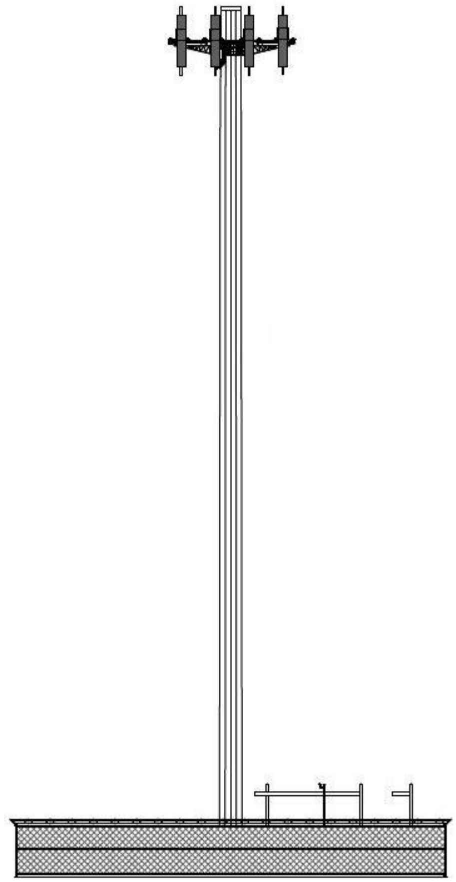
Environmental

Sound

Assessment



Wireless Communications Facility

85 Washington Road

Pembroke, Massachusetts   02359

November 4, 2021

Prepared For:

Verizon Wireless
118 Flanders Road
Westborough, MA 01581

Prepared By:

Modeling Specialties
30 Maple Road
Westford, MA 01886

ENVIRONMENTAL SOUND ASSESSMENT

Verizon Wireless proposes to install and operate a Wireless Telecommunications Facility in Pembroke, MA to support personal wireless communication in the area. The proposed Verizon Wireless installation will include antennas mounted on a 110-foot monopole. Supporting electronic cabinets will be in a fenced compound at the foot of the tower. A fully enclosed stand-by power generator will be located in the compound. This generator will operate only during power failures and for routine daytime testing of about one half-hour per week.

This report addresses the existing sound levels in the area, sources of sound expected at this installation and an evaluation of its potential to affect the neighboring land uses. The equipment configuration and siting were designed specifically to minimize environmental effects.

Overview of Project and Site Vicinity

The project is located in a wooded area on a lot in Pembroke, MA. Daytime and nighttime field measurements were made to survey existing conditions. The daytime measurement was dominated by the sound from traffic on Washington Street and other area roadways, building mechanical equipment on area commercial buildings, occasional commercial aircraft pass-byes and a few birds. During nighttime conditions, the sound field in the Circle Furniture rear lot was the building mechanical sound from various area buildings and very few vehicles on area roadways. This location was selected because the nearest residential receptors are also somewhat shielded from the roadway. The project sound was analyzed at the site property lines and also at area residences. Because sound levels are reduced with distance, only the nearest residences in representative directions are included in this study. Figure 1 is a Google Earth aerial photograph annotated to show the equipment location and surrounding area.

The equipment sound was estimated using vendor data and measurements made at similar installations. The corresponding levels expected at the nearby sensitive locations were estimated using noise modeling techniques prescribed in acoustical literature. Plans and equipment details were provided by Verizon Wireless to support this evaluation of sounds. The report is based on plans issued by Nexius Architects and Engineers on 10/15/21, which includes equipment configured like many other Verizon Wireless sites. This conservative study is based on the highest sound levels that the equipment is expected to make even though it makes that sound only a small fraction of the time.

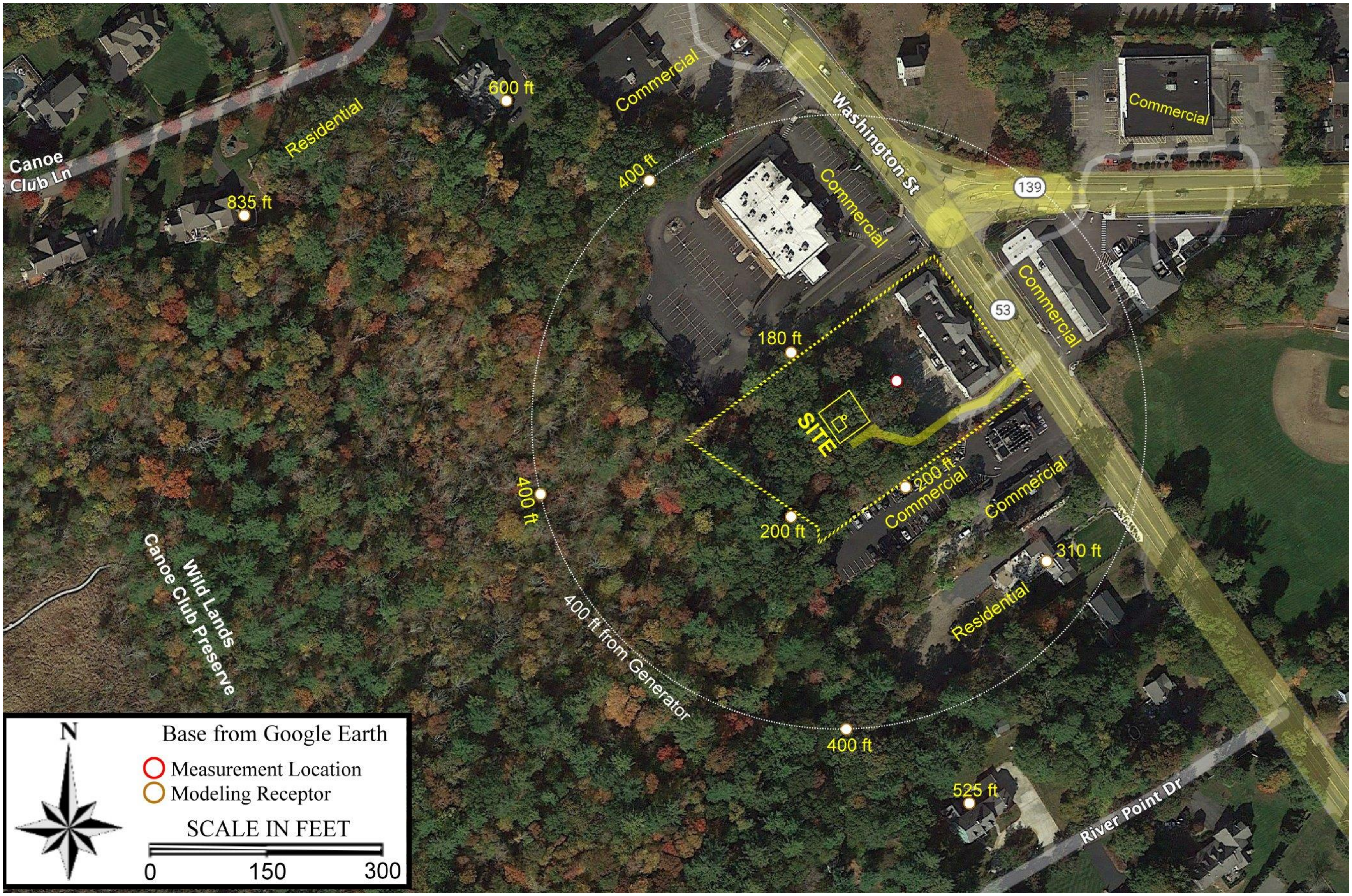


Figure 1: Project Area Showing the Host Parcel, Site Location and Receptor Distances

Discussion of General Noise Analysis Methods

There are a number of ways in which sound (noise) levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. Following is a brief introduction to the noise measurement terminology used in this assessment.

Noise Metrics

The Sound Level Meter used to measure noise is a standardized instrument.[1] It contains "weighting networks" to adjust the frequency response of the instrument to approximate that of the human ear under various circumstances. One of these is the *A-weighting* network. A-weighted sound levels emphasize the middle frequency sounds and de-emphasize lower and higher frequency sounds; they are reported in decibels designated as "dBA." All broadband levels represented in this study are weighted using the A-weighting scale. Figure 2 illustrates typical sound levels produced by sources that are familiar to most people.

The sounds in our environment usually vary with time, so they cannot always be described with a single number. Two methods are used for describing variable sounds. These are *exceedance levels* and *equivalent level*. Both are derived from a large number of moment-to-moment A-weighted sound level measurements. Exceedance levels are designated L_n, where "n" can have any value from 0 to 100 percent. For example:

- L_{90} is the sound level in dBA exceeded 90 percent of the time during the measurement period. The L_{90} is close to the lowest sound level observed. It is essentially the same as the *residual* sound level, which is the sound level observed when there are no loud, transient noises.

- L_{50} is the median sound level: the sound level in dBA exceeded 50 percent of the time during the measurement period.

- L_{10} is the sound level in dBA exceeded only 10 percent of the time. It is close to the maximum level observed during the measurement period. The L_{10} is sometimes called the *intrusive* sound level because it is caused by occasional louder noises like those from passing motor vehicles.

By using exceedance levels, it is possible to separate prevailing, steady sounds (L_{90}) from occasional, louder sounds (L_{10}) in the environment.

---

1 *American National Standard Specification for Sound Level Meters*, ANSI S1.4-1983, published by the Standards Secretariat of the Acoustical Society of America, NY.

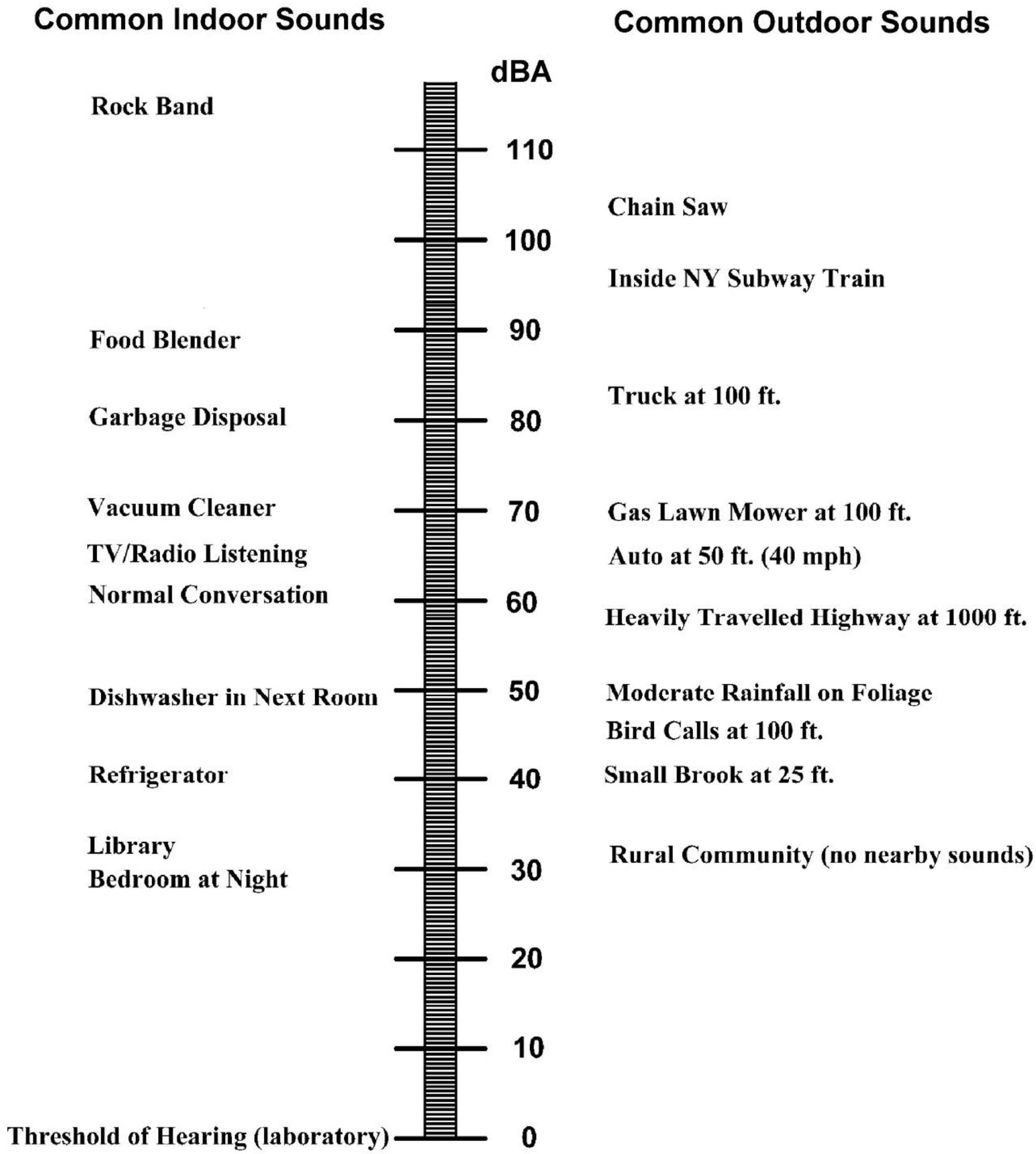


Figure 2:
Typical Sound Levels from Everyday Experience

The *equivalent level* is the level of a hypothetical steady sound that has the same energy as the actual fluctuating sound observed. The equivalent level is designated L_{eq}, and is also A-weighted. The equivalent level is strongly influenced by occasional loud, intrusive noises. When a steady sound is observed, all of the L_n and L_{eq} are equal.

In the design of noise control treatments, it is essential to know something about the frequency spectrum of the sound of interest. Noise control treatments do not function like the human ear, so simple A-weighted levels are not useful for noise-control design or the identification of tones. The spectra of sounds are usually stated in terms of *octave band sound pressure levels*, in dB, with the octave frequency bands being those established by standard.[2] The sounds at the proposed site were evaluated with respect to the octave band sound pressure levels, as well as the A-weighted equivalent sound level. Only the A-weighted values are presented here, since they represent the more easily recognized sound scale that is relevant to the applicable standards.

Noise Regulations and Criteria

Sound compliance is judged on two bases: the extent to which governmental regulations or guidelines are met, and the extent to which it is estimated that the community is protected from the excessive sound levels. The governmental regulations that may be applicable to sound produced by activities at the project site are summarized below.

Federal

- Occupational noise exposure standards: 29 CFR 1910.95. This regulation restricts the noise exposure of employees at the workplace as referred to in OSHA requirements. Workers will not routinely attend this facility. Furthermore, the facility will emit only occasional sounds of modest levels, as demonstrated by this study.

State

- In Massachusetts, noise is regulated as an air pollutant. 310 CMR §7.10 U qualitatively prohibits "unnecessary emissions from [a] source of sound that may cause noise". This is interpreted quantitatively by MDEP's Form BWP AQ SFP3 and their DAQC Policy 90-001. The MDEP's Noise Policy states that a new noise intrusion may not increase the broadband sound level by more than 10 dBA over the pre-existing L_{90} ambient level. Tonal sounds, defined as any octave band level that exceeds the levels in adjacent octave bands by 3 dB or more, are also prohibited. The MDEP usually defers to applicable quantitative local ordinances when available.

2 *American National Standard Specification for Octave, Half-octave and Third-octave Band Filter Sets*, ANSI S1.11-1966(R1975).

Local

- **By-laws of the Town of Pembroke MA, SECTION 15 - Anti-Noise By-law.**

  Pembroke has an Anti-Noise By-law-that seems to exclude the sound from emergency generators. It states "***This section shall not apply to the operation of an emergency generator.***" For this reason, the sound from the generator will be addressed in this report based on the MADEP Noise Policy. Nevertheless, the estimated generator sound is estimated at a distance of 400 feet, the distance used by the Pembroke By-law.

Existing Community Sound Levels

A daytime site survey and noise measurement study were conducted on October 29, 2021 to measure the existing sound levels at and around the site. Based on the walk-around survey of the site, the levels measured in the project area are representative of the quiet levels at nearby receptors. The nighttime survey was conducted during the quietest hours between midnight and 5:00 AM on the same day. Even though the routine operation of the cabinet cooler or generator is not expected at night, the sound levels under these quietest community conditions were documented for completeness.

Measurement Methodology

Since sound impacts are greatest when existing noise levels are lowest, this study was designed to evaluate community sound levels under conditions typical of "quiet periods" for the area. This study uses methodology consistent with MDEP studies using the background metric (L_{90}), which statistically excludes all non-steady sources. The L_{90} metric gives the lowest ten percent of the many samples gathered during a 20-minute measurement taken in the project area. Meteorological conditions during the daytime included partly cloudy skies, a temperature of 50º F with light winds less than 5 mph at ground level from the North Northwest. Nighttime survey conditions included partly cloudy skies, a temperature of 50º F with calm air at the ground level. The measurement location was on the host property parking lot behind the commercial building. The modeled residences are also somewhat shielded from activities on Washington Road, so the measurements represent both the site and the nearest receptors. All meteorological conditions were noted from field observations but are consistent with the official reports at Boston Logan Airport (except for winds that were measured on site at the height of the microphone in a somewhat shielded area).

Daytime and nighttime attended sound level measurements were made with a Rion NA-28 sound level meter. The meter meets the requirements of ANSI S1.4 Type 1 – Precision specification for sound level meters. The meter was mounted at approximately 5 feet above the ground. The microphone was fitted with factory recommended foam windscreen. The meter was used to sample the environmental sound and to process the sound into various statistical metrics for use in this analysis. The meter is equipped with real time octave band filter set, which allowed it to process sound levels into 1/3 octave bands. While frequency specific data were collected, the survey results are reported only in combined A-weighted levels for simplicity and consistency with the applicable standards. The meter's filters comply with the requirements of the ANSI S1-11 for octave band filter sets. The meter was calibrated in the field using a Larsen Davis Cal-200 sound level calibrator before and after the measurement sessions. The results of the field calibration indicated that the meters did not drift during the study.

The results of the surveys allow both quantitative and qualitative analyses of the acoustical environment surrounding the proposed equipment. The characterization of ambient sound levels reflects the variations caused by volume of traffic on local roadways, occasional aircraft passes and community sounds.

Measurement Results

The background sound levels in the project area were established to be 51 dBA during the daytime and 41 dBA in the quietest hours of the night. The facility will not routinely include any significant sources of nighttime sound but the baseline was established for completeness. The survey results are summarized in Table 1.

Table 1: Measured Background Sound Levels in the Project Area

Period	Time	L_{90} dBA	Leq dBA
Daytime	9:05 AM	51	56
Nighttime	3:43 AM	41	44

Sounds from the Proposed Installation

Most of the equipment planned for this facility has no potential of emitting sound. Antennas, cabling and utilities are acoustically inert. Conduits and utilities will be underground. Only two occasional sources are planned for this facility as quantified in this study. The antennas will be supported by cabinet mounted radio electronics in a fenced compound at the base of the tower. There will also be a stand-by generator installed in the compound inside an acoustical enclosure. This study is based on the levels produced during its infrequent operation. Figure 4 shows the layout of the proposed fenced equipment compound.

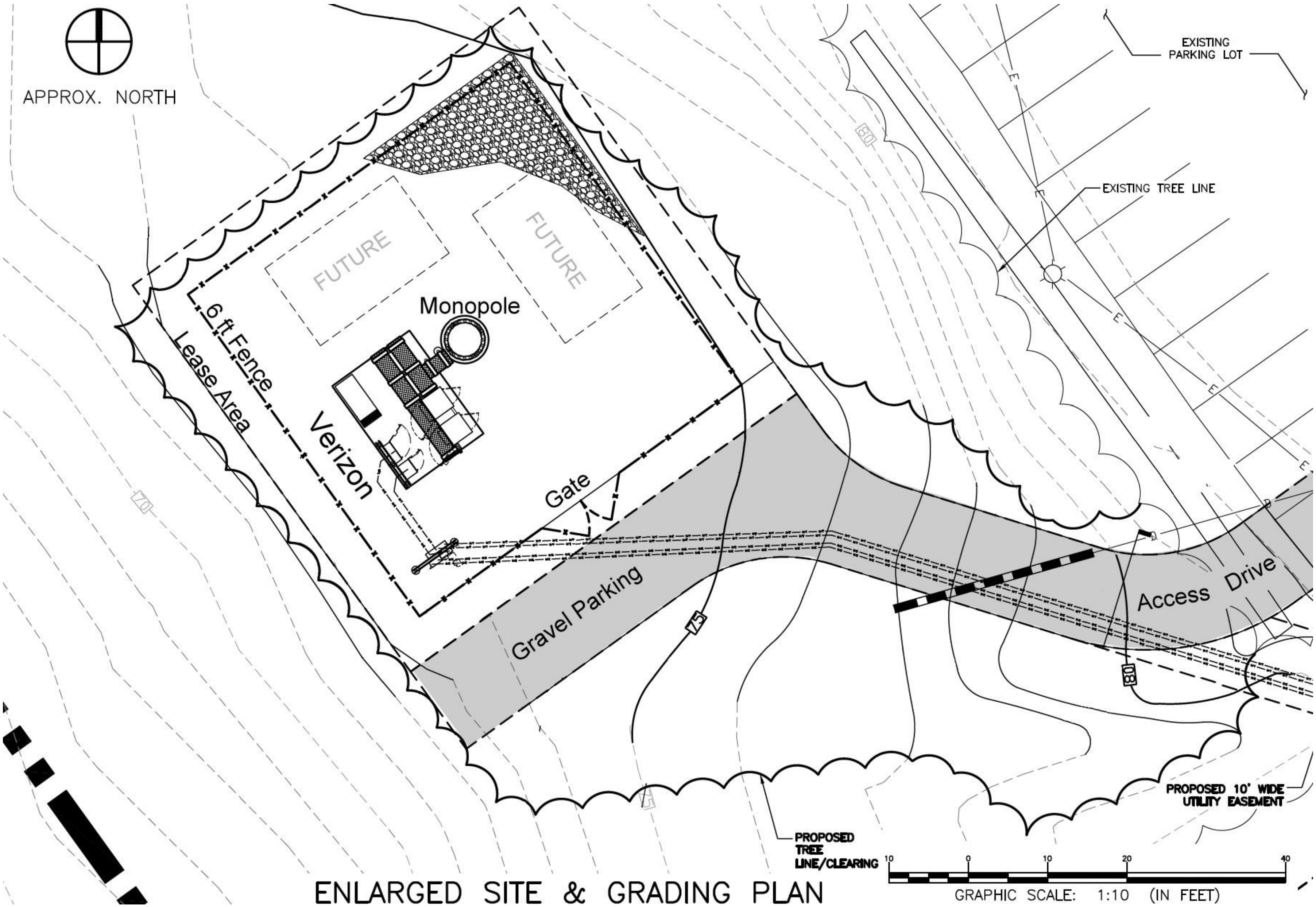
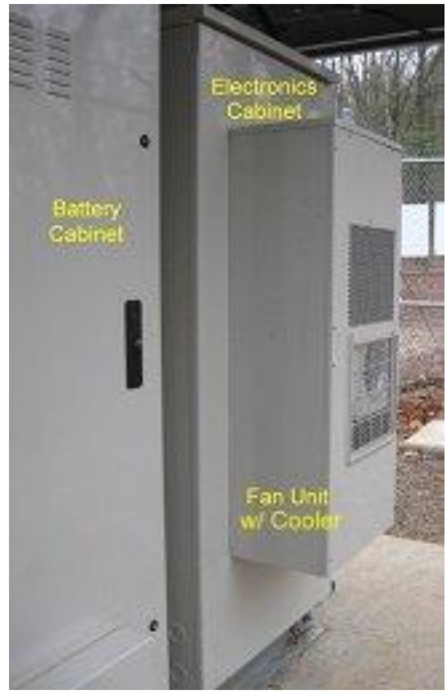


Figure 4: Plan Showing some Detail of the Site and Proposed Equipment Compound

Routine Sound Emissions

The only routine sound emissions planned for the Verizon Wireless equipment is from the electronics cabinet fan. The small fan on the front door of the cabinet draws air into the unit. It has a smooth broadband character that produces about 50 dBA at 3 feet from the unit. The fan on the electronics cabinet will operate continuously, so there will be no variation from moment to moment or cycling from equipment startup. The fan is mounted on the inside of the cabinet, so it is hardly heard from the outside of the cabinet (which will always remain closed). In this way, the cabinet configuration is designed for minimal effect on the surrounding area. The field image to the right shows fan unit and the battery cabinet. The electronics equipment in the cabinets is temperature sensitive. When the ambient conditions exceed a safe temperature, a heat exchanger mounted on the cabinet door will provide cooling for the equipment. Under maximum cooling the heat exchanger produces about 50 dBA at a distance of 23 feet from the unit. This is less than most window air conditioners or outdoor condensers used to support residences. Like residential air conditioners, the cabinet cooler will only be needed during periods of high ambient temperature.



Non-Routine Sound Emissions

The facility will include a generator installed inside a sound reducing enclosure. It has not yet been determined whether the generator will be fired by diesel or propane. Because diesel engines generally produce higher sound levels, it is the basis of this study. A Kohler 30REOZK generator rated for 30 kW is the expected diesel option. The unit will never provide routine power to the facility. It will operate only under two conditions. The unit will be remotely tested for a half-hour every week during daytime hours to assure its availability. The test is made with no load and will produce 63 dBA at 23 feet. If utility power is lost, the facility will instantly switch to battery power. The generator will then be launched to power the facility and recharge the batteries. Under load, the generator is rated to produce a sound level of 65 dBA at 23 feet. In this way, the facility can provide reliable service even in an extended power outage. The generator has a "quiet test" feature to further reduce its sound under the planned no-load tests. The generator is fitted with a very effective sound enclosure that emits sound characteristic of much smaller generators. (For example, a typical mobile residential gasoline powered generator in the range of 4,000 Watts produces sound in the range of 70 dBA at 23 feet). The proposed generator's having seven times greater output but producing less sound illustrates the level of sound mitigation that is incorporated into its design. If propane fuel is used, Kohler's corresponding propane design (Model 30CCL) emits even less sound than the diesel unit in the test mode (57 dBA).

Modeling Details

Noise prediction modeling was performed with CADNA software using conservative assumptions and under downwind conditions as part of the standard ISO 9613-2. Table 2 summarizes the modeling input parameters.

Table 2: Modeling Input Parameters

Item	Modeling Input and Description
Terrain	Flat Terrain assumed
Temperature	10ºC
Relative Humidity	70%
Weather Condition	6.5 mph, directly from facility to receptor*
Ground Attenuation	0.2, hard surface (0.5 = soft ground, 0.0 = pure reflection)
Atmospheric Inversion	CONCAWE – Category F**
# of Sound Reflections	2
Receptor Height	1.5 meter above ground level

** Propagation calculations incorporate the adverse effects of certain atmospheric and meteorological conditions on sound propagation, such as gentle breeze of 1 to 5 m/s (ISO 1996-2: 1987) from source to receiver.*
*** Category F represents a stable atmosphere that promotes noise propagation.*

Sound Level Modeling Results

The facility will typically be cooled by internal cabinet fans, so will produce almost no sound as summarized in Figure 5. Note that the existing sound level was measured to be 41 dBA at night, so any sound below that is not noticed in most communities.

Since all the equipment with the potential to emit sound will be at ground level, the surrounding forest will provide some shielding, but it is not considered in this conservative study. The compound will be enclosed by a 6-foot security fence with barbed wire. As noted, the cooler is not used unless the ambient temperature is above 90 F, so is not expected to operate at night. Since it will operate automatically to protect the delicate electronics, this conservative study represents a few hot summer nights when it could possibly operate. Table 3 summarizes the modeling results for the worst-case nighttime sound which includes the cooler. It is summarized graphically in Figure 6.

Table 3: Summary of Modeling Results of Worst-Case Nighttime Sound (Cooler)

Receptor Location	Distance (Ft)	Ambient Level Nighttime (dBA)	With Cooler (dBA)	Standard (dBA)	Compliance?
P/L Southeast	**118**	**41**	**35**	**51**	**Yes**
P/L South	**133**	**41**	**34**	**51**	**Yes**
P/L Northwest	**103**	**41**	**36**	**51**	**Yes**
400 Ft Perimeter	**430**	**41**	**24**	**51**	**Yes**
Residence East	**310**	**41**	**26**	**51**	**Yes**
Residence South	**525**	**41**	**22**	**51**	**Yes**
Residence NW	**835**	**41**	**18**	**51**	**Yes**
Residence North	**600**	**41**	**21**	**51**	**Yes**

Note: It is customary to conduct all calculations using precise values, but to round the result to whole dBA. All modeling results are rounded to units (dBA).

Like the nighttime operation, the routine daytime operation includes neither the cooler or generator. Only one half-hour period per week during the daytime will include a generator test, being the worst-case daytime sound level. The resulting level will be 37 dBA or less at the nearest residential receptor. Additional receptors were added to represent the nearest residences in various directions from the equipment. The Pembroke Anti-Noise By-law describes a location 400 feet from the source, so it is also modeled. Table 4 provides a summary of these worst-case modeling results. A graphical summary of the daytime modeling results is also provided in Figure 7.

Table 4: **Summary of Modeling Results of Worst-Case Daytime Sound (Generator plus Cooler)**

Receptor Location	Distance (Ft)	Ambient Level Daytime (dBA)	Combine Cooler & Generator (dBA)	Standard (dBA)	Compliance?
P/L Southeast	118	51	46	61	Yes
P/L South	133	51	45	61	Yes
P/L Northwest	103	51	47	61	Yes
400 Ft Perimeter	430	51	35	61	Yes
Residence East	310	51	37	61	Yes
Residence South	525	51	33	61	Yes
Residence NW	835	51	29	61	Yes
Residence North	600	51	32	61	Yes

Conclusions

The potential sound of the proposed Wireless Telecommunications Facility was evaluated using measured field data and numerical modeling methods. Ambient sound levels were established by field measurements using equipment that is standardized to the current ANSI standards. Equipment operating sound levels were quantified using vendor estimates confirmed by representative field measurement at other installations. Cooling using cabinet fans is usually adequate especially at night without solar heating. Because of this the facility will produce essentially no sound as shown in Figure 5. The cabinet is equipped with a cooler to protect it from one or several nights a year when the ambient temperature stays above 90° F at night. This represents the worst-case nighttime sound, which will result in levels at the nearest residence to the southwest of 26 dBA shown in Figure 6. This is far below the existing 41 dBA nighttime sound level in the area so is not expected to be noticed.

Infrequently, about one half-hour per week in the daytime, the facility sound will include the testing of the stand-by generator. The worst-case daytime sound would be a condition that included both the generator test plus the cabinet cooler. The facility's sound is expected to be 37 dBA or less at the nearest residence during that test shown in Figure 7. The results indicate that the facility sound will remain in compliance with the MADEP standards under all routine operations.

Figure 5: Graphical Summary of the Sound from the Typical Facility Operation (Cooling is Provided by Internal Fans)

Figure 6: Graphical Summary of the Worst-Case Nighttime Facility Sound
(includes Cabinet Cooler that Operates only over 90° F at night)

Figure 7: Graphical Summary of the Worst-Case Operating Facility Sound Level (includes Generator during its weekly half-hour test)