

The National Radio Quiet Zone

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Abstract

NRAO operates the National Radio Quiet Zone at Green Bank. We briefly outline its salient characteristics, and our experience with its day to day operation.

1. Introduction

A very special, important, and as yet unique tool for spectrum management at the Green Bank site of the National Radio Astronomy Observatory is our National Radio Quiet Zone (NRQZ). This was set up in 1958 in the earliest days of Green Bank's use as a site for radio astronomy, while there was an imperative for the USA to match the Russian space exploits first heralded by their launching of the Sputnik satellites. The Green Bank site was carefully chosen in the first instance for its relative proximity to Washington, its radio-quiet properties that are in part due to terrain shielding, and for the natural features of its surroundings, which suggested there was little danger of its ever being densely settled or industrialized in the future. The Federal Government therefore determined at that time to augment these natural advantages by creating a radio-quiet zone around Green Bank, which is our NRQZ. The formal document detailing the coordination requirements and operational paradigm for the NRQZ is included here as an Appendix.

2. The Green Bank Radio Quiet Zone

Green Bank is not a totally radio-quiet site. The satellite services are sources of rfi for Green Bank, just as they are for everyone else. Moreover, in accordance with long established procedures of spectrum management, active services with existing valid transmitter licenses continue to have priority over new users. So the airport surveillance radar near Bedford, Virginia, about 104 km from Green Bank, continues to operate at 1256 & 1292 MHz: it thus remains a severe source of rfi for observers of red-shifted 21 cm radiation from galaxies (cf Rick Fisher's contribution to this volume). However, the grandfathered transmitters are not a big problem in the NRQZ, as it was established so long ago that there were VERY few pre-existing services. We in practice have more problems from transmitters on big mountains, just outside the NRQZ, which we could wish to be just a little bit bigger. Still, the problematic transmitters from outside the NRQZ are so few that we know them all. The key feature to the success of the NRQZ in remaining a radio-quiet zone is its terrain shielding.

Under the rules governing the NRQZ, which are administered by the FCC and/or the NTIA as appropriate, any potential licensee for the operation of new fixed transmitter(s) in the vicinity of the Observatory must engage in a close coordination with the NRQZ Administrator. This in practice means that the precise siting, and often the exact form of the installed equipment, can be adjusted so as to maintain Green Bank as a radio-quiet site after the new service is operational. For example from 538 transmitter sites evaluated in 2002, ERPd restrictions were required for only 24. In 2003 592 transmitter sites were evaluated with ERPd restrictions required for just 30. Nevertheless, by working diligently with the applicants, mutually acceptable solutions were found for most of the sites that were issued with power restrictions. Our experience thus shows that it is rare indeed for a technical solution to both the Observatory's needs and those of new licensees **NOT** to be found. Note, however, that it is not known how many applications were not filed as a result of the existence of the NRQZ.

Mobile transmitters are harder to control and necessitate eternal vigilance, both in identifying their licensing requests before their potential eruption on the scene, and in monitoring the real-time environment of the site. But they also offer some of our greatest satisfactions. An observer may experience unexpected rfi, on the basis of which he/she alerts the NRQZ administrator. The advantages of local know-how and long acquaintance with our local environment can then sometimes kick in. Thus on one such occasion we considered the time of day (Friday near 16:00), the time of the year (summer), and so deduced that X was quite probably mowing his field. We accordingly made a site visit, confirmed our deduction, and then successfully mediated an end to the rfi. On another occasion we got a call that broadband rfi was being detected by the observers. After loading our truck with a receiver, amplifier, spectrum analyzer, and a directional antenna, we set out to locate the source by triangulating our way to the spot, only to find that an old couple had a penned dog. The dog lay on a heating pad, which had become so worn that cracks in its wiring were arcing across. We preserved our radio-quiet environment in this case by replacing the pad. Our bottom line is that communal sources of rfi, both intentional and unintentional, that are not covered by the NRQZ rules, are handled with great success in a spirit of mutual cooperation.

Due to the ever-increasing demand for spectrum, the level of effort required to administer the NRQZ has grown steadily. We have a stream of licensee and potential licensee applications to evaluate in a timely and earnest fashion, some of which take a great deal of effort to reach mutually satisfactory coordination agreements. It is always best if potential licensees contact us at as early a stage as possible in their planning, since this is by far the most cost-effective way of initiating a new service. However a few of our reviews do result in bad feelings, and even threats of litigation. But the payoff for Astronomy from operating the NRQZ is large and very worthwhile.

The payoff for Green Bank as an operational site is probably even larger, as the existence of the NRQZ comes under attack from time to time. Until now these attacks have been fended off by concerned friends at NTIA, the part of government that looks after federal science interests with regard to their use of the spectrum, and by concerned members of Congress. However, the existence of the NRQZ was a prime motivation for the location of the new 100 m Robert C. Byrd Green Bank Telescope (GBT), and we trust that the significant investment in the GBT will, in turn, help to preserve the NRQZ.

3. Controlling Self-Generated RFI

The boon of having the benefit of a NRQZ makes it all the more incumbent and important for the Green Bank site to pay exceedingly close attention to controlling and suppressing all sources of self-generated rfi. Indeed this need has influenced many facets of the detailed design of the complement of equipment for the GBT, including particularly the sequestration of much of its digital equipment and control computers at a distance from the telescope in carefully shielded rooms. Using rfi conscious designs for the racks, housings, control & power lines, as well as shielded rooms our engineers have endeavored to make our in-house electronic systems "invisible" to radio astronomy instruments. These efforts naturally extend to limiting traffic movement around the site to transportation within the Observatory's own fleet of rfi-quiet diesel vehicles.

With time receiver systems become ever more sensitive. Green Bank has a history of making incremental improvements to its equipment, and is always pushing the bounds by lowering the system temperature: with the GBT we have also achieved greater sensitivity by using an off-axis feed arm to reduce both the blockage this would otherwise cause, and baseline ripple. But these improvements lead to a concomitant need to improve the levels to which rfi from on-site equipment is suppressed, which in turn leads to a need for ever better rfi-detection equipment. Our Interference Protection Group (IPG) has recently installed a remotely controlled field measurement station, and developed a 0.5 - 18 GHz portable rfi measurement system, as well as commissioned an anechoic chamber, the better to characterize rfi from individual pieces of equipment. Finally our staff continues to work diligently to mitigate power line rfi and other sources of interference originating in the local community.

4. Community relations

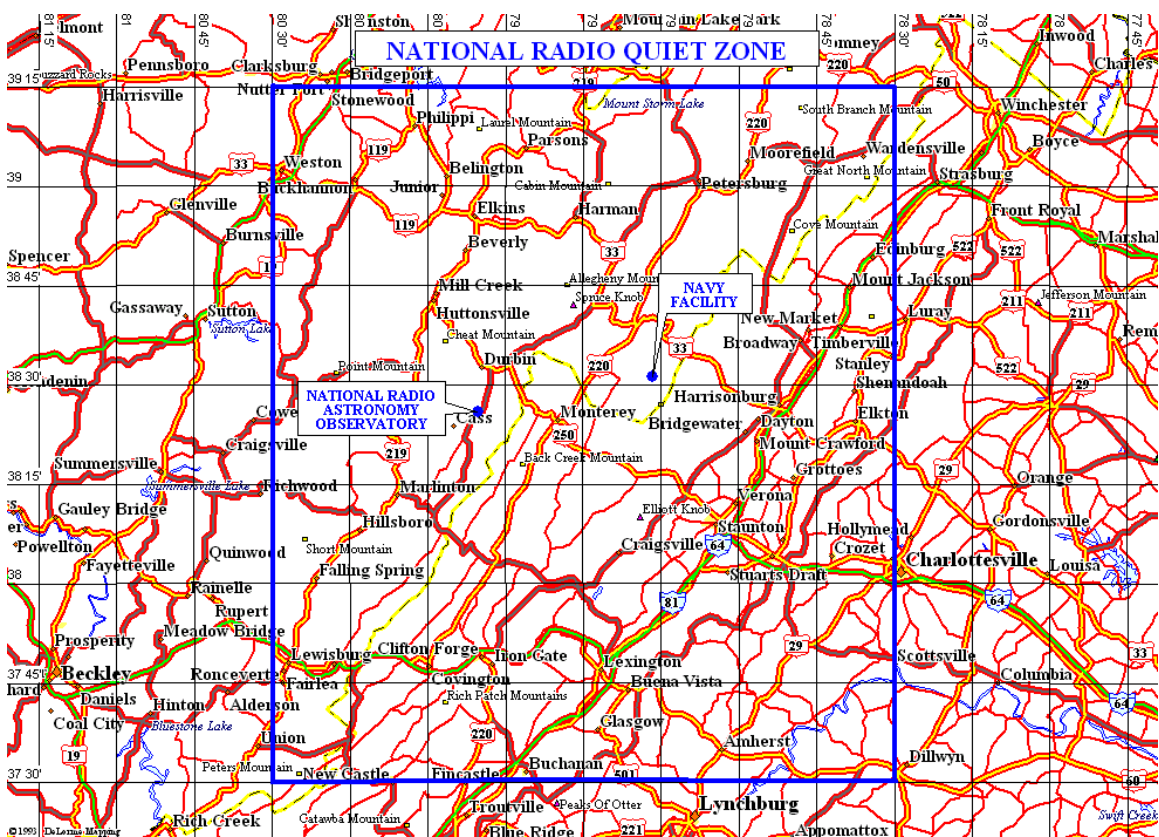
The Green Bank telescope attracts tourists, which in its own right presents challenges. Many of the needs of tourists are accommodated in our new Science Center, which is of course well shielded and located near the edge of our site. Moreover visitors enter the Center via a curving corridor lined with very evident radio-wave absorbing material, to ensure that its exhibits do not produce any radiation that can escape to the outside. We thus kill two birds with one stone, by using the occasion of visitors seeing the Observatory to impress on them the detrimental effect rfi has on our observations, as well as the need for having a NRQZ to further our science. Acceptance of the constraints of an operational NRQZ is naturally dependent on the continuance of good public outreach, as well as an ongoing demonstration of the positive aspects of hosting an Observatory for the surrounding community.

Appendix

National Radio Quiet Zone

Description

The National Radio Quiet Zone (NRQZ) was established by the Federal Communications Commission (FCC) in Docket No. 11745 (November 19, 1958) and by the Interdepartmental Radio Advisory Committee (IRAC) in Document 3867/2 (March 26, 1958) to minimize possible harmful interference to the National Radio Astronomy Observatory (NRAO) in Green Bank, WV and the radio receiving facilities for the United States Navy in Sugar Grove, WV. The NRQZ is bounded by NAD-83 meridians of longitude at 78d 29m 58.0s W and 80d 29m 58.5s W and latitudes of 37d 30m 0.9s N and 39d 15m 0.8s N, and encloses a land area of approximately 13,000 square miles near the state border between Virginia and West Virginia.



Coordination Requirement

In order to minimize harmful interference to operations in Green Bank and Sugar Grove, all requests for frequency assignments within the NRQZ shall be coordinated by the applicant, prior to authorization, with:

Director (Attn: Interference Office)
National Radio Astronomy Observatory
P. O. Box 2
Green Bank, WV 24944

This procedure applies to all stations except mobile and transportable stations.

Federal Government Transmitters:

All frequency assignments for Federal Government transmitters which are to be located within the NRQZ are required by the National Telecommunications and Information Administration (NTIA) to be successfully coordinated with the NRAO Interference Office prior to the approval of the assignment.

Non-Federal Government Transmitters:

All applicants for non-Federal Government transmitters for certain radio services within the NRQZ are required by the FCC to notify the NRAO Interference Office prior to or simultaneously with the filing of the FCC application. Both a copy of the completed FCC application form and the antenna technical data should be sent to the Interference Office.

Applicants for some radio services are required to file their applications through independent frequency coordinators (e.g. APCO, PCIA, and IMSA). The coordinators assume the responsibility of notifying the Interference Office that an FCC application has been filed and hold the application until the Interference Office responds with its evaluation.

Transmitter Evaluation

The NRAO Interference Office reviews all assignments or applications for new or modified fixed transmitters within the NRQZ to insure that the computed power flux density at the reference point does not exceed frequency-dependent thresholds. In order for the Interference Office to accurately and promptly review the transmitter application, the applicant should forward the following technical data to the Interference Office:

- Name and address of applicant.
- Radio service.
- Frequency of each transmitter.
- Transmitter power.
- Transmission line losses in dB.
- Antenna location(s) in latitude and longitude to nearest second.
- Antenna site ground elevation(s) above mean sea level (AMSL).
- Antenna height(s) above ground level (AGL).
- Antenna gain or horizontal pattern and orientation in azimuth.

These data are required to compute the transmitter's effective radiated power relative to a dipole (ERPd) towards Green Bank, WV and Sugar Grove, WV.

In some instances, the ERPd requested by an applicant exceeds the level that is harmful to observations in Green Bank or Sugar Grove. When this occurs, applicants should discuss possible modifications to their transmitters (e.g. using a directional antenna, relocating the antenna to an area that provides additional terrain shielding, or selecting a different frequency where the power density limits are different) with the Interference Office. In our experience, a technical solution can almost always be found to provide the area coverage desired by the applicant while simultaneously minimizing the impact of the interference upon Green Bank or Sugar Grove. In the extremely rare case when differences between the applicant's desires and the Interference Office's evaluation cannot be resolved, both the applicant and the Interference Office should forward comments on the transmitter installation to the FCC or IRAC for a final resolution.

We emphasize that the Interference Office has no authority in the granting of an FCC license or a Federal Government frequency assignment. The Interference Office only has the privilege of submitting its comments on a particular transmitter installation to the FCC or IRAC.

Applicants who feel that their applications have been evaluated unfairly or inadequately can contact the office of the Green Bank Site Director for a review of their circumstances.

Preliminary Evaluations

As a service to applicants who are planning to install transmitters within the NRQZ, the Interference Office can evaluate proposed transmitter installations long before an applicant decides upon a final transmitter location or equipment configuration. These preliminary evaluations can help the applicant determine the best location for a transmitter while keeping NRQZ interests in mind and can ultimately expedite the application process. The result produced by the preliminary evaluation is the maximum ERPd that can be radiated by the proposed transmitter towards Green Bank. Requests for preliminary evaluations should be submitted to the Interference Office at the above address and should contain the following information:

- Name and address of proposer or future applicant.
- Radio service.
- Frequency of each transmitter.
- Antenna location(s) in latitude and longitude to nearest second.
- Antenna site ground elevation(s) above mean sea level (AMSL).
- Antenna height(s) above ground level (AGL).

Reference Point

The reference point for calculations of transmitter power density is the prime focus of the Green Bank Telescope (GBT). The location of the GBT prime focus is

Latitude: 38d 25m 59.2s N (NAD83)
Longitude : 79d 50m 23.4s W (NAD83)
Ground Elevation : 776 Meters or 2546 Feet AMSL (NAVD88)
Height : 139.6 Meters or 458 Feet AGL

Power Density Thresholds

The calculated power density of the transmitter at the reference point should be less than

- $1 \times 10^{-8} \text{ W/m}^2$ for frequencies below 54 MHz
- $1 \times 10^{-12} \text{ W/m}^2$ for frequencies from 54 MHz to 108 MHz
- $1 \times 10^{-14} \text{ W/m}^2$ for frequencies from 108 MHz to 470 MHz
- $1 \times 10^{-17} \text{ W/m}^2$ for frequencies from 470 MHz to 1000 MHz
- $f^2 \text{ (in GHz)} \times 10^{-17} \text{ W/m}^2$ for frequencies above 1000 MHz

except for frequencies that reside in the radio astronomy observing bands, in which case the power densities listed in Recommendation ITU-R RA.769-1 shall apply.

Applicable Radio Services

The radio services that are affected by the NRQZ and the FCC rules that discuss them are:

FCC Rule	Radio Service
1.924	Public Mobile, Wireless Communications, Maritime, Aviation, Private Land Mobile, Personal Radio, Fixed Microwave
21.113(a)	Domestic Public Fixed
23.20(b)	International Fixed Public
25.203(f)	Satellite Communications
73.1030(a)	Radio Broadcast
74.12, 74.24(i)	Exp., Aux., & Special Broadcast
78.19(c)	Cable Television Relay
97.203(e), 97.205(f)	Amateur Radio (repeaters, beacons)

NRQZ coordination is also required for the Personal Communications Service (FCC Part 24) and the General Wireless Communications Service (FCC Part 26). These services are not exempt from NRQZ coordination under geographic area licensing.

For more information about the NRQZ please contact:

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