333	444	656
	250	56	198	301	423	671	825
	500	56	281	456	767	1056	1681
	750	56	456	923	1783	3806	
	1000	56	1223	5056			
	1250	56			No buffer strips,		
	1500	56			windbreaks, or vegetative		
	1750	56		barriers needed.			
	2000	56					
10	0	93	193	293	370	481	693
	250	93	235	338	460	708	862
	500	93	318	493	804	1093	1718
	750	93	493	960	1820	3843	
	1000	93	1260	5093			
	1250	93			No buffer strips,		
	1500	93			windbreaks, or vegetative		
	1750	93		barriers needed.			
	2000	93					

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QUICK REFERENCE CHART FOR DESIGN OF WINDBREAKS, VEGETATIVE BARRIERS, OR BUFFER STRIPS FOR SOUTH CENTRAL KANSAS

Soil Erodibility I = 48

Ridge Roughness K = 0.7

Climate Factor C = 40 IKC = 13.4 T./A./Yr.*

Direction of windbreaks, barriers & strips: EW (perpendicular to prevailing winds)

Angle of Deviation: 0°

Barrier Height (Ft.)	Crop Residue During Critical Erosion Period (Flat small grain equiv.)	Recommended Barrier Spacing (Feet) for Maximum Soil Loss (T./A./Yr.) of:					
		0	1	2	3	4	5
15	0	140	240	340	417	528	740
	250	140	282	385	507	755	909
	500	140	365	540	851	1140	1765
	750	140	540	1007	1867	3890	
	1000	140	1307	5140			
	1250	140	No buffer strips, windbreaks, or vegetative barriers needed.				
	1500	140					
	1750	140					
	2000	140					
20	0	186	286	386	463	574	786
	250	186	328	431	553	801	955
	500	186	411	586	897	1186	1811
	750	186	586	1053	1913	3936	
	1000	186	1353	5186			
	1250	186	No buffer strips, windbreaks, or vegetative barriers needed.				
	1500	186					
	1750	186					
	2000	186					
30	0	279	379	479	556	667	879
	250	279	421	524	646	894	1048
	500	279	504	679	990	1279	1904
	750	279	679	1146	2006	4029	
	1000	279	1446	5279			
	1250	279	No buffer strips, windbreaks, or vegetative barriers needed.				
	1500	279					
	1750	279					
	2000	279					
40	0	372	472	572	649	760	972
	250	372	514	617	739	987	1141
	500	372	597	772	1083	1372	1997
	750	372	772	1239	2099	4122	
	1000	372	1539	5372			
	1250	372	No buffer strips, windbreaks, or vegetative barriers needed.				
	1500	372					
	1750	372					
	2000	372					

1/ Not Applicable

*Maximum soil loss from wind erosion from a bare, smooth and wide field.