5.0 NOISE

5.1 Noise Standards

Bodwell EnviroAcoustics performed an analysis of the anticipated sound levels associated with the Three Rivers Solar Project (Project) in accordance with sound level limits as set forth by Maine Department of Environmental Protection (DEP) Site Location of Development regulations for Control of Noise (ref. 06-096 CMR c. 375.10). The Sound Level Assessment evaluates sound levels at nearby noise sensitive land uses from full operation of all Project components including solar inverters and the electrical substation transformer during stable atmospheric conditions.

Assuming that sound levels at nearby protected locations meet the criteria for quiet areas, the Project is required to meet the following sound level limits as detailed in Chapter 375.10.C(2) of Site Location of Development Law Regulations:

a) 75 dBA at any time of day at any property line of the development or contiguous property owned or controlled by the project developer; and
b) 55 dBA between 7:00 a.m. and 7:00 p.m. (the “daytime limit”), and 45 dBA between 7:00 p.m. and 7:00 a.m. (the “nighttime limit”) at any protected location.

Although the Maine DEP noise regulation specifies a 75 dBA at the facility property line, the most restrictive limits apply at noise sensitive land uses that meet the definition of a “protected location”, as set forth in Chapter 375.10.C(2). The quiet nighttime limit of 45 dBA applies on portions of a protected location within 500 feet of a dwelling (or other sleeping quarters), or at the lot line of the protected location, whichever is closer to the dwelling. At portions of the protected location greater than 500 feet from the residence or sleeping quarters, the 55 dBA daytime limit applies 24 hours a day. Sound from regular and routine maintenance of the Project is subject to the same sound level limits as routine operation.

When a development is located in a municipality that has duly enacted a quantifiable noise standard that (1) contains limits that are not higher than the Maine DEP limits by more than five dBA, and (2) limits or addresses the types of sounds regulated by the Maine DEP, then the Maine DEP is to apply the local standard rather than the Maine DEP standard. When noise produced by a facility is received in another municipality, the quantifiable noise standard of the other municipality must be taken into consideration (ref. Maine DEP 375.10.B.1).

Three Rivers Solar is located entirely within Township T16 MD, which, like all unorganized townships in Maine, has no local land use ordinances.

5.2 Sound Assessment

The sound level assessment determined predicted sound levels for the Project at full rated sound output and compared them to the Maine DEP sound level limits. The sound level assessment conservatively estimates Project sound levels associated with construction and operation of Three Rivers Solar including the following:

a) Use of heavy machinery for clearing, installation, and substation construction.
b) Equipment operating at the Project site for gravel excavating and processing.
c) Operating sound sourced from the power inverters distributed within the solar panel array and the substation transformer.

The Maine DEP noise rule requires that 5 dBA be added to the measured sound level at a protected location if sound from a development generates either 1) a tonal sound or 2) SDR sound events over a one-hour measurement interval.

Bother the power inverters and substation transformer have the potential to generate a tonal sound as define by Maine DEP 375.10. As such, 5 dBA has been added to calculate sound levels at the nearest protected locations to the Project.

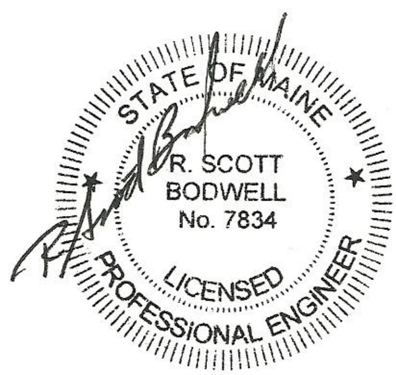
The sound level assessment establishes sound level limits to be applied to Three Rivers Solar and provides sound level predictions for full rated operations using a terrain-based computer model. Sound level predictions reflecting conservative assumptions and contingencies for potential uncertainties indicate that full operation of Three Rivers Solar will meet all Maine DEP sound limits including quiet nighttime limit of 45 dBA within 500 feet of dwellings on nearby protected locations. Additional sound level data and information is available in the Sound Level Assessment (Exhibit 5-1).

Exhibit 5-1

Three Rivers Solar Power Sound Level Assessment

Sound Level Assessment
Three Rivers Solar Energy Project
Hancock County, Maine

October 2019



Prepared for:
Next Phase Energy Services

Prepared by:
R. Scott Bodwell, PE
Bodwell EnviroAcoustics, LLC
55 Ocean Drive
Brunswick, Maine 04011

Bodwell EnviroAcoustics LLC

1.0 Introduction

Bodwell EnviroAcoustics LLC (BEA) assessed sound levels expected to result from construction and operation of the Three Rivers Solar Energy Project (Three Rivers or Project) proposed for Hancock County, Maine. The Project plans to install approximately 400,000 individual panels transforming sunlight each day into renewable electrical energy that will be fed into the New England regional electrical grid. The Project entails placement of the solar panels covering approximately 500 acres located in Township T16 MD resulting in a total generating capacity of 100 megawatts (MW).

The objective of this Sound Level Assessment is to evaluate sound levels at nearby noise sensitive land uses from full operation of all Project components including solar inverters and the electrical substation transformer during stable atmospheric conditions. A computer sound model is used to calculate sound propagation and predict sound levels at noise sensitive land uses (protected locations) in the vicinity of the Project. The predicted "worst-case" sound levels are compared to applicable sound level limits as set forth by Maine Department of Environmental Protection (DEP) Site Location of Development regulations for Control of Noise (ref. 06-096 CMR c. 375.10).

This report describes the project and surrounding area, applicable state noise regulations, sound data for project components, the details and results of predictive sound model, and evaluation of sound compliance.

2.0 Environmental Acoustics

The study of environmental acoustics primarily concerns the functions and effects that audible sounds (or noise) have in the outdoor environment and how changes to existing and new sound sources can impact that environment. From a geographic standpoint, this is an extremely diverse area of study ranging from wilderness to urban settings and from airborne and indoor sound to the underwater sound environments of oceans and lakes. Environmental acoustics is most commonly associated with assessing the noise impact of industrial, transportation, energy, or commercial land uses for suitability with nearby land uses. The following subsections provide an overview of acoustic terminology and characteristics.

2.1 Sound and Decibels

Sound is produced by many different sources that generate pressure fluctuations in air that the human ear often has the capability to detect as audible. Sound can also travel through other media such as water, metal, and structural components of a building. The types of sounds that humans experience every day can be divided into two distinct categories as natural and man-made sound. However, the range of sound subcategories is extensive.

There are many types of natural sounds audible to humans and other animals. The most common of these are wildlife (e.g. birds, frogs, mammals, insects), sounds generated by wind forces acting on terrain and vegetation, and sounds generated by water action such as ocean waves, falling rain, and river rapids. There are also many man-made sounds generated by industrial, transportation, energy and construction sources as well as sounds generated for warning signals or strictly for enjoyment such as music. Common residential sounds include outdoor recreation, yard maintenance, human voices, and amplified music.

The magnitude or loudness of sound waves is measured in units of pressure (pascals) that yield very large numbers that are difficult to interpret. For simplicity, the decibel unit, dB was developed to quantify sound pressure levels to reduce the exponential range of typical sound pressures. The dB unit equates to an exponential ratio of the actual sound pressure to a standard pressure, usually 20 micropascals. This is a logarithmic expression of the pressure ratio similar to the Richter scale for earthquakes so that a small change in sound level expressed in dB represents a larger change in the sound pressure. For example, a 10 dB change in sound level is a tenfold increase in sound pressure as pascals. However, this does not mean that the received sound is perceived as ten times as loud. A change in sound levels of 3 dB is a doubling of the sound pressure but is considered to be threshold of change perceptible to human hearing. A change of 5 dB becomes quite noticeable and an increase of 10 dB is perceived as twice as loud.

The frequency or pitch of sound is expressed in Hertz (Hz) and is the number of sound waves passing a specific point each second, i.e. cycles per second. Frequencies generally considered audible to the human ear range from 20 to 20,000 Hz. Within this range, there are octave bands that represent a range of frequencies for purposes of sound characterization and calculating sound propagation and attenuation. Standard whole octave bands are centered around 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz and 8000 Hz. The center frequency of each octave is double that of the previous octave. Octave bands can be further divided (typically third octaves) and used to determine if a sound source generates an audible pure tone such as a whistle, buzzing or hum that may be more perceptible than a broad mixture of frequencies. Low frequency sound is typically considered to be at frequencies of 200 Hz and below. Within this range, infrasound has frequencies below 20 Hz and is not generally considered audible to humans except at very high decibel levels.

Sound levels in frequencies ranging from 500 to 2500 Hz are more audible to humans than frequencies below 100 Hz. Accordingly, the A-weighting scale was developed to express sound pressure levels in units of dBA to simulate the hearing response of humans. Under this weighting system, the sound pressure level at low frequencies is reduced based on its audibility to humans. The linear (no weighting) and C-weighting scales are often used to determine the relative contribution of low frequency sounds during a sound measurement. These low frequency sounds have reduced audibility to humans, hence the use and wide acceptance of the A-weighting network for noise standards. Figure 2-1 provides a graph that shows the reduction by frequency for A- and C-weighting scales.

Sound level measurements are also time-weighted to represent the relevant parameters or timeframes of interest or identify short duration events. The most common time weightings are “Fast” and “Slow”. Fast-time weighting is based on 1/8 second intervals and is useful for determining rapid changes in sound levels. The slow-time weighting integrates the measured sound levels over a one-second period that reduces the rapid fluctuations for ease of observation.

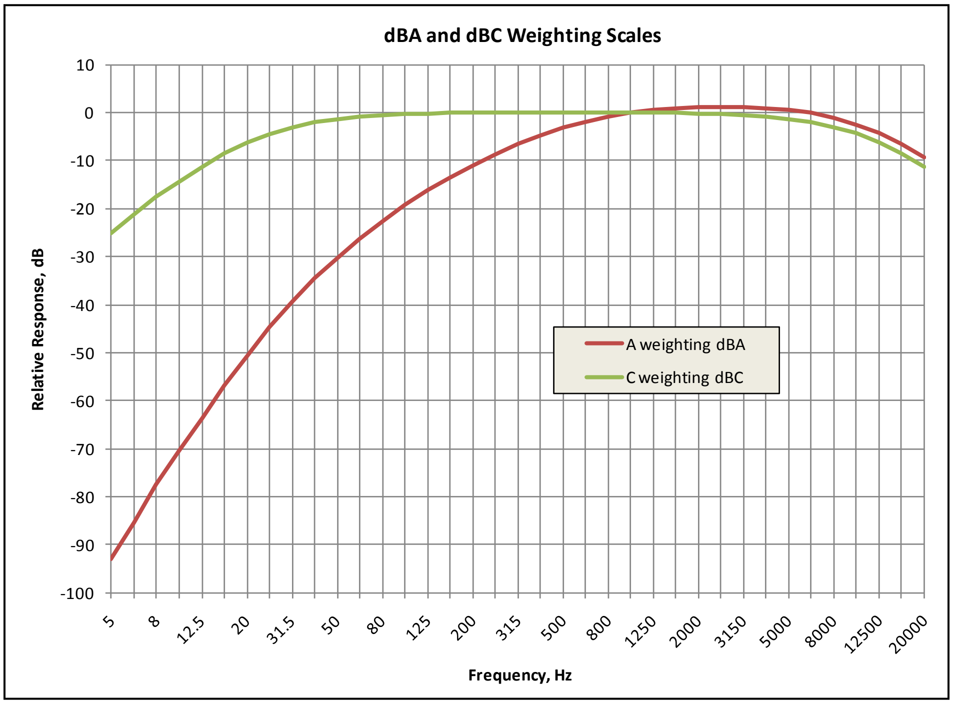


Figure 2-1. Weighting Curves for dBA and dBC Sound Levels

Similar to the size and period of ocean waves, sound pressure waves can vary considerably in amplitude and frequency. When using fast-time weighting, a sound level meter will measure a sound pressure level every 1/8 of second which results in 480 measurements each minute and 28,800 measurements in an hour. Because it would be nearly impossible to evaluate over 28,000 measurements per hour, numerous statistical parameters have been developed for use in quantifying long-term sound level measurements. The most common is the A-weighted equivalent sound level or LAeq, which represents the time-varying sound level as a single dBA level by effectively spreading the sound energy across the entire measurement period. Other common parameters are percentile levels that represent the percentage of time that a specific sound level was exceeded. For example, the LA10 provides the sound level that was exceeded 10% of the time during the measurement period. This means that 10% of the measured sound levels were higher and 90% were lower than the measured LA10. Other commonly used percentiles include the LA50 or median sound level and the LA90 for which 90% of the measured sound levels are higher. The LA90 is often referred to as the background sound level as it eliminates most fluctuations from short term sound events such as aircraft flights and wind gusts. Figure 2-2 presents a graph that shows the measured sound pressure levels and the resulting equivalent (LAeq), LA10 and LA90 sound level parameters.

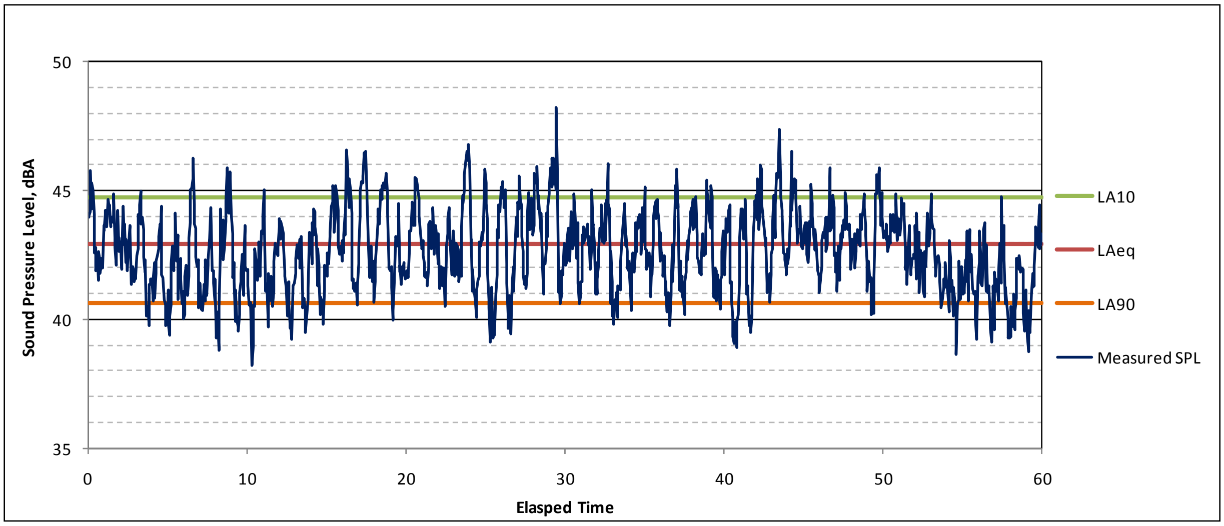


Figure 2-2. Measured Sound Pressure Levels and Statistical Parameters.

For purposes of quantifying industrial and other man-made sound sources, the term "sound power level" is used. The unit of sound power level is watts and the term is commonly expressed as Lw. When applied to sound power, the dB unit represents a logarithmic ratio of the source sound power to a reference sound power (10^{-12} watt). Sound power levels are determined by measuring the sound pressure level from a source at a specific distance and calculating the sound attenuation between the source and measurement location. The sound power level provides a mechanism for ranking and quantifying noise sources in a consistent and standardized manner. It is commonly used in sound performance specifications and as a source input to sound level prediction models. By its nature, the sound power level cannot be measured directly and can be a source of confusion to the public relative to sound pressure levels that are predicted and measured at community locations.

The combination of all existing sound sources, natural and man-made, at a specific location or in a community is known as the ambient sound environment or soundscape. The amplitude and characteristics of the soundscape vary significantly depending on the amount of industrial and residential development, proximity to transportation uses such as highways and airports, and the presence of natural sounds such as wind, flowing water, and wildlife. In general, the more rural or undeveloped an area is, the lower the ambient sound levels will be. Ambient sound levels are usually higher during daytime hours than at night due to more traffic and human activity, higher wind speeds and other natural sounds during the day. At night, these daytime sources typically diminish and sound levels are reduced with the exception of strong winds or rain occurring during the overnight period.

Noise is generally defined as unwanted sound. The perception of noise as an unwanted sound can vary significantly by individual and preferences concerning types of sound. A simple example of this is music. One person may enjoy a certain type of music that another may find extremely annoying. Some individuals find enjoyment and solitude in listening to natural sounds or the nighttime quiet of a rural area while others have little interest in such soundscapes.

The character of sound is determined by its loudness or amplitude and its pitch or frequency. Humans can detect a wide range of sound level amplitudes and frequencies as audible but are more sensitive to a specific range of frequencies. Consequently, the perceived loudness of sound also depends not only on its amplitude but on its frequency characteristics as well. For example, the sound of birds, frogs or flowing water is often perceived as quieter than man-made sounds at the same amplitude. The sound levels associated with some common noise sources and sound environments is presented as Table 2-1.

Indoor Setting	**Outdoor Setting**	**Sound Sources**	**Sound Pressure Level, dBA**
*Rock Concert**		*Jet Takeoff at 300 feet**	*120*
Ship Engine Room	*Loud Thunder**	*Rifle Blast at 100 feet*	*110*
*Movie Theater**		*Chain Saw high rpm at 5 feet* *Siren at 100 ft*	*100*
*Heavy Industrial Work Space**		*Lawn Mower high rpm at 10 feet* *Large Truck or Loader high rpm 50 feet**	*90*
Busy Airport	*Heavy Rain*	*Motor Boat high rpm at 100 feet*	*80*
Light Industrial Workspace	*Heavy Surf Beach** *Busy City or Highway*	*AC Unit at 5 feet* *Automobile 45 mph at 50 feet*	*70*
Busy Office/Conversation Room with TV	*Urban Daytime*	*Strong Wind in Trees** *Nighttime Frogs* *Airplane Flyover**	*60*
	Suburban Daytime/Urban Nighttime	*Bird Calls/Morning Chorus* *Small waves on shoreline*	*50*
Quiet Office *Library*	*Rural Area Daytime*	*Moderate Wind in Trees*	*40*
Sleeping Quarters at Night	*Rural Area Nighttime*	*Light Wind in Trees*	*30*
Idle Recording Studio	*Very Remote Area Nighttime* *Perceived Silence*		*20*
			10
		Threshold of Hearing	*0*

Table 2-1. Typical A-Weighted Sound Levels

Note: These are typical sound levels and subject to significant variation depending on the number of and distances from sound and transportation sources.

**Sound with prominent Low Frequency components*

Sources:
www.mvn.usace.army.mil/ss/osha600/s600/refer/menu14c.pdf
Measurements and Observations by R. Scott Bodwell, P.E.

2.2 Outdoor Sound Propagation

Sound travels through air at a speed of approximately 1126 feet per second or 768 miles per hour. Thus it takes just over two seconds for a sound wave to travel a half mile. The number of sound waves that travel past a given point in one second is determined by its frequency or pitch. The sound pressure level decreases or attenuates as sound spreads out and travels over distance through the air. Attenuation results from distance, atmospheric absorption, and terrain effects. The rate of attenuation due to distance or spreading of the sound wave (i.e. divergence) is the same for all frequencies, which is approximately 6 dB per doubling of distance from a simple point source.

Table 2-2 provides the sound pressure level at various distances from a point source having a sound power level of 106 dBA. This relationship is shown graphically in Figure 2-3. The sound level reduction shown in Table 2-2 and Figure 2-3 is due only to distance attenuation and does not include attenuation from atmospheric absorption, terrain and foliage, or reflection from hard surfaces.

Source Sound Power Level, LwA = 106 dBA	
Distance, Feet	**Sound Pressure Level, dBA**
25	80
50	74
100	68
200	62
400	56
800	50
1600	44
3200	38

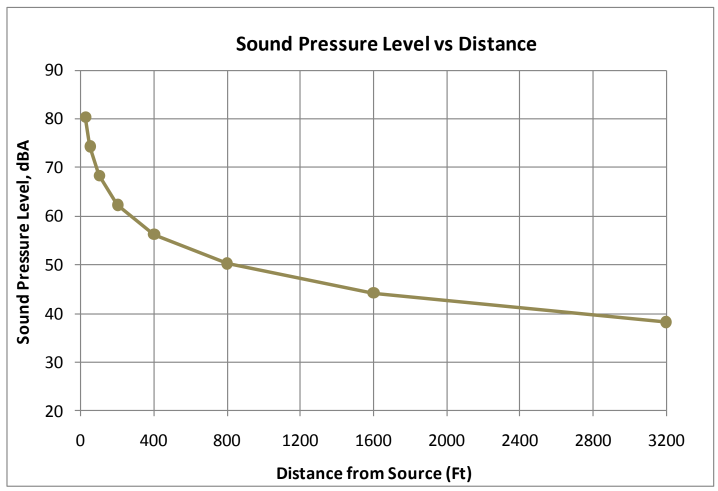


Table 2-2 & Figure 2-3. Attenuation of Sound Levels over Distance

Sound energy is absorbed by the atmosphere as it travels through the air. The amount of absorption varies by the frequency of the sound and the temperature and humidity of the air. More sound is absorbed at higher frequencies than at lower frequencies due to the relative wavelengths.

In addition to temperature and humidity, wind speed and direction can affect outdoor sound propagation. When sound travels upwind the sound waves can bend upward creating a “shadow” zone near the ground where sound levels decrease when compared to downwind sound propagation. Wind gradients, temperature inversions and cloud cover can cause refraction or bending of sound waves toward the ground resulting in less sound attenuation from terrain and ground cover over large distances.

Sound attenuation can also result from intervening terrain and certain types of ground cover and vegetation. An example of intervening terrain is a hill or ridge that blocks the horizontal sound path between a sound source and receiver. This same effect can result from buildings and other solid structures such as a sound barrier fence. Sound will also attenuate as it travels over soft ground cover or through vegetation such as trees and shrubs. The amount of ground and foliage attenuation depends on the characteristics of the ground cover and the height and density of vegetation. Conversely, reflective ground or the surface of a water body can cause reflection of sound and less overall attenuation.

When multiple sound sources are present in an area, the sound level contribution from each source must be added to determine of the combined sound level of all sources. Due to logarithmic basis of the dB unit, adding sound levels is different than standard arithmetic. Adding two equal sound sources that each measure 50 dBA at a specific point will result in a combined sound level of 53 dBA. It will then take two more equal sound sources of 50 dBA each, or four total, to cause the sound level to increase by another 3 dBA. Thus, four equal sources at 50 dBA results in a total sound level of 56 dBA.

Specifications for calculating outdoor sound propagation have been developed by international standards organizations as well as individual countries based on empirical data developed over many years. These specifications form the basis for computerized sound level prediction models that allow calculation of outdoor sound propagation through the use of three-dimensional terrain models. The most widely used and accepted standard for calculating outdoor sound propagation is ISO 9613-2 Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation. This standard has been applied to accurately calculate the sound levels that result from operation of wind turbines and is the standard applied in this analysis. Further details concerning the sound level prediction model developed for Three Rivers Solar to account for various site and weather conditions can be found in Section 6.2 of this report.

2.4 Noise Impact and Regulation

The noise impact from a project depends on several factors, notably the change or increase in ambient or background sound levels that will result. The ambient sound levels for rural areas are relatively low and vary by time of day, weather conditions, and to some degree by season, with the lowest ambient sound levels during winter nighttime periods.

During the planning stages of a energy project, considerable effort is made to accurately map land uses and the topography of the entire area potentially impacted by sound from proposed operations. Along with equipment sound performance data, this information is used to develop a sound level prediction model for the project. The model inputs and settings are typically adjusted to produce conservative sound level predictions for facility operation. These results are compared to various noise regulations and/or guidelines to assess the impact of the proposed energy project.

In 1989, the Maine legislature approved noise control regulations developed by the Maine DEP as Chapter 375.10 of Site Location of Development Law Regulations. This regulation specifies sound level limits for development projects such as energy facilities that include lower hourly sound limits of 55 dBA daytime and 45 dBA nighttime for quiet rural areas based on an hourly equivalent sound levels (LAeq) at protected locations. The Maine DEP nighttime limits apply up to 500 feet from a residence on a protected location or at the property line if closer. In most cases, the resulting sound levels at the residence will be lower. Beyond 500 feet, the daytime limit applies 24 hours per day. There are also special provisions and “penalties” that apply when the sound generated by a facility results in tonal or short duration repetitive (SDR) sounds. This standard is described in more detail in the remainder of this report.

3.0 Project Description

Three Rivers is a 100 MW solar energy project proposed by Next Phase Energy and located within Hancock County in the unorganized township of T16 MD BPP west of the Narraguagus River and south of State Route 9 and township T22 MD. It is also due east of existing Bull Hill and Hancock Wind projects. Figure 3-1 provides a Project Location Map that shows Three Rivers in relation to surrounding land uses and area wind projects. The Project will consist of approximately 400,000 solar panels and power collection system distributed over 500 acres of mostly cleared blueberry land within the 696 acres of the commercial subdistrict as designated by the Maine Land Use Planning Commission (LUPC).

The Project area generally consists of commercial wild blueberry fields with some mixed forests, surrounded by commercially-operated forest land. Portions of the land have been developed for cultivating wild blueberry crops over the past five years which includes de-stumping and leveling. Minimal leveling will be necessary to accommodate the solar panels, and there will be continued cultivation of blueberries on any land within the Project area that is not used for solar panels.

The land cover will be maintained to the standards of Maine DEP meadow buffers with disturbed soils revegetating with various plants. The project area will be mowed between 1-2 times per year and have motorized vehicle traffic limited to maintenance of the panels, as specified in the deed restrictions for meadow buffers.

The DC power produced by the solar panel will be converted to AC power and combined via an underground 34.5 kilovolt (kV) collection system flowing to a proposed new substation located within the project area near the Operations and Maintenance (O&M) facility. The majority of the collector lines will be placed underground to transmit AC power from the aboveground DC to AC invertors. The inventers will be skid-mounted and installed in groups of five totaling 170 inverters and 34 skids. The new substation will be located within a fenced area and “step up” the 34.5 kV power from Three Rivers for grid transmission using an existing 115-kV transmission line for connection to the New England regional electrical via Emera Maine’s existing 115 KV transmission line.

Three Rivers has a lease agreement for land to host the entire Project with landowner Duane Jordan of Elliot Jordan & Sons, Inc.

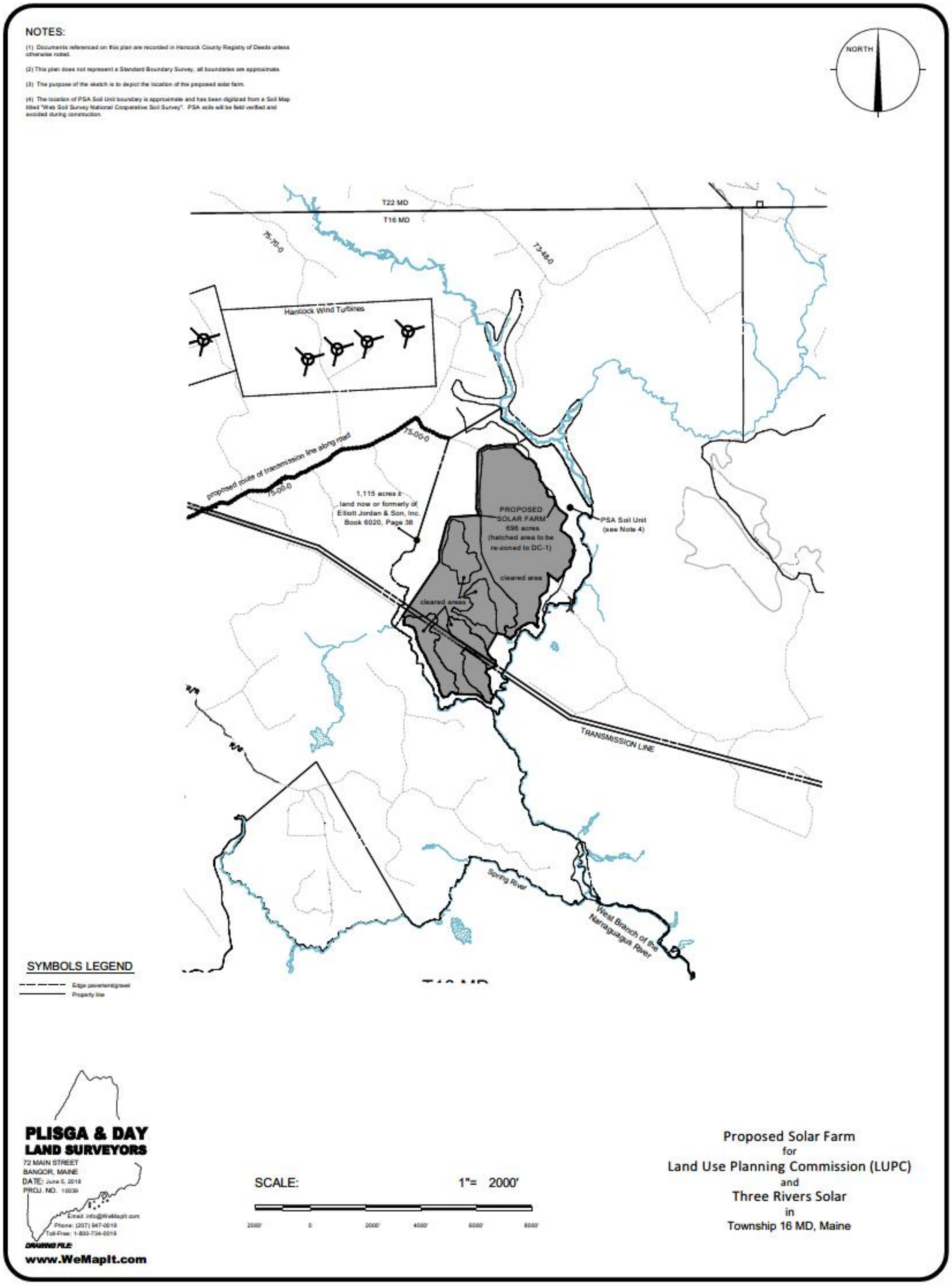


Figure 3-1. Project Location Map

General site topography is nearly flat to gently sloping between the small hills and low ridges with project elevations ranging from approximately 150 to 300 feet. Large portions of the project area have been commercially managed for blueberry and timber production with many existing gravel roads providing vehicular access. Two wind projects operating in the area are 18-turbine Bull Hill Wind to the west and south, and 17-turbine Hancock Wind to the west and northwest. The nearest turbines are at Hancock Wind approximately 5,100 feet from the closest solar panel at Three Rivers.

Other land uses in the area are undeveloped forestry land and rural residential and seasonal properties such as hunting and lakeside camps. Although the majority of residential and seasonal properties are located within the Town of Osborn along Spectacle Pond and the Town of Eastbrook, over three miles from the proposed solar project, there are a few seasonal/hunting camps on leased land located closer to the Project within T22 MD. Other than a dwelling owned by a participating landowner, the nearest dwelling to the project is located approximately 4,260 feet from an inverter skid.

4.0 Solar Energy Components

Three Rivers proposes to install approximately 400,000 individual photovoltaic solar energy panels with a nominal generating capacity of 2,500 watts each to produce a total overall electric power of up to 100 megawatts (MW). The proposed solar panels produce DC power which is converted into AC power for grid distribution. The DC/AC inverters are skid-mounted in groups of five and distributed evenly amongst the solar panels. Other than the project substation transformer, the DC/AC inverters are the primary type of sound source associated with Three Rivers Solar.

Sound performance ratings for the inverters were derived from sound reports of similar equipment and for the proposed substation transformer from National Electrical Manufacturers Association (NEMA) TR 1 ratings. From the total exposed surface area, inverter and transformer sound power levels are quantified as "point sources" for the purpose of calculating the resulting sound levels at nearby protected locations from full project operations. The following provides a brief description of the specific characteristics of the proposed equipment and its sound performance.

4.1 Substation Transformer

The primary noise source at the project substation located in the southeast section of the proposed solar panel/inverter array. The transformer will "step up" the 34.5 kV power from Three Rivers for grid transmission using an existing 115-kV transmission line for connection to the New England regional electrical via Emera Maine's existing 115 KV transmission line. As provided by HICO America assuming standard Basic Insulation Level (BIL), the rated sound levels would be 79/81/82 dBA depending upon operation of cooling fans. The octave band sound levels were derived by applying dB adjustments by frequency from the Edison Electric Institute, Electric Power Plant Environmental Noise Guide, 1984.

Octave Band Center Frequency, Hz									
	31.5	63	125	250	500	1000	2000	4000	8000
NEMA Overall Rating = 82 dBA									
Correction	-3	3	5	0	0	-6	-11	-16	-23
Net SPL	79	85	87	82	82	76	71	66	59

Table 4-1. Rated Sound Pressure Level for Proposed Substation Transformer, dBA

The approximate dimensions of the transformer are as follows:

Height = 6.89 m
Length = 8.63 m
Width = 4.82 m

This yields a total exposed surface area including the top and all sides of 227 square meters (m^2). The overall sound power level per ANSI/IEEE C57.12.90-2015 Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers is derived from the following:

Lw = SPL Rating + 10 log S, where S = total surface area

Lw = 82 + 23.6 = 105.6 dBA

From this, the sound level adjustments are applied per Table 4-1 to each octave band sound level.

4.2 Power Inverters

The primary noise source within the solar panel array are the skid-mounted DC/AC power inventors distributed throughout the project area. Each skid assembly includes five TMEIC Solar Ware Ninja Inverters as shown by Figure 4-1. As a new inverter model, sound measurements and performance data is currently pending. Consequently, the estimated sound level was derived from a Noise Assessment for similar equipment for the Pittsfield Solar Photovoltaic by SE Ambrose, which puts the rated sound level at 77 dBA at 1 meter from the inverter surface. Similar to the transformer, octave band sound levels were derived by applying dB adjustments by frequency from the Edison Electric Institute, Electric Power Plant Environmental Noise Guide, 1984. The resulting octave band sound levels are shown in Table 4-2.

Octave Band Center Frequency, Hz									
	31.5	63	125	250	500	1000	2000	4000	8000
Estimated Sound Level at 1 m = 77 dBA									
Correction	-3	3	5	0	0	-6	-11	-16	-23
Net SPL	74	80	82	77	77	71	66	61	54

Table 4-2. Rated Sound Pressure Level for Proposed Power Inverter, dBA

From the approximate dimensions for the exposed surface of the inverters on each steel, the overall surface area including the top and all sides of 32.2 square meters (m^2). The overall sound power level per ANSI/IEEE C57.12.90-2015 Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers is derived from the following:

Lw = SPL Rating + 10 log S, where S = total surface area, m^2

Lw = 77 + 15.1 = 97.1 dBA

From this, the sound level adjustments are applied per Table 4-2 to each octave band sound level for the power inverters.

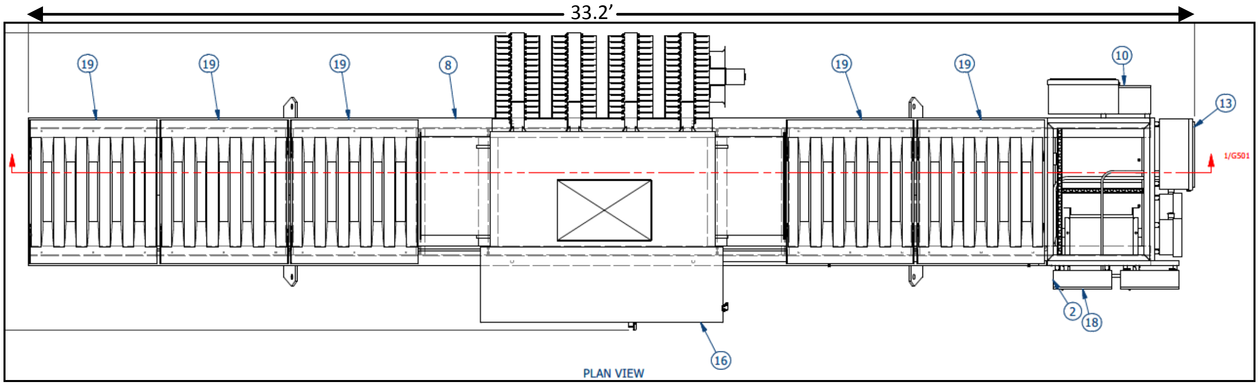


Figure 4-1. Skid-Mounted Power Invertors (5 Total)

4.3 Meteorological Conditions

Meteorological conditions have the potential to affect source sound levels and sound propagation over distance. This sound level assessment uses a widely recognized sound level prediction methodology and modeling assumptions that have been demonstrated by testing to be reliable for accuracy. In addition, during winter operations, frozen ground conditions can result in lower ground absorption and increase resulting sound levels at nearby protected locations. Section 6.3 of this report provides further detail on assumptions used for the sound level prediction methodology.

5.0 Noise Standards and Guidelines

The following provides a description of State of Maine noise regulations including applicable sound level limits, model uncertainty, compliance determination and consideration of noise standards, if any, enacted by a local municipality.

5.1 Maine DEP Sound Level Limits

Maine DEP Chapter 375.10, Control of Noise, establishes hourly sound level limits for site developments based on time of day. These limits are described in Section C. Sound Level Limits, and apply to sound levels resulting from routine operation of a development.

Assuming that sound levels at nearby protected locations meet the criteria for quiet areas, Three Rivers Solar is required to meet the following sound level limits (ref. Maine DEP 375.10.C(2)):

- 75 dBA at any time of day at any property line of the development or contiguous property owned or controlled by the project developer; and
- 55 dBA between 7:00 a.m. and 7:00 p.m. (the "daytime limit"), and 45 dBA between 7:00 p.m. and 7:00 a.m. (the "nighttime limit") at any protected location.

Although the Maine DEP noise regulation specifies a 75 dBA at the facility property line, the most restrictive limits apply at noise sensitive land uses that meet the definition of a "protected location". A protected location is defined as:

> "Any location accessible by foot, on a parcel of land containing a residence or planned residence or approved residential subdivision, house of worship, academic school, college, library, duly licensed hospital or nursing home near the development site at the time a Site Location of Development application is submitted; or any location within a State Park, Baxter State Park, National Park, Historic Area, a nature preserve owned by the Maine or National Audubon Society or the Maine Chapter of the Nature Conservancy, The Appalachian Trail, the Moosehorn National Wildlife Refuge, federally-designated wilderness area, state wilderness area designated by statute (such as the Allagash Wilderness Waterway), or locally-designated passive recreation area; or any location within consolidated public reserve lands designated by rule by the Bureau of Public Lands as a protected location.
>
> At protected locations more than 500 feet from living and sleeping quarters within the above noted buildings or areas, the daytime hourly sound level limits shall apply regardless of the time of day.
>
> Houses of worship, academic schools, libraries, State and National Parks without camping areas, Historic Areas, nature preserves, the Moosehorn National Wildlife Refuge, federally-designated wilderness areas without camping areas, state wilderness areas designated by statute without camping areas, and locally-designated passive recreation areas without camping areas are considered protected locations only during their regular hours of operation and the daytime hourly sound level limits shall apply regardless of the time of day.
>
> Transient living accommodations are generally not considered protected locations; however, in certain special situations where it is determined by the Board that the health and welfare of the guests and/or the economic viability of the establishment will be unreasonably impacted, the Board may designate certain hotels, motels, campsites and duly licensed campgrounds as protected locations." (ref. MDEP 375.10 G(16))

Maine DEP Chapter 375.10 defines a "residence" as:

> "A building or structure, including manufactured housing, maintained for permanent or seasonal residential occupancy providing living, cooking and sleeping facilities and having permanent indoor or outdoor sanitary facilities, excluding recreational vehicles, tents and watercraft." (ref. MDEP 375.10 G(14))

The quiet nighttime limit of 45 dBA applies on portions of a protected location within 500 feet of a dwelling (or other sleeping quarters), or at the lot line of the protected location, whichever is closer to the dwelling. At portions of the protected location greater than 500 feet from the residence or sleeping quarters, the 55 dBA daytime limit applies 24 hours a day. Sound from regular and routine maintenance of the Project is subject to the same sound level limits as routine operation.

Construction during daytime or daylight hours, whichever is longer, is exempt from the Maine DEP sound limits by Maine statute (ref. 38 MRSA 484). Sound from nighttime construction that occurs beyond daytime or daylight hours is subject to the nighttime limits that apply to routine operation. More information concerning construction of Three Rivers is presented in Section 6.1 of this report.

Sound associated with certain equipment and activities is exempt from the Maine DEP noise regulation. Examples that may be associated with the proposed project include:

- Registered and inspected vehicles traveling to and from the project
- Forest management, harvesting and transportation
- Snow removal and landscaping
- Emergency maintenance and repairs, warning signals and alarms
- Major concrete pours when started before 3:00 pm
- Sounds from a regulated development received at a protected location when the generator of the sound has been conveyed a noise easement for that location
- A force majeure event and other causes not reasonably within control of the owners or operators of the development

The Maine DEP limits do not apply to noise received within the project boundary or where Three Rivers Solar has obtained a sound easement. As set forth by Maine DEP 375.10, Section C.5.s, a landowner may grant a noise (sound) easement that exempts the project from Maine DEP noise limits for the specific development, parcel of land, and term covered by the agreement. In addition, dwellings located on lease lots are subject to the terms of the lease agreement whereby the landowner can grant an easement from Maine DEP noise limits.

5.2 Tonal and Short Duration Repetitive (SDR) Sounds

Maine DEP Chapter 375.10 requires that 5 dBA be added to tonal and short duration repetitive (SDR) sounds when determining compliance with hourly sound level limits. Further details and an assessment of these types of sound for Three Rivers Solar are presented in Section 6.4 of this report.

5.2.1 Tonal Sounds

A tonal sound from the Project exists at a protected location, if the 10-minute equivalent one-third octave band sound level in the band containing the tonal sound exceeds the arithmetic average of the sound pressure levels of the two contiguous one-third octave bands as follows:

- by 5 dB for center frequencies at or between 500 Hz and 10,000 Hz
- by 8 dB for center frequencies at or between 160 and 400 Hz, and
- by 15 dB for center frequencies at or between 25 Hz and 125 Hz.

When a tonal sound occurs from routine operation of the Project, 5 dBA is added to the hourly equivalent sound level of the tonal sound for purposes of demonstrating compliance with the applicable daytime and nighttime sound level limits (ref. Maine DEP 375.10.C.1(d)).

5.2.2 Short Duration Repetitive (SDR) Sounds

An SDR sound is a sequence of repetitive sounds clearly discernible as an event resulting from the development and causing an increase in the sound level of 6 dBA or greater on the fast meter response above the sound level observed immediately before and after the event.

When routine operation of a development produces SDR sounds, a 5 dBA penalty is to the SDR sound levels to calculate the resulting hourly LAeq (ref. Maine DEP 375.10. C.1(d).

5.3 Compliance with the Sound Level Limits

Compliance with the applicable sound level limits for solar energy and other developments is demonstrated in accordance with section H(4) of Maine DEP 375.10, which may be required for validation of the Project's calculated sound levels when requested by the Maine DEP. Measurements shall be obtained during representative weather conditions when the development sound is most clearly noticeable. For Three Rivers Solar, this equates to full power production with the nearest protected location downwind of facility noise sources.

Compliance is demonstrated when the measured hourly sound levels, including any applicable adjustments for the presence of tonal and SDR sounds, are below the most restrictive nighttime sound limit of 45 dBA at the nearest protected location.

5.4 Local Standards

When a development is located in a municipality that has duly enacted a quantifiable noise standard that (1) contains limits that are not higher than the Maine DEP limits by more than five dBA, and (2) limits or addresses the types of sounds regulated by the Maine DEP, then the Maine DEP is to apply the local standard rather than the Maine DEP standard. When noise produced by a facility is received in another municipality, the quantifiable noise standards of the other municipality must be taken into consideration (ref. Maine DEP 375.10.B.1).

Three Rivers Solar is located entirely within Township T16 MD, which, like all unorganized townships in Maine, has no local land use ordinances.

5.5 Sound Model Factors and Uncertainty

To evaluate compliance with Maine DEP noise rules, a predictive sound model used to calculate sound levels produced by Three Rivers Solar during predictable worst case conditions for impact on adjacent properties. To meet this objective, the predictive model factors in sound propagation with low ground absorption and no attenuation for foliage between noise sources and protected locations. In addition, the full rated sound power output of the power invertors and substation transformer (NEMA TR 1) were applied in the sound model operating during nighttime stable atmospheric conditions. Other model inputs are:

- Attenuation due to geometric spreading with each source modeled as a point source
- No attenuation for intervening terrain which would serve to reduce sound propagation
- Attenuation due to air and ground absorption (mixture of soft and frozen ground)
- Inclusion of an "uncertainty factor" adjustment to the maximum rated output of the sound sources based on the manufacturer's recommendation

6.0 Sound Emissions

The following provides an assessment of sound levels associated with construction and operation of Three Rivers Solar.

6.1 Construction Sound Levels

Construction of Three Rivers Solar will involve the use of heavy machinery to clear and rough/finish grade areas for access roads and equipment pads, installation of solar panels and collection system, and substation site. This equipment will include heavy trucks, excavators, loaders, bull dozers, cranes, portable generators and compressors among other machines. Construction staging yards will also be established in designated areas for storage of equipment, materials, and facility components.

Depending upon whether aggregate material can be found on site or transported to the project, there may also be equipment operating at the project site to excavate gravel, crush rock and process aggregate. Sound levels from mobile construction and portable processing equipment is likely to generate sound levels in the range of 75 to 95 dBA at 50 feet. Due to the size and configuration of the project site, most of this equipment will be well distributed and not focused in a single area.

Operation of heavy equipment for site work and other major construction activity between 7 am and 7 pm or during daylight hours, whichever is longer, is not subject to the Maine DEP noise control regulation per Maine statute (ref. 38 MRSA Section 484). Construction activity during nighttime, non-daylight hours must comply with the nighttime limits applicable to routine facility operation.

6.2 Operating Sound Levels

The primary noise sources associated with Three River Solar are the power invertors distributed within the solar panel array and the substation transformer.

Sound performance data for the DC/AC invertors was estimated from a similar project which has been incorporated in the sound model per the expected distribution within the solar panel array.

Transformer sound levels are specified in accordance with TR-1 based on the power ratings and physical dimensions as provided by Next Phase Energy. Assuming standard BILs, the specified dBA sound levels are 79/81/82, so a maximum of 82 dBA as an average at a distance of three feet from the transformer casing and cooling fans. The sound power level for the sound sources was determined from the total exposed surface area. In addition, 5 dBA was added to the rated sound power levels to account for the potential to generate tonal sounds per Maine DEP 375.10. To ensure conservative estimates, an adjustment of +2 dBA was also applied for uncertainty of the specified sound levels and model accuracy.

6.3 Sound Prediction Model

A sound level prediction model was prepared to calculate the sound levels from full rated operation of Three Rivers Solar. The predictive sound model was created using Cadna/A software developed by DataKustik of Germany. Cadna/A provides the platform to construct topographic surface models of area terrain for calculating sound attenuation from multiple sound sources such as an array of solar invertors. Mapping of proposed equipment locations, roads, parcels, land uses and water bodies was imported to Cadna/A in order to calculate the resulting sound levels within the study area. The invertors and substation transformer were modeled to determine the expected sound level at regulated protected locations.

Sound level predictions are calculated in accordance with ISO 9613-2, an international standard for calculating outdoor sound propagation. This method calculates sound levels as though all receiver points were located downwind simultaneously from the sound sources, which is for calculation purposes and not a physical possibility. According to ISO 9613-2, the calculation method is also equivalent to sound propagation for a "well-developed moderate ground-based temperature inversion." The stated accuracy of the ISO 9613-2 method is $\pm$3 dBA for a source and receiver mean height of 5 to 30 meters and a distance of 100 to 1000 m, at or near the project dimensions.

The parcel boundaries and dwelling locations for the model were also provided by project mapping consultants. Dwellings locations were mapped through use of aerial photography and field verification in 2019 with the parcel associations confirmed from review of tax assessor records. Any additional parcels with approved residential building permits or that are part of an approved residential subdivision since 2014 were researched in August 2019 by review of state and municipal records.

Cadna/A allows flexibility in defining model settings and adjustments related to calculation methods, ground absorption and other factors. Additionally, as discussed above, conservative assumptions are utilized with respect to each of these factors. Sound measurements of numerous energy projects in Maine have been evaluated to ensure that the model is "calibrated" to actual sound levels for reliable model predictions. As the following describes, model settings have been applied to predict the high range of facility sound levels as measured under a wide variety of site and weather conditions at other projects.

Other model settings were selected to calculate ground attenuation using the spectral method per ISO 9613-2 and using a default ground absorption factor of 0.5 to represent a mix of hard/reflective and soft ground. Surface water bodies were mapped and assigned a ground absorption factor of 0.0 for an acoustically reflective surface. Attenuation resulting from intervening terrain using USGS contours and atmospheric absorption using standard day conditions (temperature 10^{o}C, relative humidity 70%) was also calculated. No attenuation was calculated due to intervening terrain, trees or other foliage that could act to reduce sound levels at community locations.

6.4 Tonal and Short Duration Repetitive (SDR) Sounds

The Maine DEP noise rule requires that 5 dBA be added to the measured sound level at a protected location if sound from a development generates either 1) a tonal sound or 2) SDR sound events over a one-hour measurement interval.

6.4.1 Tonal Sounds

Both the power invertors and transformer substation have the potential to generate a tonal sound as defined by Maine DEP 375.10. As such, 5 dBA has been added to calculate sound levels at the nearest protected locations to the Project.

6.4.2 Short Duration Repetitive (SDR) Sounds

The primary noise sources associated with Three Rivers Solar operate in a near steady-state mode slowly rising and decaying in response to sun conditions. Therefore, there is virtually no potential for the generation of SDR sounds or the associated sound penalty.

6.5 Predicted Sound Levels

From the project sound model, facility sound levels during full operations were calculated for a height of 5 feet above ground level as specified by Maine DEP 375.10. To evaluate compliance with applicable sound limits, sound levels were calculated and presented specifically for selected community receptor points. "Receptor points" are the locations in each direction from Three Rivers Solar with the greatest potential to exceed the Maine DEP sound level limits.

Sound level predictions for Three Rivers were calculated with all equipment operating at full-rated sound power output, and the addition of 2 dBA for uncertainty and model accuracy, and 5 dBA for potential tonal sounds. Sound levels at nearby dwellings/protected locations as receptor points were calculated for the entire project area as presented in Figure 6-1. Figure 6-1 also shows the sound source, parcel boundaries, and dwelling locations, public and private roads, and water bodies.

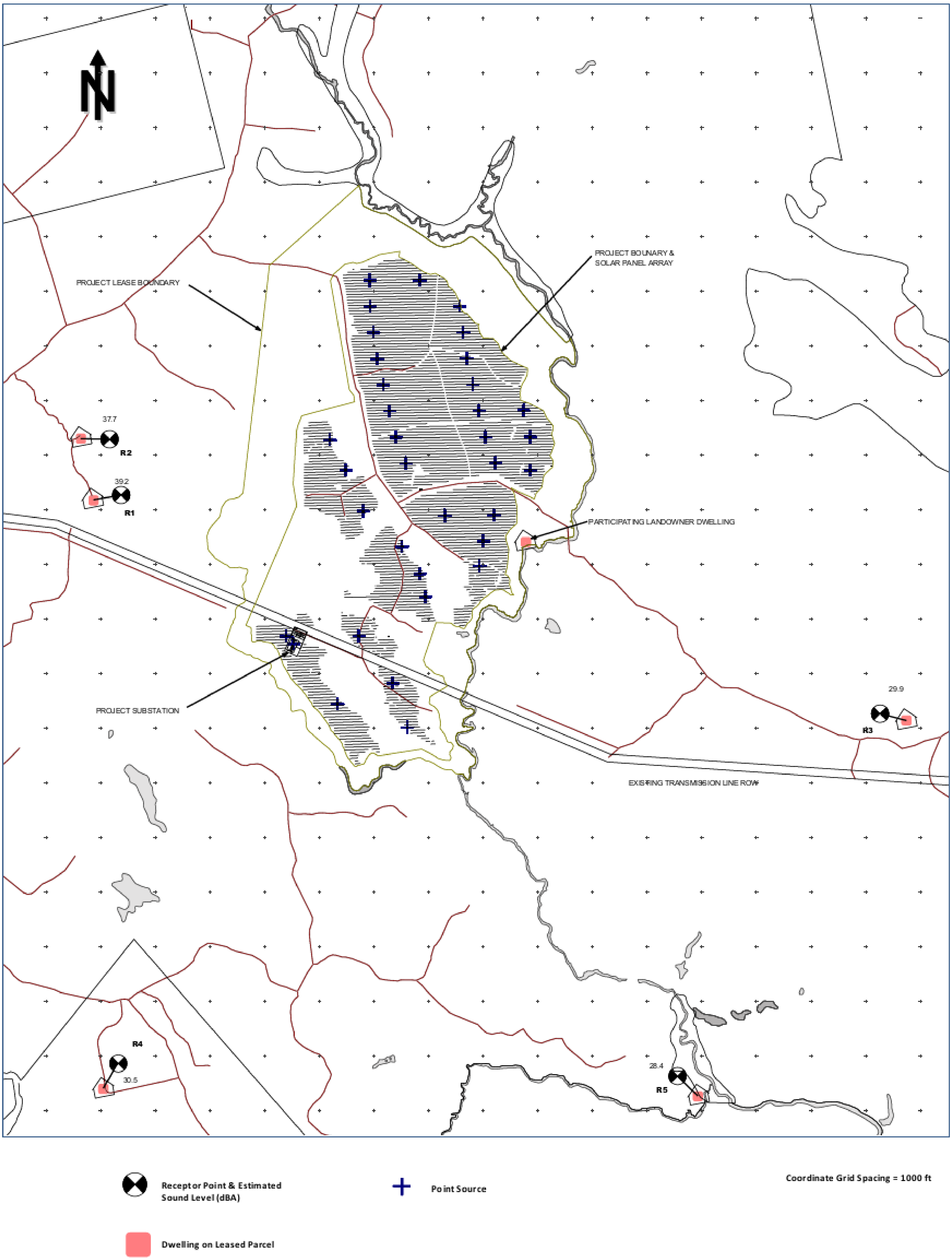
A summary of predicted sound levels at the receptor points for full operation of Three Rivers Solar is provided in Table 6-1. This table also provides the distance from each receptor point to the nearest noise source of the Project and the applicable nighttime sound level limit.

Receptor Point	Description and Approximate Distance to Power Inverter		Predicted Hourly Sound Level and Nighttime Sound Limit, dBA	
	Description	Approx Distance (ft)	Three Rivers	Sound Level Limit
R1	T16 MD – Dwelling on Leased Lot	3,950	39.2	45
R2	T16 MD – Dwelling on Leased Lot	3,990	37.7	45
R3	T16 MD – Dwelling on Leased Lot	8,650	29.9	45
R4	T16 MD – Dwelling on Leased Lot	7,700	30.5	45
R5	T16 MD – Dwelling on Leased Lot	8,080	28.4	45

Table 6-1. Predicted Sound Levels from Full Rated Operations at Receptor Points

Receptor points consist of the nearest protected locations to Three Rivers Solar. With discretionary settings, tonal penalty, and uncertainty included in the predictive model totaling 7 dBA, the resulting sound levels are below the Maine DEP nighttime limit of 45 dBA at all receptor points. A review of predicted sound levels indicates that when operating at full sound output, Three Rivers will comply with the most stringent of all potentially applicable Maine DEP sound level limits.

Figure 6-1. Predicted Sound Levels from Full Routine Operation of Three Rivers Solar



7.0 Sound Level Testing

The purpose of sound level testing is to confirm by measurement that sound levels emitted by Three Rivers Solar are at or below the sound level limits applicable to the project.

7.1 Project Construction

Construction of Three Rivers Solar is planned to primarily occur during daytime hours when sound levels generated by construction activity are exempt from the Maine DEP sound level limits by Maine statute Therefore, no sound level testing is planned for the construction phase of the project.

If nighttime non-daytime construction occurs, such construction activity is required to comply with nighttime sound level limits for routine operation and maintenance of the project.

7.2 Project Operations

Given the conservative nature of the sound level predictions and larger distances to protected locations, sound testing of Three Rivers Solar is not essential for demonstrating sound level compliance. However, if sound complaints are received, spot sound checks at the complainant location are warranted under similar operating/weather conditions. The objective of sound testing would be to quantify project sound levels under sun and weather conditions when such sounds are most prominent at the protected locations. Notice of planned sound testing and specific test conditions should be provided to all interested and affected parties.

8.0 Summary of Findings

This Sound Level Assessment establishes sound level limits to be applied to Three Rivers Solar and provides sound level predictions for full rated operations using a terrain-based computer model. Model settings reflect conservative assumptions and contingencies for potential uncertainties. Sound level predictions indicate that full operation of Three Rivers Solar will meet all Maine DEP sound limits including quiet nighttime limit of 45 dBA within 500 feet of dwellings on nearby protected locations.

9.0 References

ANSI/IEEE C57.12.90-2015 Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.

Edison Electric Institute, Electric Power Plant Environmental Noise Guide, 1984.

Maine Department of Environmental Protection (DEP) Site Location of Development Regulations for Control of Noise (06-096 CMR c. 375.10), 1989 and 2012.

Maine Revised Statutes Annotated, Standards for Development, 38 MRSA 484, Subsection 3, 1993.

National Electric Manufacturers Association (NEMA) Publication No. TR 1-1993, Transformers, Regulators and Reactors, R2000.

SE Ambrose & Associates, Noise Assessment, Pittsfield Solar, LLC, Solar Photovoltaic Facility, March 2017.