EXHIBIT 1

Report of Arizona Telephone Microwave Systems
Effect of vacating the 2 GHz Microwave Band

Freq GHz		2	4	6	10	11 Low-density routes		
Path Length	Miles	Path Loss	Path Loss	Path Loss	Path Loss	Path Loss	Equip	In Service
Blue Ridge	48.2	136.7	142.7	146.2	150.7	151.5	36	28
Tonto Basin	11.5	124.2	130.3	133.8	138.2	139.0	36	22
Hyder	20.5	129.3	135.3	138.8	143.2	144.1	30	26
Roosevelt	36.7	134.3	140.3	143.9	148.3	149.1	48	36
Supai Long Mesa to TK Tank	24.5	130.8	136.8	140.3	144.8	145.6	96	19
TK Tank to Grand Canyon	22.5	130.1	136.1	139.6	144.0	144.9		

Total miles 1,639

6 paths = 27.3 mi avg

REA IN ACTION AT THE GRAND CANYON

Because the nearest road is 10 miles away—straight up—Supai village's new microwave system is not just a convenience; it's a must.

BY DIANNE HAMMER, ASSOCIATE EDITOR

CARVED out gradually over billions of years by the Colorado River, the Grand Canyon inspires immediate awe in the hordes of tourists who gape over its edge every year.

They gasp at the tremendous beauty, take some photographs, do some camping and a little bit of hiking during their stay. And after a few days of roughing it, they go home—back to the modern conveniences that come with city or suburban life. Public transportation, the mega-mall down the street and pizza delivery just a phone call away.

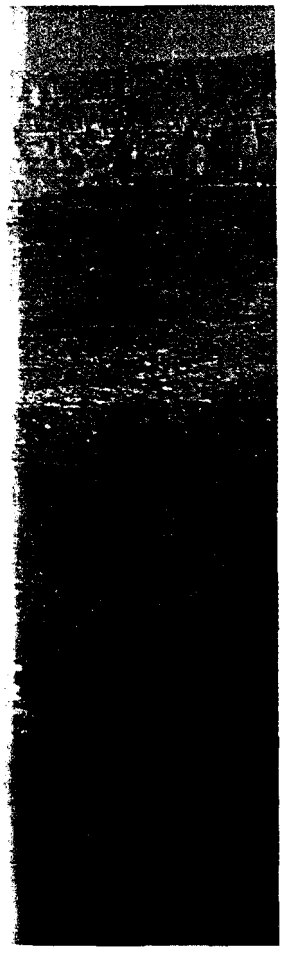
That way of living is a far cry from the lives of those in Supai Village, Ariz., year-round residents who live near the Grand Canyon. Ask a group of villagers there if they can get a 30-minute delivery from Dominos and

someone might chuckle and retort, "Only by helicopter."

Supai is home to one of the most isolated U.S. Indian reservations. Inhabited by about 500 Havasupai Native Americans, the village is nestled 10 miles down at the bottom of Havasu Canyon and 40 miles west of the Grand Canyon's South Rim. You can get there only by your own two feet, by horse or mule, or by helicopter—but that's where the choices end.

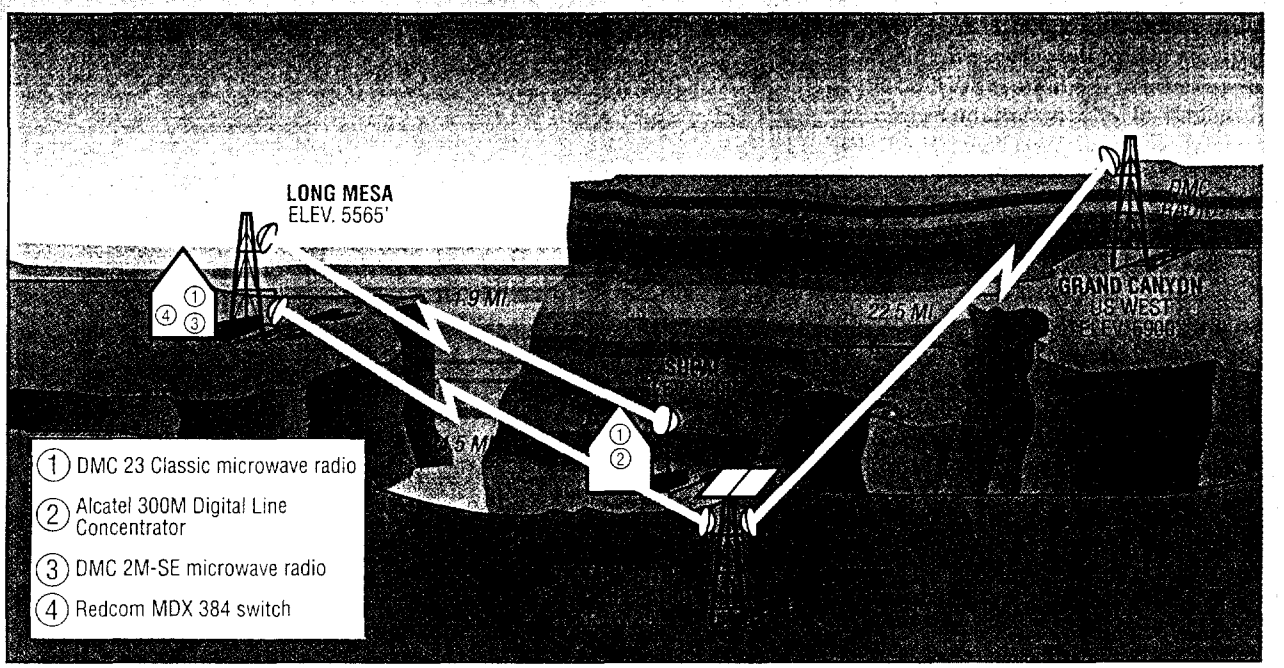
The residents have—except for tourists who make the trip down—the grandeur of the canyon all to themselves. But this can be dangerous in an emergency without reliable communications with the world above. A modified pole-and-wire phone system that is subject to the whims of theft, limited capacity and Mother Nature is just not enough.

Due to efforts by the Rural Electrication Administration (REA), the National Exchange Carrier Association (NECA) and Arizona



LEFT: *A spectacular view of Supai village from Long Mesa.*
RIGHT: Top. *Rollie Nehring, president of Arizona Telephone, shakes hands with Havasupai Tribal Chairman Don Watahomigie.*
Middle. *Former U.S. Sen. Barry Goldwater makes the system's inaugural call to Arizona Gov. Fife Symington. Standing behind is Nehring; to the left is Watahomigie; and on the right is Tribal Vice Chairman Tommie Siyuja.*
Bottom. *A Havasupai dance group welcomes Goldwater with a traditional ceremony.*

SUPAI'S NEW DIGITAL MICROWAVE SYSTEM



THE HUT ON LONG MESA.
LEFT: *Nehring explains the new system to reporters, and REA and NRTA (National Rural Telecom Association) officials.*
RIGHT: *The bay on the right holds DMC's indoor, protected 2M-SE radio. In the middle of the photo is test equipment, while at the left is part of the Redcom MDX 384 switch.*

Telephone, that doesn't have to be enough anymore. The villagers now have reliable telephone service via a point-to-point digital microwave system.

Arizona Tel personnel, supplier representatives and the press gathered in Supai recently to celebrate bringing the new system online as Barry Goldwater, former Republican Senator from Arizona, made the inaugural call to Arizona Gov. Fife Symington.

▶ The old system

The Digital Microwave Corp. (DMC) system replaces a network with parts that date back to 1929. Arizona Tel President Rollie Nehring explains: "The best way to establish telephone service in low-density service areas where there was no power and long distances [between] was with poles and wire because you could transmit long distances without having to amplify the signal."

Plant installed in 1929 was extended in the 1950s to Hualapai Hilltop, "which was the end of the road—and still is today," says Nehring. From there, installers attached wire to the side of the canyon cliffs in herringbone fashion for the 10 miles down to the village. They had to drill each of the nearly 100 anchor positions with sledgehammers and steel bits because there wasn't any power along that area during that time. Two toll-station phones were installed, and an operator 175 miles away connected callers. The phones were used primarily for emergencies.

Nehring founded Arizona Telephone in 1967 and bought the existing Supai system one year later. He upgraded it to dial operation, added Western Electric "O" carrier to expand the one available channel to six, and installed a used, modified North Electric CX-100 switch in Supai. Village resident Leon Rogers maintained the system inside the canyon, while Arizona Tel was responsible for the installed plant leading to the canyon.

And that's the way the residents received phone service until Jan. 23.

"The system was reliable in the early stages," notes Nehring, "but it became less and less reliable as it aged. And we were always susceptible to lightning and extreme weather like heavy snowstorms. The other problem was theft of the wire," not in the canyon area but in

nearby U S West territory. For example, the RBOC had 82 spans stolen in the two weeks before the microwave network cutover. "In fact, our old system was off the air at cutover time," admits Nehring.

▶ The new system

In the late 1980s, Nehring decided the original system had served its purpose and it was time to implement microwave radio. With a $300,000 REA loan, a $65,000 grant received by the Bureau of Indian Affairs, and general funds that include money received from the NECA pooling process, Arizona Tel purchased three digital microwave radio hops from San Jose, Cal.-based DMC. Installing the entire system cost roughly $450,000, according to Nehring

The main object in designing the new network was to install most of the equipment on the plateau above the village. "We have moved most of the technology up to Long Mesa where we can drive to the site, rather than having to ride a horse or mule or helicopter in [to Supai]."

The only equipment in the village is an Alcatel 300M Digital Line Concentrator, a DMC 23 Classic 23GHz microwave radio and a Microflect 20-foot monopole *(see figure)*. Up at Long Mesa, Nehring installed a hut with another DMC 23GHz radio, a DMC 2M-SE 2GHz radio and a Redcom Laboratories MDX-384 digital switch. An 80-foot Microflect microwave tower and antennas from Gabriel Electronics allow line-of-site transmission between Long Mesa and Supai.

Long distance calls transmitted from the village up to Long Mesa travel to TK Tank. A solar-powered Peninsula Engineering Group repeater then amplifies the signal and sends it on to the Grand Canyon site, where another DMC 2GHz radio picks it up. From Grand Canyon, U S West takes over and transmits the call via mountain repeaters to Phoenix.

The new system will provide Supai residents with much more reliable phone service. "These systems are designed to be able to operate despite extreme weather conditions," assures DMC President and Chief Operating Officer Douglas Morais.

The new system cost roughly $450,000, says Nehring.

For DMC, this installation is particularly important—the first six months of operation are actually an REA trial. REA approval after this period will mean the DMC equipment is automatically available to telco borrowers without the supplier having to go through a bidding process on a case-by-case basis. While Marais notes that individual REA purchases aren't large, when added together their numbers could be significant.

The Supai microwave system has a capacity of 96 channels, but the village currently uses just 18. Nehring says the village uses 47 access lines, but predicts a 40% increase within the next year. "We expect it to increase considerably because the system is used primarily for long distance calling, and the blockage due to the limited number of circuits in and out with the old system discouraged people from taking service. Now that that has been corrected, we have been receiving a lot of orders from new service from the Havasupai residents."

The new system is dedicated to Goldwater. "It goes to his support for Universal Service, [and this] is a prime example of what Universal Service policy is all about." The health, welfare and economic survival of the Supai people is dependent on a good communications infrastructure, Nehring says.

This is a specific case of why "the policy of universal telephone service was embraced by Congress and the FCC and why the REA loan program exists," concludes Nehring, clearly plugging the loan program. "Certainly from the REA loan standpoint, where there has been some controversy of late, I can only say—and Supai is a prime example of it—the job is certainly still not done." ■

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Rocky Mountain Telecommunications Association

EXHIBIT 3 - ENGINEERING STATEMENT

1. This Engineering Statement is prepared on behalf of Rocky Mountain Telecommunications Association in support of maintaining primary status of point-to-point common carrier service in the 2 GHz frequency band in rural geographical areas. As shown below, the transmission path reliability is decreased for path lengths over 30 miles (48 kilometers), for higher frequency bands of the private and common carrier services. Such long point-to-point microwave hops are essential for cost-effective operation in many rural locations, especially so in mountainous terrain.

2. In the Commission's Report examining the possibility of creating emerging technologies, "Creating New Technology Bands for Emerging Telecommunications Technology", FCC/OET TS92-1 (January, 1992), several factors affecting the reliability of a transmission link at different frequencies are examined. These factors include (a) increased antenna gains at higher frequencies, (b) increased free space loss at higher frequencies, (c) increased fade loss at higher frequencies and (d) increased rain attenuation at higher frequencies. In a comparison of the 2 and 6 GHz frequency bands, the FCC concludes from its study that the increased antenna gain at 6 GHz (approximately 19 dB) tends to offset the increased losses due to fading (approximately 8 dB) and free space (10 dB); and that the rain attenuation at 6 GHz is insignificant. The conclusion reached by the FCC in its report theorizes that greater reliability is obtained at 6 GHz than at 2 GHz, for identical path lengths and antenna sizes. However, the Commission's Report has overlooked important details regarding the detrimental effects realized at the higher frequencies which predict decreased transmission reliability at 6 GHz compared to 2 GHz, particularly where long paths are used in areas of mountainous terrain. As demonstrated by this report, closer examination of the transmission characteristics for an identical micowave path at 2 GHz and 6 Ghz demonstrate a decrease in transmission reliability at the higher frequency.

Free Space Path Loss Versus Frequency

3. In the Commission's report, the additional free space loss at 6 GHz (compared with 2 GHz) is correctly given as 10 dB. It is beneficial, however,

to show the increase in free space loss associated with each frequency band in the private and common carrier service.

4. The difference in path loss between two frequencies in free space for a fixed distance path can be determined using the following formula:

$$LOSS_{freq} = 20 \times LOG_{10}(FREQ_{new}/FREQ_{current}) \quad \text{in dB.}$$

$FREQ_{new}$ and $FREQ_{current}$ must be in the same units (typically MHz or GHz for microwave paths). The 2 GHz band for the Commission's proposed emerging technologies is centered at 2.025 GHz. Using this frequency as the current frequency in the above equation, the additional loss realized by a change to the higher frequency bands of the private and common carrier services are provided in Table 3.1 below.

TABLE 3.1 - INCREASED FREE SPACE LOSS(DB)
AT HIGHER FREQUENCIES COMPARED TO 2.025 GHZ

Frequency Band	MidBand Frequency	Loss
3.7-4.2 GHz	3.95 GHz	5.8
5.925-6.425 GHz	6.175 GHz	9.7
6.525-6.875 GHz	6.700 GHz	10.4
10.7-11.7 GHz	11.2 GHz	14.9
11.7-12.2 GHz	11.95 GHz	15.4
12.7-13.25 GHz	12.975 GHz	16.1
17.7-19.7 GHz	18.7 GHz	19.3

Waveguide and Coaxial Line Loss versus Frequency

5. As the frequency is increased to the other available bands, the transmission loss attributed to the transmission line is also typically increased. Tables 3.2 and 3.3, below, show the loss attributed to 100 feet of coaxial cable and elliptical waveguide, respectively, for each point-to-point microwave frequency band. Andrew FSJ4-50B transmission line is used to determine the losses listed in Table 3.2. The Andrew elliptical waveguide with the least amount of loss available for use in a frequency band is used to determine the

losses listed in Table 3.3. The losses are taken from the charts in Andrew Catalog 33, on pages 178 and 218, which are included herein as Figures 3A and 3B, respectively.

TABLE 3.2 - TRANSMISSION LOSS (DB/100 FEET) FOR ANDREW LDF4-50A COAXIAL CABLE AT DIFFERENT FREQUENCIES

Frequency Band	MidBand Frequency	Loss
1.85-2.20 GHz	2.025 GHz	5.1
3.7-4.2 GHz	3.95 GHz	8.0
5.925-6.425 GHz	6.175 GHz	10
6.525-6.875 GHz	6.700 GHz	11
10.7-11.7 GHz	11.2 GHz	14
11.7-12.2 GHz	11.95 GHz	not given
12.7-13.25 GHz	12.975 GHz	not given
17.7-19.7 GHz	18.7 GHz	not given

TABLE 3.3 - TRANSMISSION LOSS (DB/100 FEET) FOR APPROPRIATE ANDREW WAVEGUIDE AT DIFFERENT FREQUENCIES

Frequency Band	MidBand Frequency	Loss
1.85-2.20 GHz	2.025 GHz	0.4
3.7-4.2 GHz	3.95 GHz	0.7
5.925-6.425 GHz	6.175 GHz	1.2
6.525-6.875 GHz	6.700 GHz	1.3
10.7-11.7 GHz	11.2 GHz	3.1
11.7-12.2 GHz	11.95 GHz	3.7
12.7-13.25 GHz	12.975 GHz	3.5
17.7-19.7 GHz	18.7 GHz	5.9

7. As shown in Figure 3B, choosing a different coaxial cable transmission line will result in approximately the same amount of increased loss between 2 and 6 GHz. For a microwave link requiring 100 feet of cable at each

antenna site, approximately 10 dB of additional coaxial cable loss will be realized at 6 GHz compared with 2 GHz. The relationship between the length of transmission line required and the additional amount of coaxial cable loss is linear. For example, twice the amount of transmission line (200' towers) will result in twice the loss, or 20 dB.

8. A microwave link requiring 100 feet of waveguide at each antenna site will result in approximately 1.6 dB of additional waveguide loss at 6 GHz compared with 2 GHz.

Rain Attenuation Versus Frequency

9. Multipath fading does not occur during periods of heavy rainfall; therefore, as pointed out in the FCC's report, the entire fade margin is typically available to compensate for rainfall at frequencies of 6 GHz and below. Upon closer examination, the attenuation due to rainfall at 6 GHz may not be compensated fully by the fade margin of a microwave path for distances of 50 miles or more. Rain attenuation is related to the intensity of the rainfall and is not directly related to average rainfall. An instantaneous intensity of 2 to 4 inches per hour of rainfall (very heavy rain) can greatly effect the performance of a 50 mile microwave path, even at 6 GHz. Figure 3C is copied from Page 47 of Engineering Considerations for Microwave Communications Systems by GTE Lenkurt , copyright 1975. According to Figure 3C, at 6 GHz, a rainfall intensity of 4 inches per hour (very heavy rain) will cause 1.1 dB per mile of rainfall attenuation at 6 GHz. This is equal to 55 dB for a 50 mile microwave path at 6 GHz. Although rain attenuation at 2 GHz is not shown on Figure 3C, a rain intensity of 4 inches per hour will cause less attenuation than at 4 GHz, which is shown on Figure 3C to be 0.18 dB per mile. This equals 9 dB for 50 miles. At 6 GHz compared to 4 GHz, the difference between 55 dB and 9 dB, which is 46 dB, is the additional loss along the 50 mile microwave link predicted to occur during a heavy rainfall. Compared to 2 GHz, an additional 50 dB of rain attenuation can be expected along the path. A fade margin of 30, or even 40 dB, will not adequately compensate for this loss.

10. Although 4 inches per hour rain intensity is not common in some areas of the country, it will occur often enough to cause significant outages along a 6 GHz microwave path during electrical storms. Table 3.4, below, is the increased rain attenuation during heavy rainfall (4 inches per hour) at 6 GHz compared to 4 GHz for different path lengths. Since 4 GHz frequencies are

commonly used by interexchange carriers to haul toll traffic, these channels are often not available, creating the need to utilize the 6 GHz band if 2 GHz is reallocated.

TABLE 3.4 - INCREASED RAIN ATTENUATION (DB) DURING HEAVY RAINFALL (4 INCHES PER HOUR) AT 6 GHZ COMPARED TO 4 GHZ

Distance (miles)	Increased Attenuation (dB)
20	18.4
25	23.0
30	27.6
35	32.2
40	36.8
45	41.4
50	46.0
60	55.2
75	69.0

Antenna Gain Versus Frequency

11. The FCC's report states that the increase in antenna gain of two standard parabolic 8-foot antennae at 6 GHz compared to 2 GHz is approximately 19 dB (9.5 dB per antenna)[1]. With an increase in antenna gain, however, is the detrimental effect of a decrease in antenna beamwidth. At 2 GHz, the 8-ft antenna has a beamwidth of approximately 4 degrees. At 6 GHz, the beamwidth of the 8-ft antenna is reduced to approximately 1.3 degrees. The reduced beamwidth will reduce the reliability of the transmission path due to the twist and sway that can result to the towers supporting the microwave antennas.

[1] The antenna gains of the standard 8-foot parabolic antennas at 2 GHz and 6 GHz manufactured by Mark, Model numbers P-21A96 and P-60A96, are listed as 32.4 dBi and 41.5 dBi, respectively. The overall antenna gain of the path using these antennas would be 17.4 dB, not 19 dB.

Fade Margin and Transmission Path Reliability at 2 and 6 GHz

12. The fade margin is determined below for a typical 50-mile microwave path at 2.025 GHz and at 6.175 GHz. The following assumptions are made:

(a) 300 feet of waveguide is required;

(b) Standard 8-foot parabolic antennas are used;

(c) The receive threshold is -78 dBm at both frequencies;

(d) The transmitter output power for both frequencies is 2 watts (33.0 dBm).

13. The fade margin at 2.025 GHz, $FM_{2.025}$, is determined using the following equation:

$FM_{2.025}$ (dB) = TPO - lineloss - fsl + AntGains - REC_{TH},
where TPO = transmitter output power (dBm),
lineloss = total system line loss (dB),
fsl = free space loss (dB),
AntGains = sum of both antenna gains (dB),
REC_{TH} = receiver threshold (dBm).

= 33.0 dBm - 1.2 dB - 136.7 dB + 65.6 dB - (-78 dBm).
= 38.7 dB.

14. The fade margin at 6.175 GHz, $FM_{6.175}$, is calculated to be the following:

$FM_{6.175}$ (dB) = 33.0 dBm - 1.2 dB - 146.4 dB + 83.0 dB - (-78 dBm).
= 46.4 dB.

15. The difference between the fade margins is only 7.7 dB which is not enough to offset the increased detrimental effects at the higher frequency due to increased fade loss and/or increased rain attenuation. At 6 GHz, a heavy rain, as discussed above, will cause 55 dB of rain attenuation along the 50-mile path. This will exceed the fade margin thus causing an outage of the 6-GHz microwave path. At 2 GHz, a heavy rain will cause less than 9 dB of rain attenuation along the 50-mile path. Therefore, a similar outage at 2 GHz would not result. The reliability of the path is, therefore, decreased at 6 GHz compared to 2 GHz.

SPECTRUM INEFFICIENCY

16. The Commission in its Notice of Proposed Rulemaking, advocates relocating all existing 2 GHz microwave band licensees to a higher portion of the microwave frequency spectrum. As discussed in the FCC's Report, the use of frequencies at 10 GHz and above are not feasible as replacement frequencies for 2 GHz, except for very short hops. Furthermore, neither the 4 GHz or 6 GHz frequency bands are channelized by the Commission and assignments are presently being made by frequency coordinators on a "first-come, first-served" basis. In other words, if a potential FCC applicant informs a coordinator of its intention to use a 30-MHz bandwidth microwave transmitter, the coordinator will examine the existing licensees in the given area to see if the spacing between existing assignments will accommodate an additional 30 MHz bandwidth user. These frequency assignments are made regardless of the requested center frequency since channelization was never established. Assignments are generally made for either a 10 or 30 MHz bandwidth in the 4 and 6 GHz spectrum.

17. The Commission now proposes to allow new applicants, who would have typically been 2 GHz band users, to apply for 4 or 6 GHz band frequencies, apparently without regard to the minimum channel loading requirements now in effect; and has also suggested that it would waive certain eligibility requirements. Given the fact that many of the typical 2 GHz band users are smaller rural telephone companies, they may not have the capital to purchase new 4 or 6 GHz radios. These rural telephone companies (and other 2 GHz users) will most likely opt to purchase used analog transceivers which are flooding the market due to the high rate of conversion to digital transceivers. Even if they

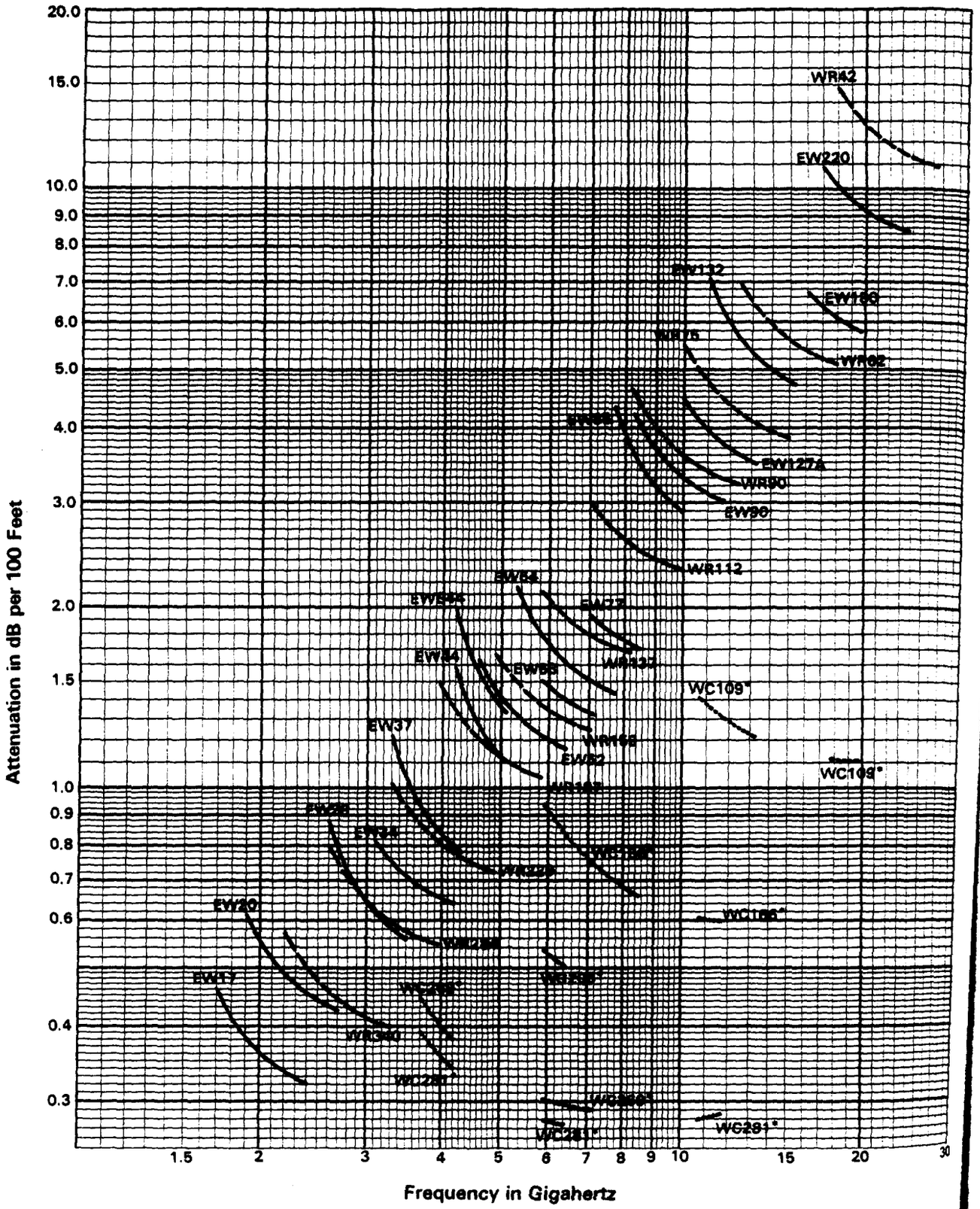
can purchase new equipment, 99% of the 4 and 6 GHz band equipment manufactured for use under Part 21 of the Commission's Rules is channelized for at least 10 MHz of bandwidth. Equipment using 10 to 30 MHz bandwidth equipment would have circuit capacities of 900 to 3,000 voice grade channels. However, these rural telephone companies may require as few as 15 voice grade channels, and their requirements may never grow beyond 100 channels. Yet, these companies will, under the Commission's proposal, be allowed (and in many cases, required) to occupy 30 MHz of bandwidth for an operation which may never need more than 500 kHz of bandwidth, thereby wasting a significant portion of the available microwave spectrum.

18. Further complicating the problem is the number of 4 and 6 GHz channels available if assignments are made using 30 MHz bandwidth. Given the fact that there can only be 24 of the 20 MHz wide channels at 4 GHz and 16 of the 30 MHz wide channels for 6 GHz available, the Commission does not address where the smaller rural telephone companies should seek frequency spectrum once these 40 channels have been assigned to other users in its area. The Commission seems to believe that fiber optics would be a solution; however, the cost of laying fiber optic cable to sparsely population areas may be prohibitive, and the terrain does not lend itself to burying cable, especially through 2,000 to 8,000 feet mountain ranges. It is this type of topography which requires the use of the 2 GHz band radios.

19. If the Commission is to make efficient use of the 4 and 6 GHz bands, it would have to channelize the spectrum, and establish new loading requirements which would make frequency assignments based on projected loading capacity, making allowance for those applicants with lower capacity needs. Channelizing these microwave bands would be an unmanageable task because the Commission would have to first relocate every existing licensee now using 10 to 30 MHz of bandwidth, accommodating them elsewhere in the allocated spectrum. Many of these licensees require the full 30-MHz bandwidth they now occupy. Otherwise, in many cases, there will not be enough spacing between the existing 4 and 6 GHz licensed facilities to accommodate coverting existing 2 GHz systems to these bands.

Microwave Waveguide
Attenuation – dB/100 Feet

Figure 3A

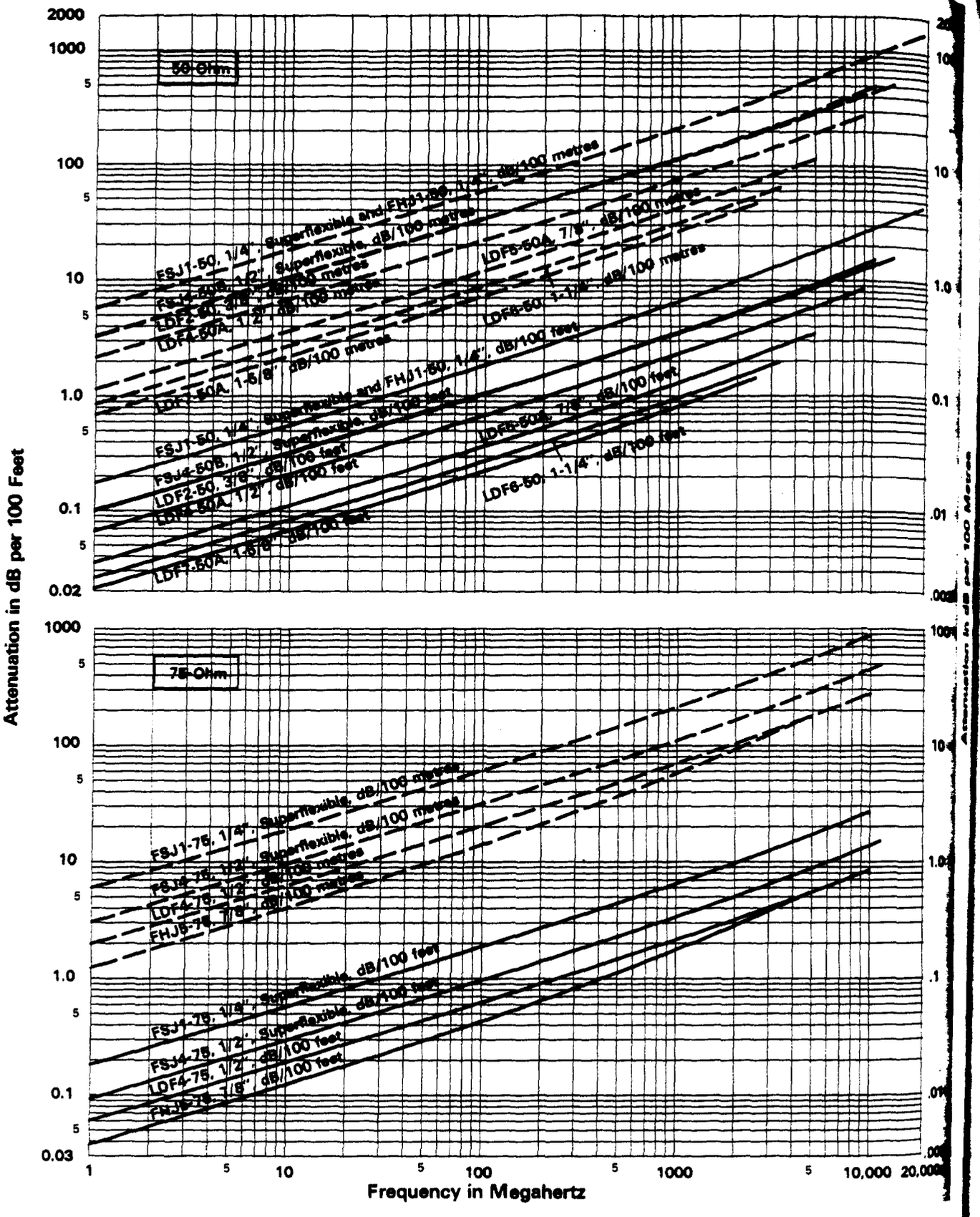


Attenuation curves based on:
VSWR 1.0
Ambient Temperature 24°C (75°F)
High Conductivity Copper

The above attenuation curves are guaranteed within ±5%

*Does not include transition or network losses. See pages 196 and 198.

Figure 3B



Attenuation Curves based on:
VSWR 1.0
Ambient Temperature 24°C (75°F)
Atmospheric Pressure, dry air

Conversion Data:
For other ambient temperatures, see curve on page 219.

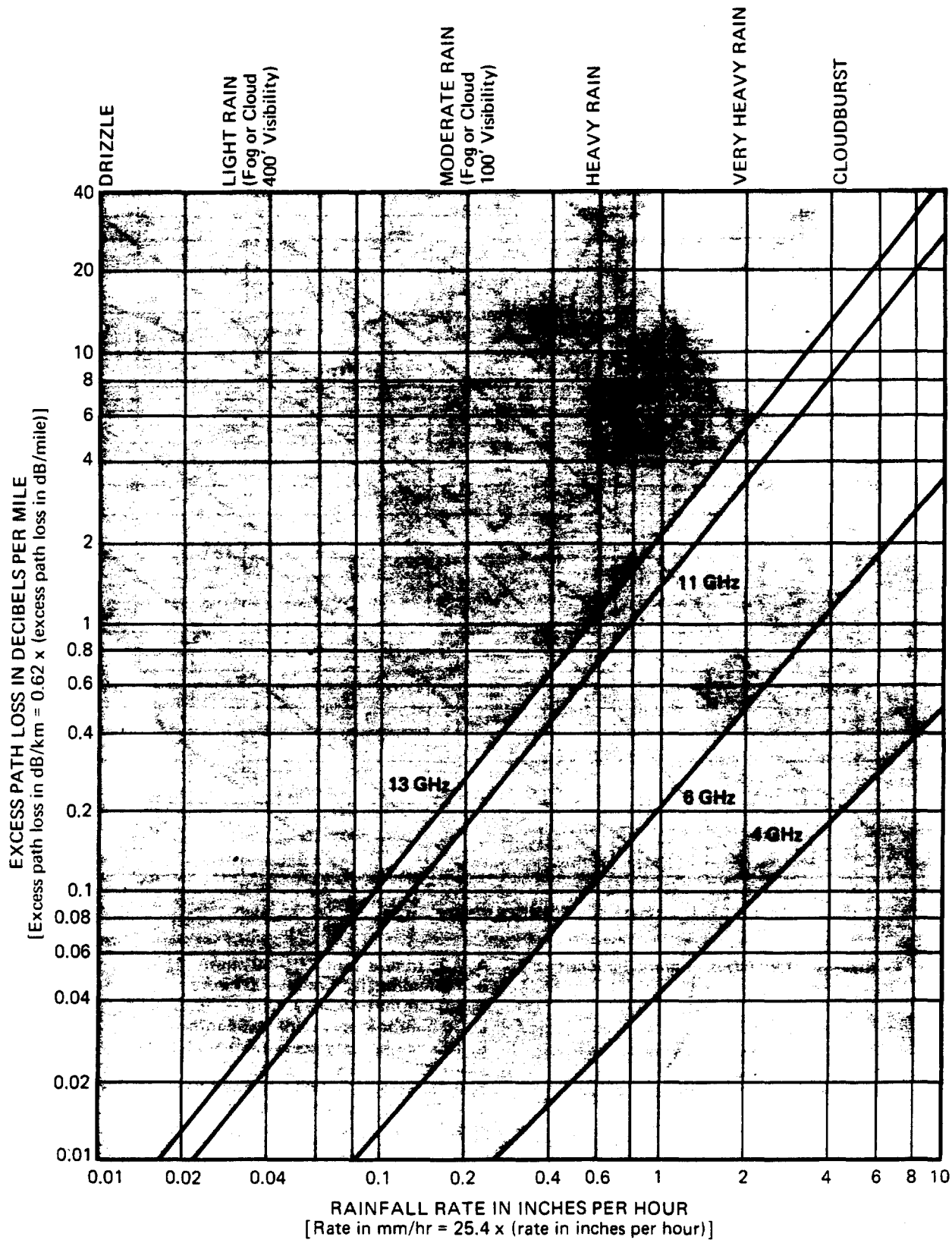


Figure 17. Rain Attenuation vs. Rainfall Rate (Theoretical, after Ryde and Ryde)

ENGINEERING REPORT

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Rocky Mountain Telecommunications Association

Darryl K. DeLawder has a Bachelor of Science degree in electrical engineering from Villanova University and has been retained by Rocky Mountain Telecommunications Association to prepare this engineering statement. Darryl K. DeLawder has either prepared or directly supervised the preparation of all technical information contained in this engineering statement.

Except with regard to those facts of which the Commission can take official notice, the facts stated in this Engineering Statement are true of my own knowledge, except as to such statements as are herein stated to be on information and belief, and as to such statements I believe them to be true.

Darryl K. DeLawder

06-04-92

Date

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