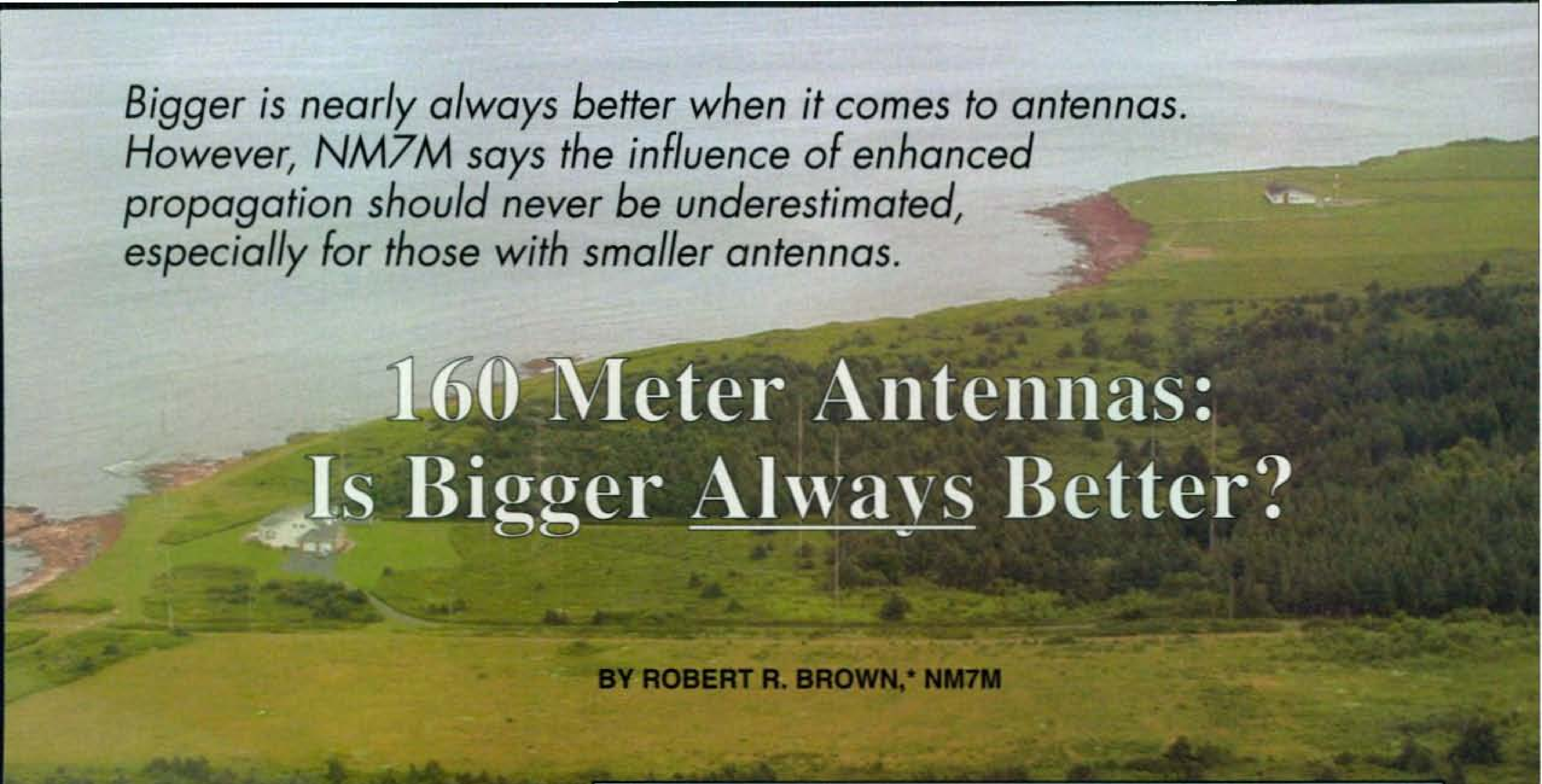

Bigger is nearly always better when it comes to antennas. However, NM7M says the influence of enhanced propagation should never be underestimated, especially for those with smaller antennas.

160 Meter Antennas: Is Bigger Always Better?

BY ROBERT R. BROWN,* NM7M

Everything considered, 160-meter DXing can be divided into three tiers or approaches. Tier One is the simplest and starts with conditions like those at solar minimum and with no simultaneous solar or geomagnetic disturbances. At this point propagation is symmetrical out to the line of sight. Except at the poles, ionospheric properties lack symmetry because of the geomagnetic field, so propagation varies with direction in going beyond the line of sight.

Tiers One and Two: Nature's Contributions

Tier One is sort of a bare-bones affair and can be pursued with full legal power and a basic antenna, such as a vertical. Ionospheric theory tells us we can expect to work out to about 10,000 kilometers (16,000 miles) by conventional *E*- and *F*-hops. That figure, or limit, was derived (Luetzelschwab, 1995)[1] from the atmospheric composition and electron-neutral collision data available at the time, as found in the PropLab Pro program.

In practice, distances beyond 10,000 km are easily reached, but theory has lagged behind. Signal ducting has been suggested as an explanation for some time, the main candidate being the electron density valley found above the *E*-region at night, as shown in fig. 1.

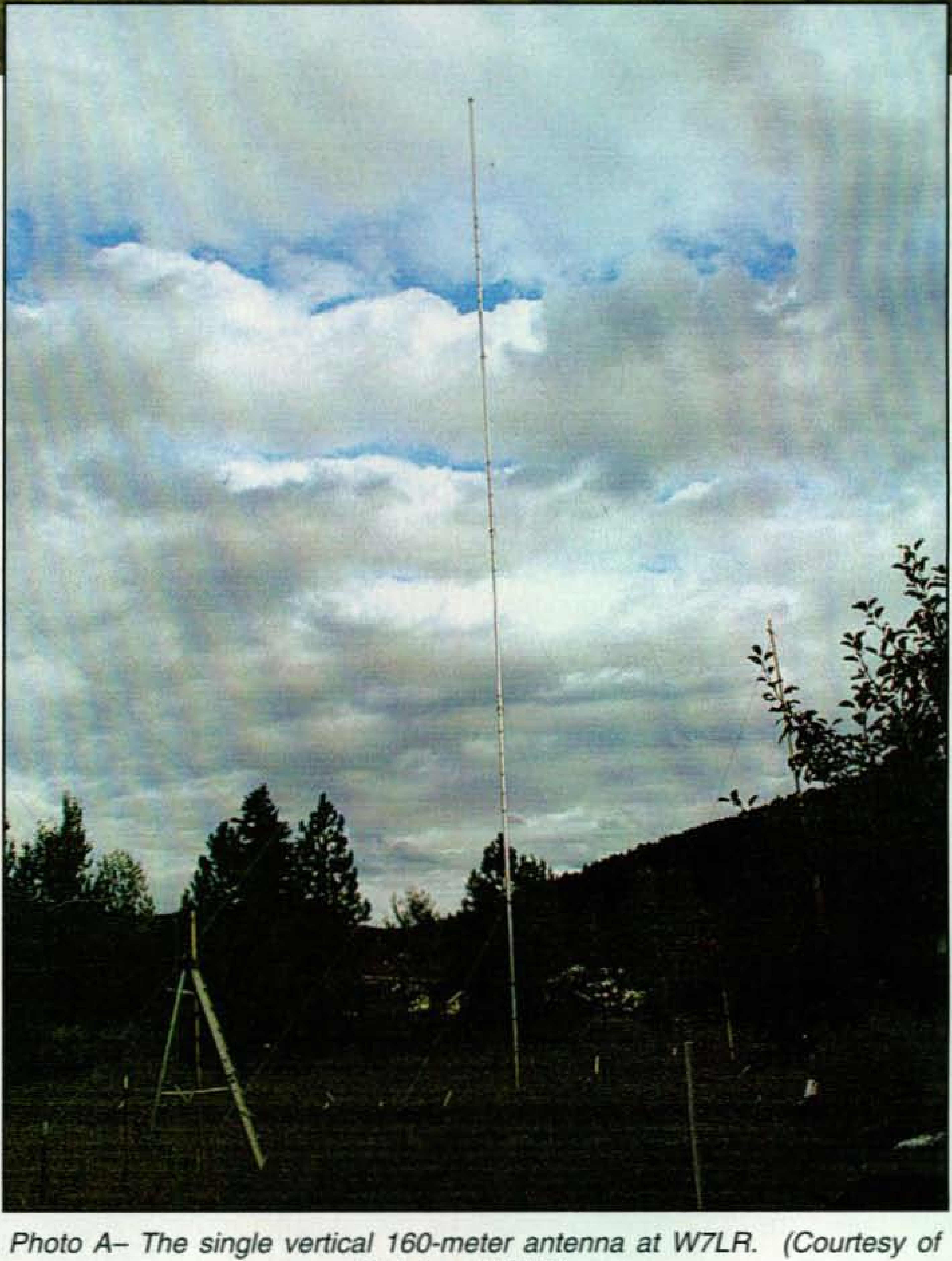

Photo A– The single vertical 160-meter antenna at W7LR. (Courtesy of Bob Leo, W7LR)

**1105 27th St., Anacortes, WA 98221*
e-mail: <nm7m@aol.com>

It was found (Brown, 2008)[2] that the ionization associated with the valley may be due to the influence of galactic cosmic rays (GCR) in the region. Signals can enter the ducting region if their critical frequency falls below the quiet value foE or the cosmic-ray ionization falls below the corresponding level.

Theory shows that signals may be ducted to a distance L given by

$$L = 1 + 3.4\sqrt{GCRd} \quad \text{for } GCRd < 9\%$$

or

$$L = 2 + GCRd \quad \text{for } GCRd > 9\%$$

where GCRd is the decrease in GCR intensity (a decrease is a more negative value of the GCR value seen in neutron-monitor plots). This distance may be added to those from *E*- and *F*-refraction giving ducting-assisted distances (Brown and Luetzelschwab, 2008)[3] for Tier Two propagation that are greater than those for Tier One.

An example of this was found in the log data from W7LR for 2003 through 2007, as shown in fig. 2. As a summary figure for the five years of operation, the L-GCRd diagram has 20 GCRd bins that contain data entries for each of the QSOs, but the L-value shown for each bin is the most distant entry. About 50 DX entries are in the last 10 bins, but none of the longest entries reached the Lmax for its GCRd value. The increasing trend in the figure suggests that ducting does support DXing beyond 10,000 km. Without ducting assistance, one could expect to find the DX contacts beyond 10,000 km to be spread more evenly in the figure instead of being concentrated at the high GCRd end.

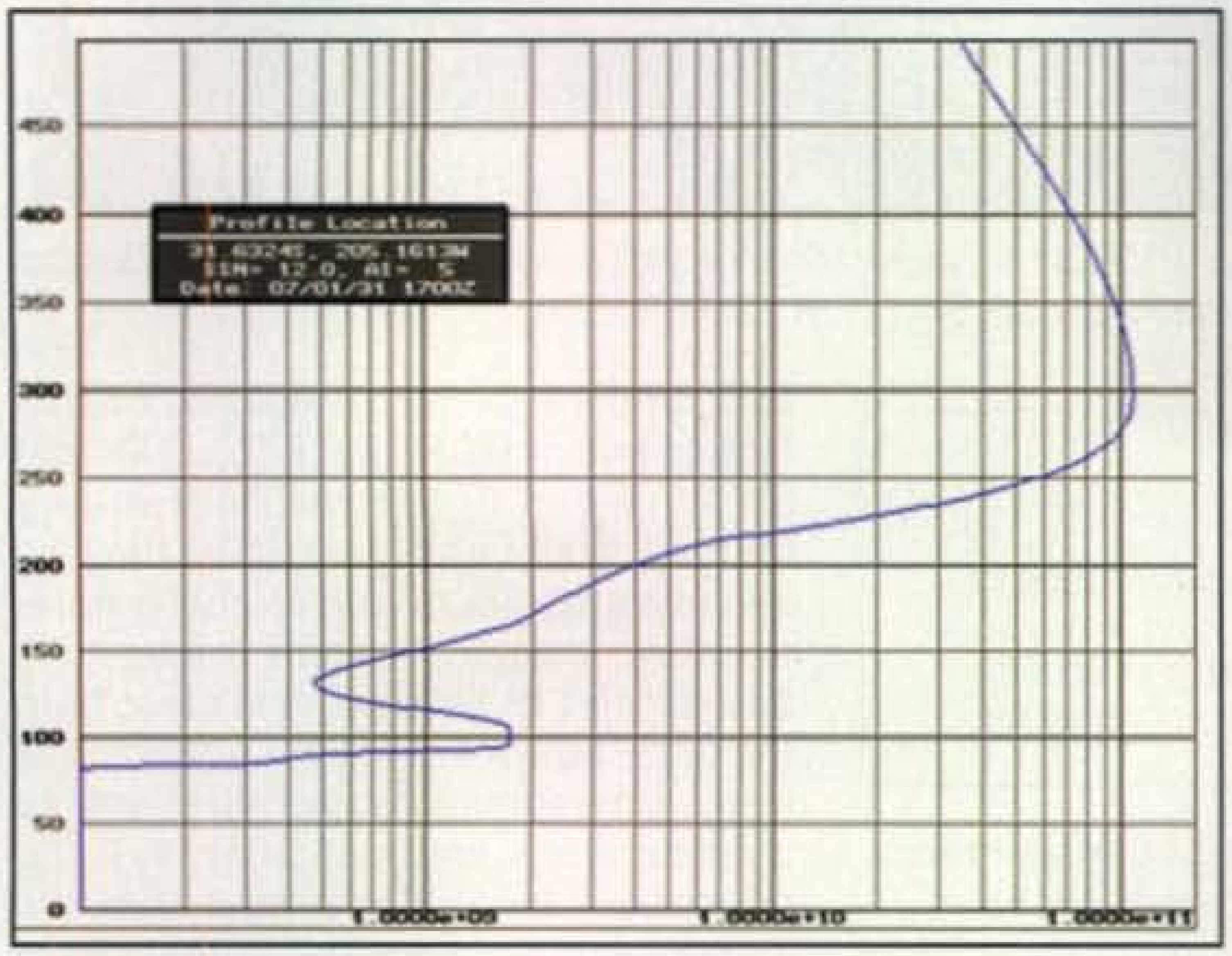

Fig. 1– The nighttime electron-density valley.

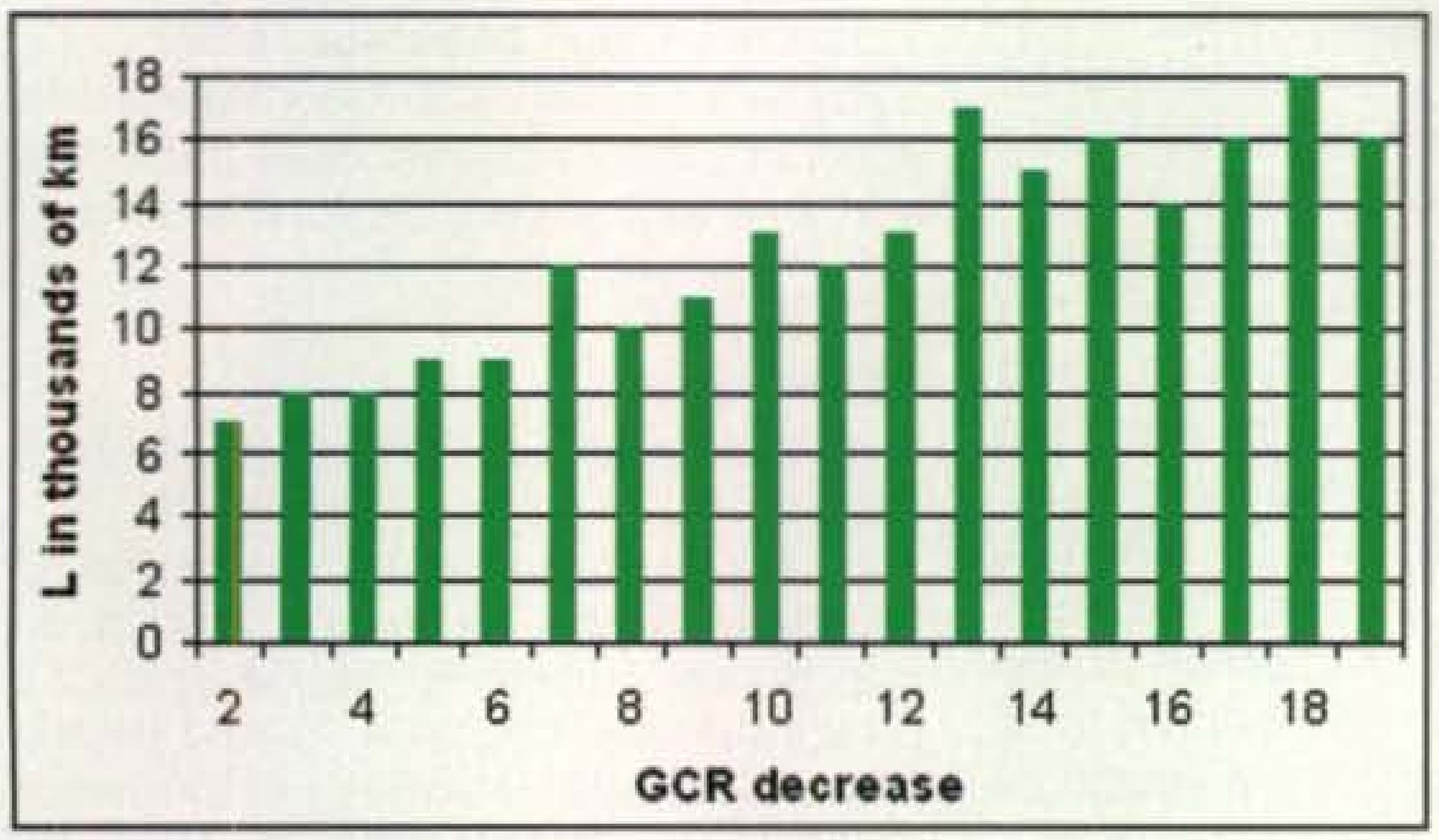

Fig. 2– W7LR log data.

Tier 3: Ham Enhancement

Now we turn to Tier Three, reached by adding one or more elements to the antenna system. That results in an increase in antenna aperture or gain, but with the loss of symmetry in the pattern itself. Pattern calculations are generally based on the use of the lowest mode for an individual radiator—e.g., in broadside, end-fire or cardioid patterns of two-element beams. Higher angles or modes may be used in simple HF propagation programs, but not with multiple radiators on 160 meters.

The properties of Tier Three systems depend on the electrical length, the number and geometry of the radiators. Thus, one learns of three-element collinear arrays, such as Yagis, on the Topband Reflector, but there seems to be a greater number of four-element systems in use—e.g., 4-square

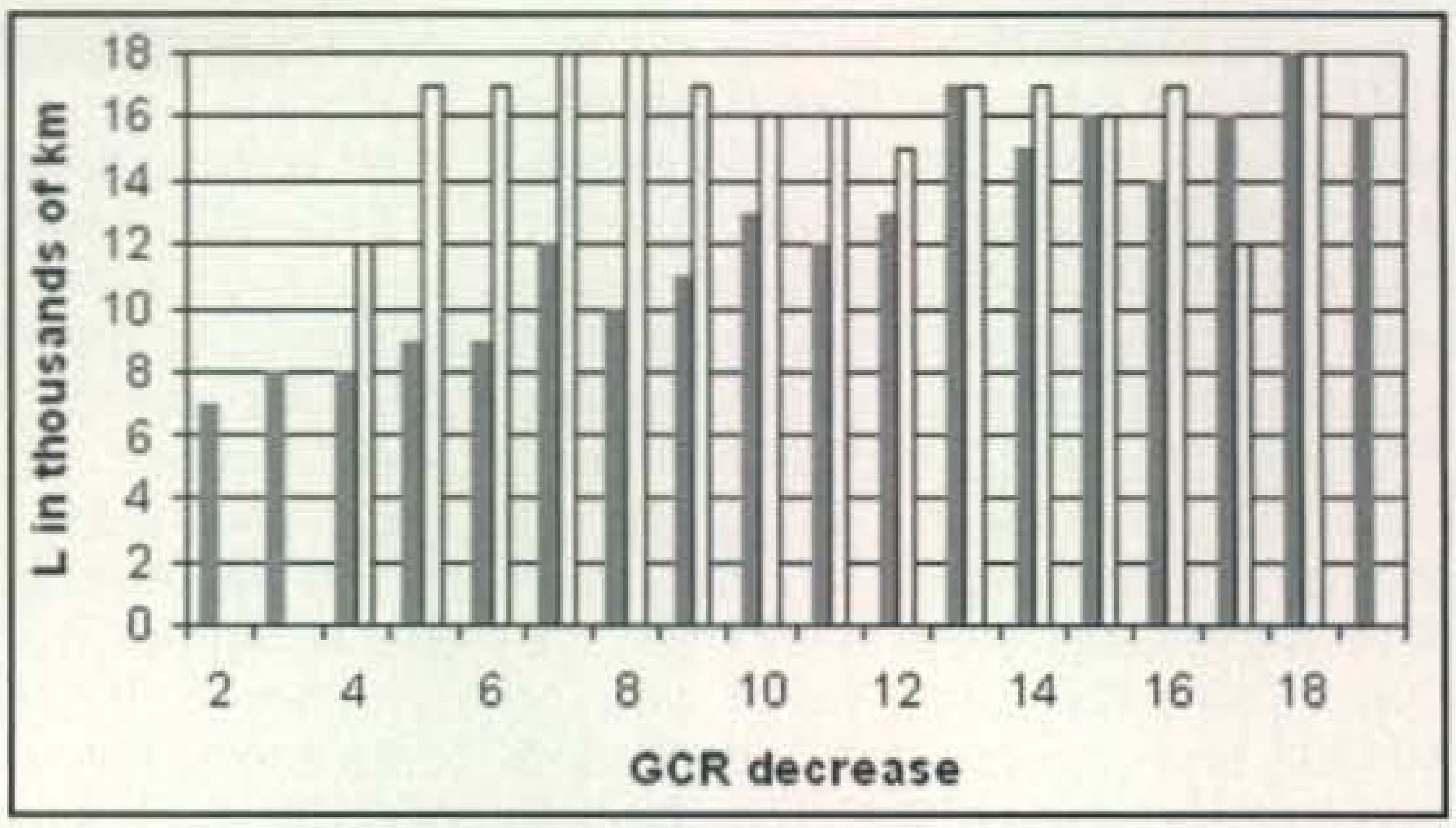

Fig. 3– VY2ZM data added to W7LR data. Dark bars show W7LR.

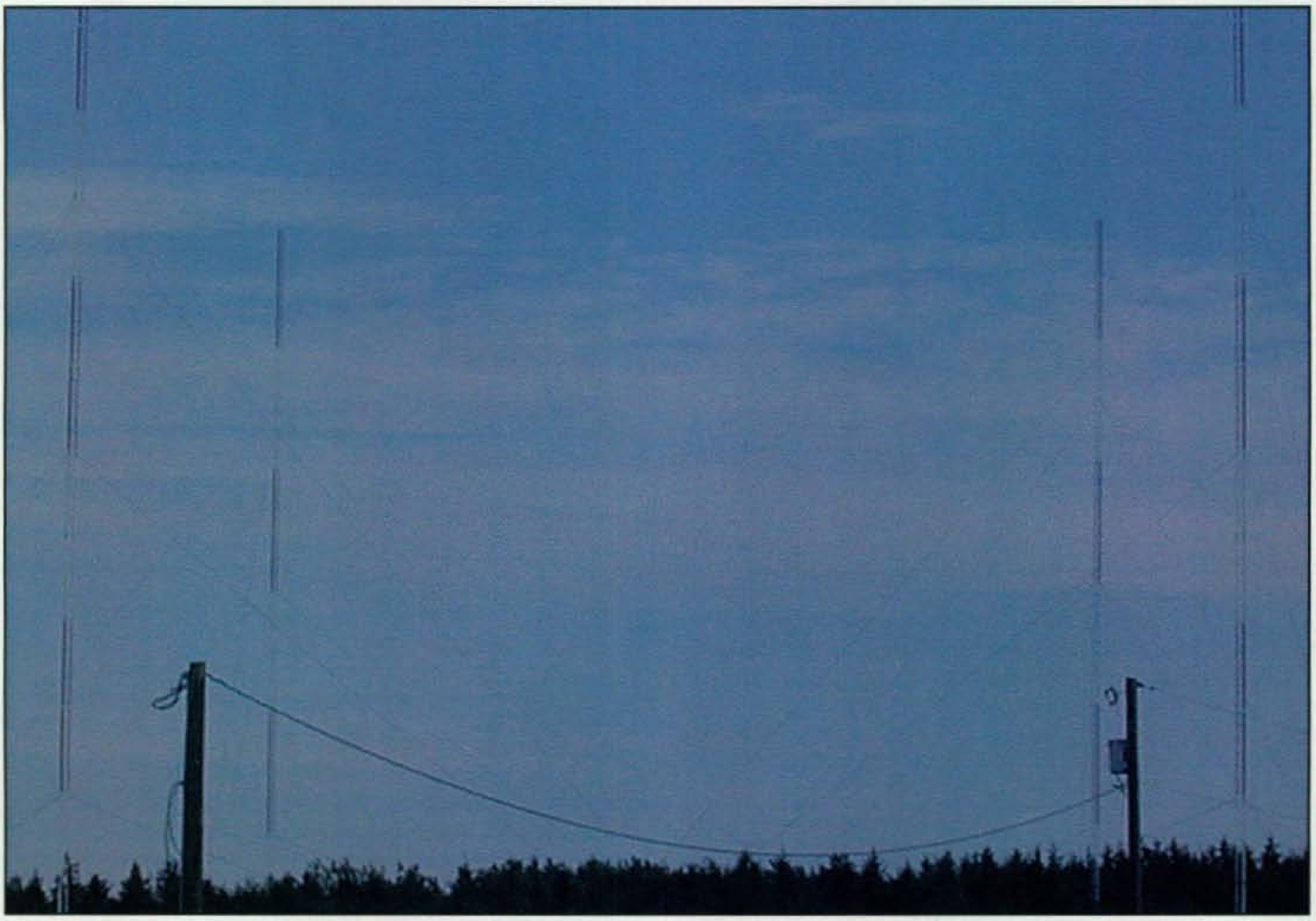

Photo B– The 2×2 steerable broadside/endfire array for 160 at VY2ZM. A wider view of Jeff's entire antenna farm can be seen in the opening photo. (Photos courtesy of Jeff Briggs, K1ZM/VY2ZM)

Condition	Gain
Unidirectional to Europe	8.25 dB
Unidirectional to VK/ZL/KH6	8.25 dB
Broadside to EU and VK/ZL/KH6	5.0 dB in each direction
North and East (at the same time)	6.0 dB in each direction
South and West (at the same time)	6.0 dB in each direction
NW (to KL7) and SE (to ZS6) at the same time	3.0 dB in each direction

Table I– Gain performance of VY2ZM's four-element 160-meter transmit array, focused in different directions from his QTH on Prince Edward Island.

arrays, probably due to the use of phasing systems to steer pattern directions.

The use of large Tier Three systems varies—for pure DXing, contesting, even QRM rejection, as was done by the VK0IR DXpedition to Heard Island with an 80-meter 4-square array. The present study uses data from the Tier Three array at VY2ZM/K1ZM on Prince Edward Island, Canada. Table I shows the gain performance of VY2ZM's four-element transmit array in different settings: The data from VY2ZM was for contest and non-contest periods and was handled exactly the same as that from W7LR, and both data sets were from the same time period, 2003–2007.

While GCRd values show a solar-cycle variation, in that period GCRd values ranged from about 5 to 20, and since both operators carried on almost daily DX operations with comparable powers, the two data sets may be compared at equal GCRd values. These are shown in fig. 3 for contacts in the Pacific Ocean area, where contacts with Australia (15,400 to 18,500 km) were numerous.

The dark bars in fig. 3 are for W7LR, shown earlier in fig. 2, while the open bars are for VY2ZM. Inspection of the data shows the augmented antenna at VY2ZM to be superior at low levels of GCRd activity, contacting VK6, VK9/C, and VQ9, but the ducting-assisted vertical antenna of W7LR held its own at high levels of GCR with FT5, ZD9, and 9V. While the superior results of an augmented system at low GCRd may be intuitively obvious, due to the greater aperture, analytical details are wanting and difficult to develop. It is clear from the data, however, that the advantages of an augmented system that are so obvious at low levels of GCRd are significantly reduced (if not negated) by the ionospheric enhancements that result from significantly higher GCRd levels.

This concludes the discussion of Tier Three with the beautiful rectangular array at VY2ZM. Other geometries and apertures may be considered but would add little to the basic understanding.

References

1. Luetzelschwab, R. C., unpublished, 1995.

2. "On Solar and Galactic Cosmic Rays," *Low Band Monitor*, September 2008, p. 5.

3. Brown, Robert R., NM7M, and Carl Luetzelschwab, K9LA, "A Theory on the Role of Galactic Cosmic Rays in 160–meter Propagation," *CQ* magazine, Vol. 64 No. 11, November 2008, p. 13.0