

## **SECTION 9. INSTALLATION, INTEGRATION, AND CHECKOUT**

**9.1 INTRODUCTION.**- This section contains instructions and installation drawings for the installation, integration, and operational verification checkout of the EFGS antenna system.

**9.2 SITE PREPARATION.**- The actual site preparations include laying out the installation with driving stakes, digging holes and trenches, and pouring concrete for pilings or continuous forms. The location of the antennas will be determined with reference to the runway point of intercept (RPI).

**9.3 CONSTRUCTION DRAWING.**- The following figures are provided in this section: 9-1 (sheet 1 of 5, which include Notes 1-14), 9-2 Piling Details "A" (sheet 2 of 5), 9-3 Trenching Details "B" (sheet 2 of 5), 9-4 Pedestal Layout Template Detail "C" (sheet 3 of 5), 9-5 Monitor Pilings Detail "D" (sheet 3 of 5), 9-6 Critical Area Detail "E" (sheet 4 of 5), Table 9-1 Main Antenna Pedestal Taping Radii Detail "F" (sheet 5 of 5), and Table 9-2 Clearance Antenna Pedestal Locations Detail "G" (sheet 5 of 5). These figures are provided to supplement the step-by-step procedures pertaining to: antenna locations, foundation layouts, and trenching for routing the RF cable.

NOTE 1 - Siting Information: The site chosen should provide a runway shoulder, graded normally, unobstructed in the area between the front and rear main antennas and to at least 500 feet forward of the front antenna. The "CRITICAL AREA", detail "E", is the area within which the movement of vehicles or aircraft may cause a disturbance to the glide slope information observed by an approaching aircraft. If installation is to be made on the side opposite to that shown, this drawing should be mirrored about the runway centerline. Layout of the system is accomplished with respect to a point known as the RPI. The RPI is the intersection of the straight-line extension of the desired glide slope with the runway centerline, and is chosen to provide an acceptable threshold crossing height (TCH). The RPI must be established before siting the antenna system. This system is not intended for installation at up-slope sites as defined in the ILS Siting Manual, FAA 6750.16.

NOTE 2 - Theodolite Location: A permanent marker for the theodolite location should be installed 25 feet from the runway edge and a distance "DT" forward of the RPI:

$$DT = (62 - DS) \times 4.77/GA, \text{ feet,}$$

Where 62 represents the approved height, in inches, for the theodolite eyepiece as defined in the FAA Flight Inspection Manual 8200.1 and "DS" is the depression in inches of the shoulder grade, at the theodolite offset distance and considering longitudinal slopes, below the elevation of the RPI. "GA" is the glide angle in degrees, and the number 4.77 is derived from  $1/(\text{TAN}(\text{one degree}) \times 12 \text{ inches})$ .

NOTE 3 - Phase Center (Origin): The phase center of the system at the shoulder grade elevation is considered to be the "ORINATION POINT" of the glide slope signal. It is also used as the origin of coordinates "X" and "Y" for laying out the locations of the antenna elements. It is positioned to ensure that no part of the antenna will be closer than 25 feet of the runway edge. A permanent marker for the phase center should be installed 75 feet from the runway edge and a distance "DP" behind the RPI:

$$DP = DC \times 4.77/GA, \text{ feet,}$$

Where "DC" is the depression in inches of the shoulder grade, at the phase center offset distance and approximate longitudinal location, below the elevation of the RPI, and "GA" is the glide angle in degrees, and the number 4.77 is derived from  $1/(\text{TAN}(\text{one degree}) \times 12 \text{ inches})$ .

NOTE 4 - Taping Points: Establish a base line ("X" - Axis) through the phase center parallel to the runway edge. Install permanent markers "TR" and "TF" with bolt insert or pin suitable for hooking on a measuring tape. These taping points will be used for initial layout of the main antennas and for future antenna pedestal positions checks.

TR	X = -80 feet,	Y = 0 feet
TF	X = +80 feet,	Y = 0 feet

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NOTE 5 - Main Antennas: Stake the rear and front #1 pedestal (PED) locations:

R	X = -218.84 feet,	Y = 39.64 feet
F	X = +227.81 feet,	Y = 23.97 feet

Check the two stake locations against the PED #1 radii from the taping points "TR" and "TF" as given in the first line of each taping table, detail "F". Before continuing with the layout, it is necessary to choose the correct column in the taping tables for each main antenna. This is done by independently computing the column heading "FRFU" (Frequency Function) for each antenna as follows:

$$\text{FRFU REAR} = \text{FREQ} - 327.60 - (0.14 \times \text{RS}),$$

where "FREQ" is the assigned station frequency in MHz and "RS" is the transverse slope of the shoulder in percent in the region of the rear antenna. If this value of "FRFU" falls between the tabular headings it will be necessary to calculate a new column of radii by interpolation. The tolerance to be applied to each radius measurement is plus or minus 1/10 foot. Compute the lateral slope from 55 feet away from the runway edge to 130 feet from the runway edge at a distance of approximately 210 feet back from the phase center.

$$\text{FRFU FRONT} = \text{FREQ} - 327.60 - (0.14 \times \text{FS}),$$

where "FREQ" is the assigned station frequency in MHz and "FS" is the transverse slope of the shoulder in percent in the region of the front antenna. If this value of "FRFU" falls between the tabular headings it will be necessary to calculate a new column of radii by interpolation. The tolerance to be applied to each radius measurement is plus or minus 1/10 foot. Compute the lateral slope from 25 feet away from the runway edge to 100 feet from the runway edge at a distance approximately 230 feet forward of the phase center.

**PILINGS NOTICE (pertaining to notes 6, 7, 8 and 9):**

Pilings are considered a suitable and perhaps the least expensive method to mount the End-Fire antennas in regions of very stable soil and shallow frost depths. However, movement of pilings has historically been problematic in regions of severe cold and where the soil is not particularly stable. Unstable pilings will result in repetitive and costly system outages, re-optimization and flight inspection re-certification. Some outages may exist for long periods through winter months. For any climate, the manufacturer strongly recommends the use of continuous form concrete foundations for mounting any antenna used in the system. Continuous form foundations greatly increase the system stability, continuity of service, and prevent piling damage by snow removal or grass cutting equipment. Regional civil engineering professionals should be consulted to determine the most suitable foundations for the local climate. Under no circumstances should the forms be poured elsewhere and laid in place or buried to support the antenna. Such a foundation will be repetitively problematic.

Figure 9-1. Construction Drawing (Sheet 1 of 5)

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Figure 9-1. Construction Drawing (Sheet 1 of 5)

NOTE 6 - Pilings, Rear and Front Antennas (See Pilings Notice in NOTE 5): Observe that the pilings are in equally spaced pairs except at the ends where they are closer to give extra support. Construct a layout template according to Detail "C", and place the corner (Mark "A") of the template against the PED #1 stake. Stretch a measuring tape from the taping point. Rotate the template about the PED #1 stake until the taped radius to Mark "D" location corresponds to the tabular value for PED #2 and drive a stake there. Also drive stakes at Marks "B" and "C" to locate the pilings for PED #1. Relocate the template corner (Mark "A") against the PED #2 stake. Rotate the template until the taped radius to Mark "E" location corresponds to the tabular value for PED #3 and drive a stake there. Also drive stakes at Marks "B" and "C" to locate the pilings for PED #2. Follow this procedure through the entire length of each antenna, using template Mark "E" for spacing to the next pedestal location, except when reaching end PED #12, use Mark "D" again for the closer spacing.

NOTE 7 - Pilings, Clearance Antenna (See Pilings Notice in NOTE 5): The clearance antenna piling locations should form a straight line oriented 9 degrees toward the runway from a line parallel to the runway intersecting the phase center. To locate the piling positions, place stakes at the XY pedestal locations given in the table below. With the template shown in Figure 9-4, sheet 3 of 5, DETAIL "C", place the inside corner of the template marked "A" over the stake for pedestal one with the long edge of the template in the direction of stake for pedestal two. Align the leading edge with the stake for pedestal two and place stakes at positions B and C of the template. Repeat this process to locate the pilings for pedestals 2, 3 and 4. For pedestal 4, the template must be flipped over so that the long edge is in the direction of pedestal 3. The template is used as a long 90-degree corner square and markings "D" and "E" should be ignored.

NOTE 8 –Pilings, Field Monitor Antennas (See Pilings Notice in NOTE 5): Drive stakes at corner piling locations:

M1      X = +560.0 feet 0 inches, Y = +3.0 feet 0 inches

As shown in Figure 9-5, sheet 3 of 5, Detail "D", lay out and stake remaining pilings in rectangles, aligning perpendicular to the runway.

NOTE 9 - Concrete: (See Pilings Notice in NOTE 5). There are 68 pilings total see Figure 9-2, sheet 2 of 5, Detail "A". Concrete shall develop 3000 psi in 28 days with a maximum slump of 3 inches. Maximum aggregate size shall be 3/4 inch. The tops of the pilings shall project at least 1 inch above the ground, and, where possible, should follow the existing shoulder curvature or grade. In the case of the main antennas, it may be necessary for very modest grading to avoid bending an antenna too sharply while following the shoulder curvature: A straight line extended from the tops of any two adjacent pairs of pilings must not pass above or below the tops of the next pair of pilings by more than 5 inches.

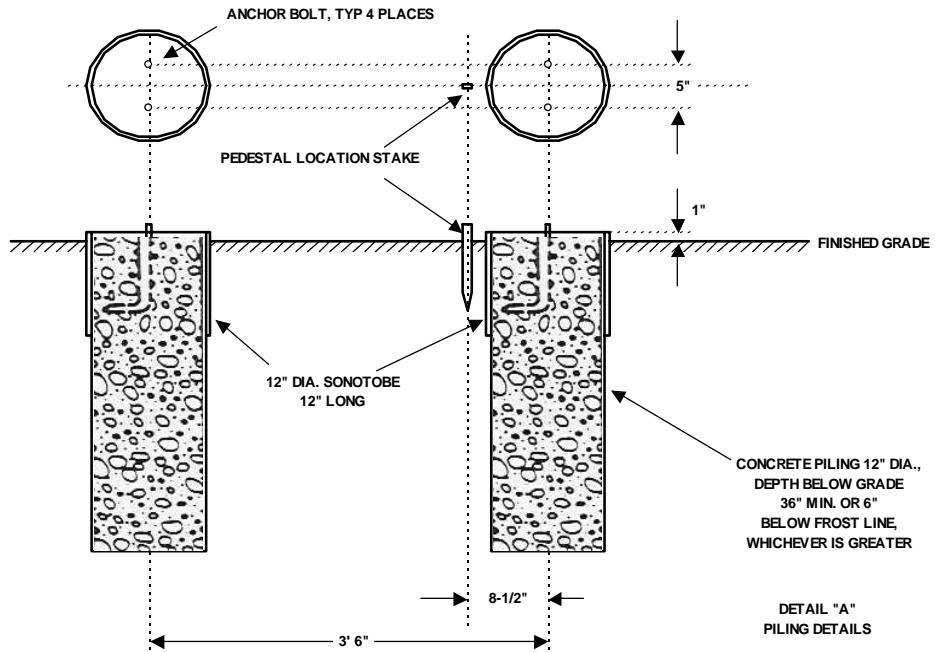


Figure 9-2. Piling Details, Detail "A"

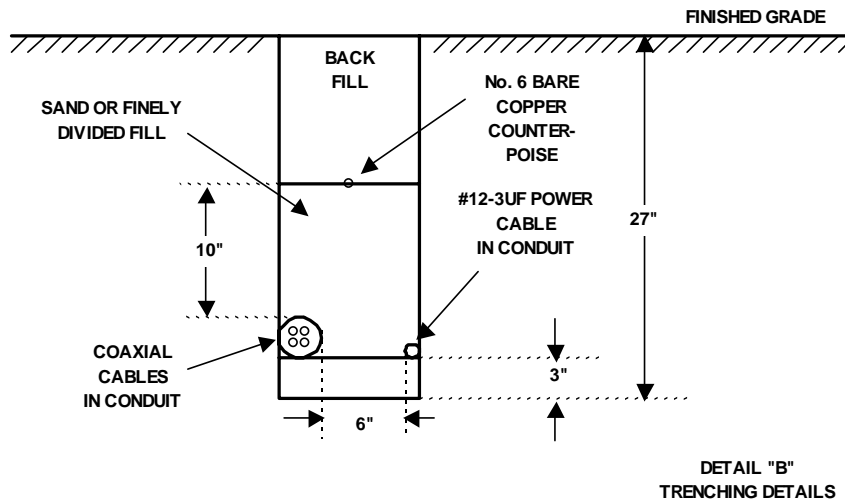


Figure 9-3. Trenching Details, Detail "B"  
 Construction Drawing (Sheet 2 of 5)

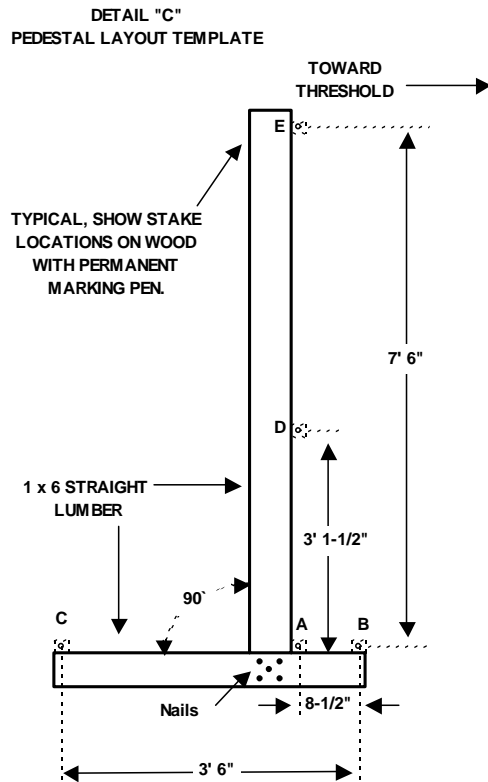


Figure 9-4. Pedestal Layout Template, Detail "C"

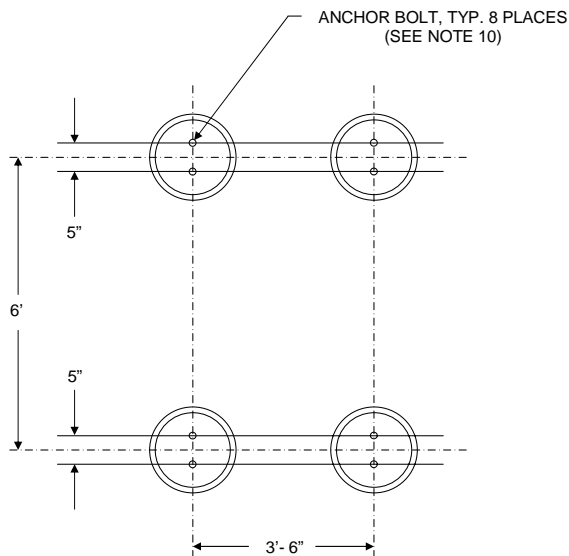


Figure 9-5. Monitor Pilings, Detail "D"  
 Construction Drawing (Sheet 3 of 5)

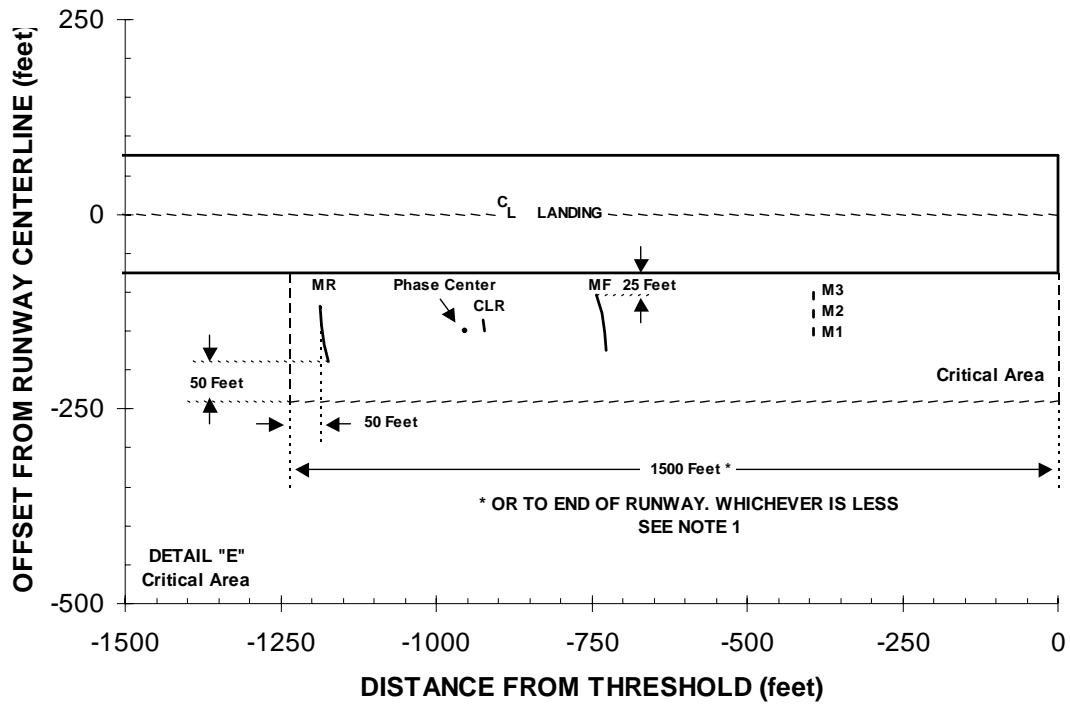


Figure 9-6. Critical Area, Detail "E"

Construction Drawing (Sheet 4 of 5)



Table 9-1. Main Antenna Pedestal Taping Radii, Detail "F"

REAR MAIN ANTENNA							
FRFU	1.0	2.0	3.0	4.0	5.0	6.0	7.0
PED	FEET	FEET	FEET	FEET	FEET	FEET	FEET
1	144.38	144.38	144.38	144.38	144.38	144.38	144.38
2	144.67	144.69	144.65	144.59	144.54	144.55	144.59
3	145.38	145.38	145.32	145.24	145.17	145.14	145.13
4	146.19	146.16	146.09	146.00	145.91	145.85	145.79
5	147.12	147.04	146.94	146.83	146.74	146.66	146.59
6	148.20	148.07	147.91	147.76	147.65	147.56	147.48
7	149.44	149.28	149.09	148.88	148.72	148.59	148.47
8	150.83	150.66	150.43	150.20	150.00	149.83	149.66
9	152.38	152.18	151.94	151.70	151.48	151.28	151.09
10	154.09	153.87	153.62	153.35	153.11	152.91	152.70
11	155.98	155.74	155.45	155.16	154.90	154.66	154.44
12	156.83	156.58	156.28	155.98	155.70	155.46	155.22
FRONT MAIN ANTENNA							
FRFU	1.0	2.0	3.0	4.0	5.0	6.0	7.0
PED	FEET	FEET	FEET	FEET	FEET	FEET	FEET
1	149.74	149.74	149.74	149.74	149.74	149.74	149.74
2	148.93	148.91	148.94	149.01	149.05	149.04	149.01
3	147.18	147.18	147.24	147.32	147.39	147.41	147.43
4	145.62	145.66	145.73	145.82	145.90	145.96	146.02
5	144.27	144.34	144.45	144.56	144.64	144.72	144.79
6	143.06	143.19	143.34	143.50	143.61	143.69	143.78
7	142.00	142.16	142.36	142.56	142.73	142.85	142.98
8	141.10	141.28	141.50	141.74	141.94	142.11	142.28
9	140.35	140.55	140.79	141.04	141.26	141.46	141.65
10	139.74	139.96	140.22	140.49	140.73	140.94	141.16
11	139.25	139.50	139.79	140.08	140.35	140.59	140.82
12	139.06	139.33	139.63	139.94	140.22	140.47	140.72

Table 9-2. Clearance Antenna Pedestal Locations, Detail "G"

PED	X	Y
1	31.00 feet	0.00 feet
2	30.28 feet	-4.53 feet
3	29.52 feet	-9.30 feet
4	28.80 feet	-13.83 feet

Construction Drawing (Sheet 5 of 5)

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NOTE 10 - Anchor Bolts: B700-J4, 184 anchor bolts, 1/2 - 13 x 8 inches, hot dip galvanized steel per ASTM A153, are required (2 per piling, Details "A" and "D"). Install with 3-inch thread projection above finish surface of concrete. The first thread at the bottom of the bolt should start no more than 1/8 inch above the level of the concrete. In the event that a continuous form concrete foundation is used to mount the antennas, see Piling Notice in Note 5, it is permissible to drill holes in the foundation and use stainless steel all-thread and epoxy in place of the standard anchor bolts. Due to the possibility of cracking the piling, drilling is not recommended when using discrete antenna support pilings.

NOTE 11 – Trenching Details and Cable Layout: Cable trenching is laid out to maintain equality of lengths of cable pairs from the shelter as follows, with tolerance of plus or minus one foot: R = F and MR = MF. All other cable lengths are not critical. Before laying cables, place a 3 inch layer of sand or finely divided fill in bottom of trenches. See Detail "B", Figure 9-2 Trenching Details, of the construction drawings sheet 2 of 5. Placing the cables in conduit is highly recommended. After cables are laid in place, cover with 10 inches of sand. Cable jackets must not be punctured. RF cables have to be separated from the obstruction light power cable by at least 6 inches. After the cables have be laid in place, lay #6 bare copper counterpoise on top of each 10-inch sandfill and back-fill to original grade.

NOTE 12 - Cables: All RF cables are air dielectric transmission lines. When "pulling in" the RF cable, care must be taken to ENSURE NO WATER is permitted to enter the cable ends and that the cable jackets ARE NOT PUNCTURED. Take care not to kink RF cables and to observe minimum bend radius. The cables run from the shelter to each location as shown in Table 9-3. Cable ends should extend 7 feet out of each trench to allow for antenna position adjustments during optimization or to accommodate a change in the station frequency assignment. Each end should be protected by a 2-foot sleeve of 1-1/2 inch PVC plastic pipe, or equivalent, where the cable exits the ground.

**Table 9-3. Cable Information**

<b>NOMENCLATURE</b>	<b>TYPE</b>	<b>FEET</b>	<b>MIN BEND RADIUS</b>
REAR FEED, R	7/8 DIA., HJ5-50	240-270	10 in.
FRONT FEED, F	7/8 DIA., HJ5-50	SEE NOTES 11, 12	10 in.
CLEARANCE FEED, C	7/8 DIA., HJ5-50	80-140	10 in.
FIELD MONITOR, M1	1/2 DIA., HJ4-50	600-635	5 in.
FIELD MONITOR, M2	1/2 DIA., HJ4-50	620-670	5 in.
FIELD MONITOR, M3	1/2 DIA., HJ4-50	635-700	5 in.
INTEGRAL MONITOR REAR, MR	1/2 DIA., HJ4-50	280-320	5 in.
INTEGRAL MONITOR, FRONT, MF	1/2 DIA., HJ4-50	SEE NOTES 11, 12	5 in.
INTEGRAL MONITOR CLEARANCE, MC	1/2 DIA., HJ4-50	80-140	5 in.
OBST.LT., R, F, MR, MF, M1, M3 (RWY END)	#12-3UF	—	—

**NOTE**

The End-Fire system can be viewed as a system of cables. The quality, precision, and uniformity of the cable lengths and their installation can greatly affect the overall stability of the system.

Cables should be as short as possible while allowing comfortable routing and maintenance of the system. Any system modification that would result in longer cable lengths should be discussed with the manufacturer.

Main Antenna feedlines R and F are considered matched pairs and **MUST BE** replaced at the same time and from the same roll of cable.

Monitor Antenna feedlines MR and MF are considered matched pairs and **MUST BE** replaced at the same time and from the same roll of cable.

The lengths of the Field Monitor lines M1, M2, and M3 as well as Clearance feed and monitor lines C and MC are not critical.

The coiling and/or burying of excess cable **WILL** adversely affect system stability and **MUST BE** removed.

Excess cable **MUST BE** removed while maintaining equal lengths for the main antenna feed and monitor lines:  $F = R$  and  $MF = MR$ .

The purchase of the "phase stabilized" version of the main antenna feed and monitor lines F, R, MF, and MR respectively, will improve the antenna systems initial stability. Consult with the cable manufacturer for the availability of phase stabilized version of the cable identified in Table 9-3.

NOTE 13 - Finish: Restore area to grade and remove surplus material. Treat the soil around each group of pilings to a radius of 6 feet with a commercial weed killer to completely eliminate vegetation. The weed killer and its application shall be approved by the resident engineer. Once the weed killer has been effective, cover the same area with limestone gravel with a height not exceeding the top of the concrete pilings. Alternatively, pave with asphalt.

NOTE 14 - Tolerances: Unless otherwise specified, tolerance on dimensions less than 250 feet is plus or minus 1 inch. Larger dimensions have a tolerance of 0.5 percent.