Brunswick Layover Environmental Assessment (EA)

Appendix E: Noise and Vibration Technical Report

September 2013

Brunswick Layover Facility
Environmental Assessment

Noise and Vibration Technical Report

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1. Executive Summary

The Preferred Alternative in this project involves the construction of a layover facility in Brunswick, Maine to support the overnight storage and turnaround servicing of Amtrak Downeaster train sets. The layover facility is proposed to be constructed at the existing Brunswick railroad yard, which is situated 0.6 miles west of Brunswick Station, the terminus of the recently expanded *Downeaster* service.

This assessment evaluates potential noise and vibration impacts due to the introduction of the layover facility for both existing and potential future *Downeaster* service levels. The extended operation of *Downeaster* trains to Brunswick on the mainline tracks, which commenced in November 2012, was previously analyzed and approved by others as part of the *Portland North Expansion Project* (2008),. The passage of *Downeaster* trains on the mainline is considered as part of the ambient noise in the study area.

Both the Federal Railroad Administration[1] (FRA) and Federal Transit Administration[2] (FTA) have published guidance manuals for the assessment of noise and vibration impacts from rail transit projects. This assessment is consistent with the guidance and procedures of both agencies. The operational assumptions and definition of the project have evolved since previous draft assessments were made public. This report presents the most current and accurate noise and vibration impact assessment of the project to date, and thus the results and findings of this report supersede those of all previous draft reports.

The results conclude that the project, as defined, will fully comply with all applicable FRA/FTA criteria so additional noise and vibration mitigation measures will <u>not</u> be required for this project.

2. Noise Fundamentals

Environmental noise is a result of everyday occurrences such as transportation systems, industrial processes, building air handling and power generation systems, wind, human activities, etc. Noise can be quantified in many different manners, depending on its temporal (time), tonal (frequency), or magnitudinal (loudness) characteristics. In general, environmental noise assessment addresses relative changes in noise levels over time and relates those changes with effects on human beings.

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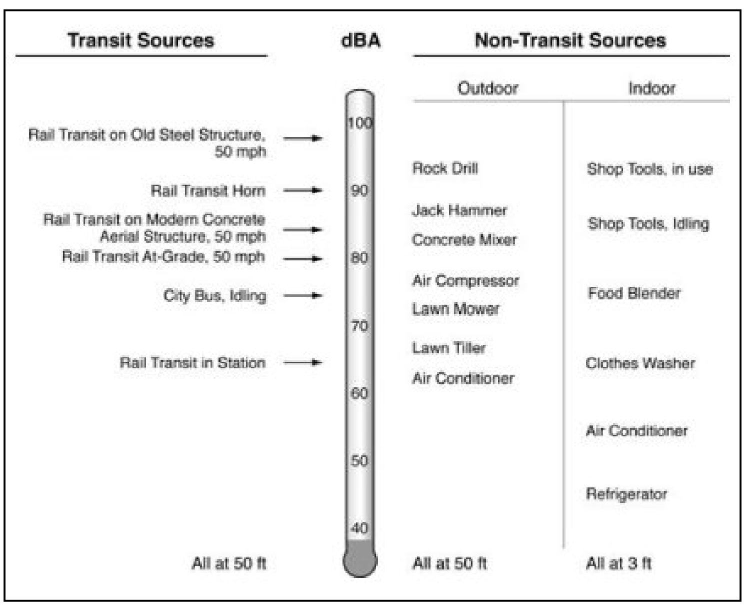
[1] FRA High Speed Ground Transportation Noise and Vibration Impact Assessment, September 2012.
[2] FTA Transit Noise and Vibration Impact Assessment, May 2006.

Noise magnitude is expressed in units of decibels (dB) which is a logarithmic quantity comparing fluctuating air pressure to that of a standardized reference air pressure of 20 micro-pascals (i.e. dB re: 20 µPa). For this reason the noise levels that humans hear are called *sound pressure levels*. Noise is expressed as a logarithmic quantity because humans are sensitive to relative changes in noise levels. To illustrate, humans can just barely perceive a change in noise levels of +/- 3 dB, can easily perceive a change of +/- 5 dB, and will generally perceive a change of +/- 10 dB as a doubling or halving in noise levels.

With respect to tonal qualities (frequency), a frequency weighting adjustment has been standardized to account for human auditory response over the audible frequency range of approximately 20 Hz to 20,000 Hz. Humans respond less sensitively to low frequency noise ranges, exhibiting a maximum sensitivity to tones in mid-frequency ranges, and being somewhat less sensitive at higher frequency ranges. This frequency weighted adjustment is referred to as "A-weighting", with results expressed as A-weighted decibels, or dBA.

The A-weighted noise level is the basic descriptor for environmental noise. Typical A-weighted noise levels are illustrated in Figure 1.

Figure 1: Typical A-weighted Noise Levels



Numerous different indices have been developed to quantify the temporal characteristics (changes over time) of environmental noise. The following noise metrics are used in this assessment:

Leq(h), or Hourly Equivalent Sound Level, is the energy-averaged single noise level that represents the same (equivalent) energy that was contained in the fluctuating noise level over a period of an hour. The Leq(h) is useful for describing the "average" noise level over time, and is expressed in dBA.

Ln, or Percentile Level, is a statistical representation of changing noise levels indicating that over some time period, the fluctuating noise level was equal to, or greater than, the stated level for "n" percent of the time. For example, the L10, L33, L50, and L90 represent the noise levels exceeded 10, 33, 50, and 90 percent of the time. The L10 is often used to identify impacts of transportation or construction noise sources, while the L90 is considered to represent steady ambient background noise levels. Ln percentile levels are expressed in dBA.

Ldn, or Day-Night Sound Level, represents an average noise level evaluated over 24 hours in which a 10 dBA "penalty" is added to the Leq(h) noise level for each of the nine nighttime hours (10 PM to 7 AM). The penalty is applied to account for both increased human sensitivity to nighttime noise intrusions during quiet activities (such as sleeping) and the reduction in ambient noise levels during the nighttime hours which may allow offending noise sources to be more noticeable. The Ldn is expressed in dBA.

Acoustical data can also be described in terms of the amount of sound power that is emitted by a source. *Sound power levels* are also expressed in decibels, however being a measure of power, they are derived relative to a reference level of 1 Pico-Watt (i.e. dB re: 1 pW). Humans do not hear sound power levels; rather they are useful to use in computer modeling of noise levels because they are a property of the source itself and as such are independent of environmental effects or distance. Sound power levels, abbreviated Lw or PWL, can be computed using the A-weighting adjustment to yield a broadband level or in discrete frequency-selective regions known as octave or third-octave bands.

3. Noise Criteria

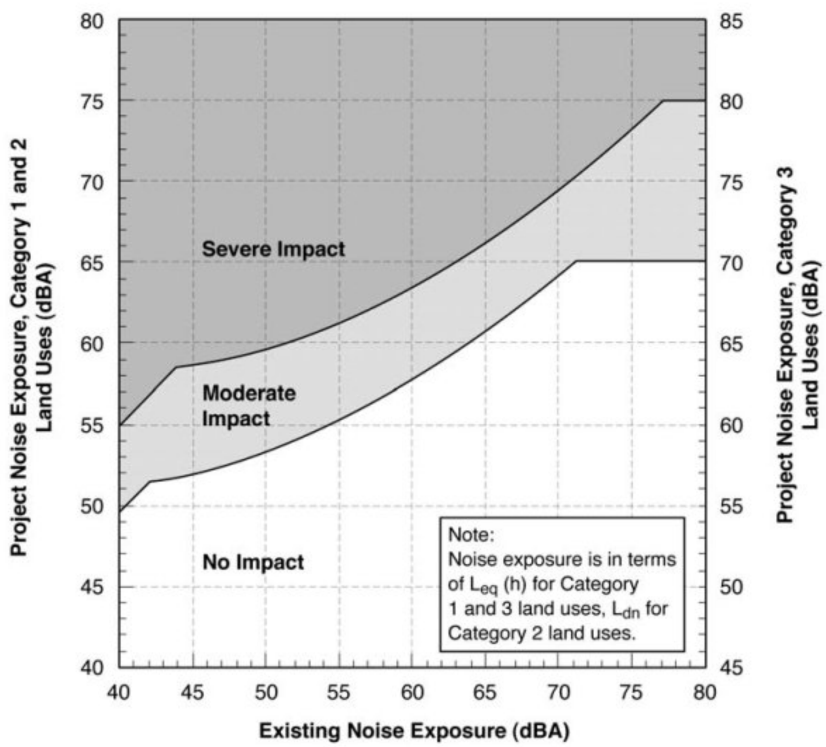
3.1 FRA/FTA

FRA and FTA use the same criteria for assessment of noise impacts from rail projects. The criteria limits incorporate both absolute criteria, which consider activity interference caused by the transit project alone, and relative criteria, which consider annoyance due to the change in the noise environment caused by the project.

Thresholds for two degrees of impact, moderate and severe, are specified. Both thresholds are dependent on the existing noise level and the land-use of the receptor. The noise criterion for *moderate impact* is the threshold at which the percentage of people highly annoyed by the change in cumulative noise level as a result of the project starts to become measurable. The corresponding criterion for *severe impact* is determined by a higher, more significant percentage of people highly annoyed.

FRA/FTA noise impact criteria are typically expressed in the form of *project* noise limits and the impact assessment involves comparing the predicted future noise levels from the project to the appropriate noise impact criteria. The FRA/FTA project noise impact criteria are shown graphically in Figure 2.

Figure 2: FRA/FTA Project Noise Impact Criteria



Noise impact criteria are also dependent on the land-use category of the receptor. Category 1 land-use includes tracts of land where quiet is an essential element in their intended purpose, such as outdoor concert pavilions, recording studios, concert halls, and historical sites with significant outdoor land-use. Category 2 land-use includes residences and buildings where people normally sleep. This category includes homes, hospitals, and hotels where nighttime sensitivity to noise is assumed to be of utmost importance. Category 3 land-use includes institutional land-uses with primarily daytime and evening use, such as medical offices, churches, schools, libraries, and theaters. Places with meditation or study associated with cemeteries, museums, monuments, and recreational facilities are also included in this category. Most general purpose commercial buildings are not included in any category.

The relevant noise metric when evaluating Category 2 receptors is the Ldn, due to the receptor's sensitivity to nighttime noise intrusion. Category 1 and 3 receptors are analyzed using the Leq for the loudest hour of transit-related activity, or Leq(h), during hours of noise sensitivity. All noise levels measured or predicted using the FRA/FTA procedure are expressed in A-weighted decibels (dBA) and are evaluated on the *exterior* of the receptor at a position closest to or facing the project.

3.2 Maine DEP and Brunswick Ordinance

It is important to note that this project is not subject to compliance with either the Maine DEP Noise Regulation or the Town of Brunswick Noise Ordinance per federal laws concerning interstate commerce and primacy of federal regulations relating to railroads. Comparisons of potential noise levels generated by this project relative to these two guidelines have been included in this report; however, these are provided for information only and not for the evaluation of mandatory compliance with regulatory requirements.

Maine Department of Environmental Protection's (Maine DEP) noise regulation can be found in *Regulation 06-096, Chapter 375, Section 10, Control of Noise*. The regulation provides noise criteria limits and definitions for, amongst other things, Routine Operation of Developments. However, railroad equipment (train sets) are explicitly *exempted* per paragraph C.(5)(a).

The Maine DEP regulations also specify that the noise limits contained in a local noise ordinance, if one exists, shall apply. In this case, the *Town of Brunswick Zoning Ordinance* includes *Section 109.4 Noise*. In paragraph A the ordinance states that property line noise levels cannot exceed the following limits:

- For Residential Districts: 55 dBA Leq(h) daytime (6 AM to 8 PM) and 45 dBA Leq(h) nighttime (8 PM to 6 AM).
- For Mixed Use Districts: 60 dBA Leq(h) daytime (6 AM to 8 PM) and 50 dBA Leq(h) nighttime (8 PM to 6 AM).

The *Maine DEP Noise Regulations* specify a different set of criteria. Per paragraph C.(1)(a) the operational noise limits at the property lines of Protected Locations would be:

- At the property line of the layover facility site: 75 dBA Leq(h) for any time of day.
- For residential locations: 60 dBA Leq(h) daytime (7 AM to 7 PM) and 50 dBA Leq(h) nighttime (7 PM to 7 AM).
- For commercial locations: 70 dBA Leq(h) daytime (7 AM to 7 PM) and 60 dBA Leq(h) nighttime (7 PM to 7 AM).

The regulation also describes alternative noise limits for areas of exceptionally quiet or exceptionally loud ambient conditions, but these do not apply in this case. Similarly, the regulation provides for noise limit adjustments for pure tones or short duration impulsive noise, however the conditions required to trigger these adjustments are not expected in this case.

4. Community Receptor Sites

The suburban area in the vicinity of the project has an existing rail line with daily Amtrak *Downeaster* service and occasional freight activities. The neighborhoods surrounding the proposed layover facility site consist of mixed commercial and residential land-uses along Route 1 north of the tracks, and residential dwellings along Bouchard Drive south of the tracks. The Church Road crossing is located to the west, and the Stanwood Street crossing is located to the east of the project site.

Three noise and vibration sensitive receptors were selected for evaluation purposes in this study as shown in Figure 3. The receptors were selected in order to represent the closest noise-sensitive abutters surrounding the proposed project. The receptors' locations, addresses, and further details are summarized in Table 1.

Figure 3. Aerial of Community Receptor Sites

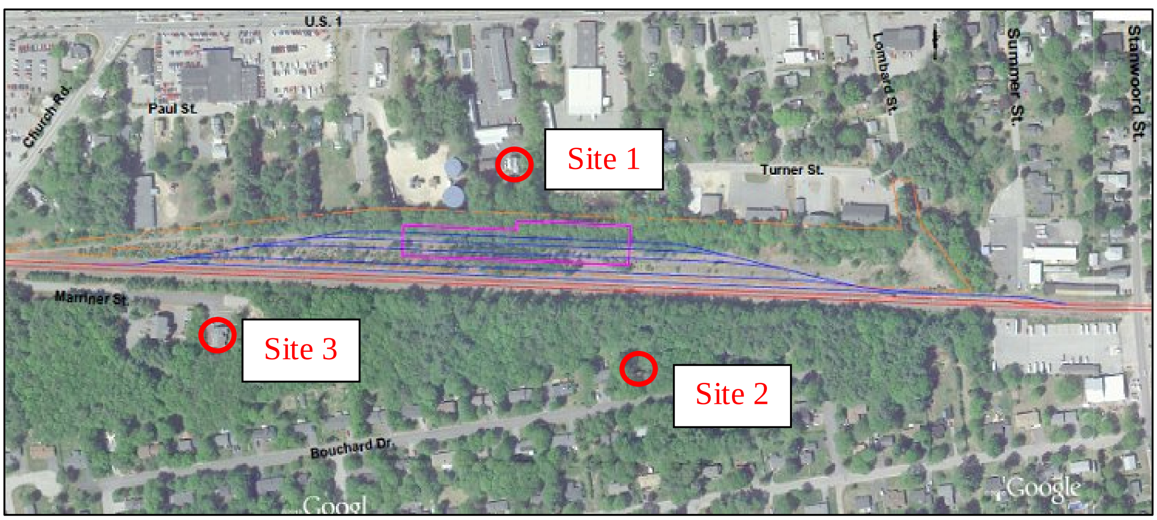


Table 1. Community Receptor Site Details

Site No.	Address	FRA/FTA Land-Use Category	Site Description
1	Knights Inn at 133 Pleasant Street, Apartment H8	2	This residential receptor is located directly north of the proposed layover facility site and is the closest abutter to the project north of the tracks. The Inn has a separate residence, Apt. H8, located behind the Inn's main building.
2	Residence at 22 Bouchard Drive	2	This residential receptor is located southeast of the proposed layover facility site and is the closest residential abutter south of the tracks. This receptor is representative of other residences along Bouchard Drive.
3	Resource Systems Engineering at 30 Parkers Way	2	This receptor is occupied by Resource Systems Engineering (RSE), an acoustical consulting firm, and is located southwest of the proposed layover facility site south of the tracks. The property is zoned for mixed use, so it has been considered to be a potential residential receptor.

5. Existing Ambient Noise Measurements

In order to establish existing noise levels in accordance with FRA/FTA requirements, ambient noise levels were measured at each of the three receptor locations from 2/13/13 to 2/20/13. Details on the noise measurement instrumentation are summarized below in Table 2.

Larson Davis Model 720 (LD 720) Environmental Noise Monitors (ANSI Standard S1.4 Type 2) were deployed at each receptor location by hanging them approximately 10 feet above the ground in trees or on porch structures in close proximity to the subject buildings. The monitors' microphones were protected by 3-inch windscreens. The monitors were programmed to measure and digitally store relevant ambient noise data in hourly intervals such as the Leq, L1, L10, L50, L90, Lmax and Lmin levels in A-weighted decibels (dBA). The response time of the noise monitors was set to RMS 'slow'. The calibration of the monitors was checked before and after use with a Bruel & Kjaer Model 4231 Portable Acoustical Calibrator (ANSI Standard S1.4 Type 1.)

Table 2. Noise Monitoring Instrumentation

Site	Manufacturer	Model	Description	Serial No.
1	Larson Davis	720	Environmental Noise Monitor	0301
2	Larson Davis	720	Environmental Noise Monitor	0303
3	Larson Davis	720	Environmental Noise Monitor	0297
All	Bruel & Kjaer	4231	Acoustic Calibrator	2099917

Typical ambient noise sources noted during the measurements included passing *Downeaster* trains, traffic from Route 1, local traffic, birds, and aircraft overpasses. Monitoring during the winter ensured that insect noise and foliage noise from wind blowing through trees, which could otherwise increase the ambient levels, would not be included in the measurements.

During the monitoring period, meteorological data was collected from the weather station at Wiscasset Airport. Weather conditions were generally fair to overcast with temperatures in the range of 20 – 40°F over the week, but there was also snow, rain, and/or strong winds on several days. Only noise data measured during periods of acceptable meteorological conditions (i.e. no snow, rain, or strong winds) were included in the results. The data was then reduced to average noise levels for each of the 24 hours. The results of the ambient noise measurements can be seen in Figures 4, 5 and 6 for receptor Sites 1, 2 and 3, respectively.

Figure 4. Ambient Noise Monitoring Data from Site 1

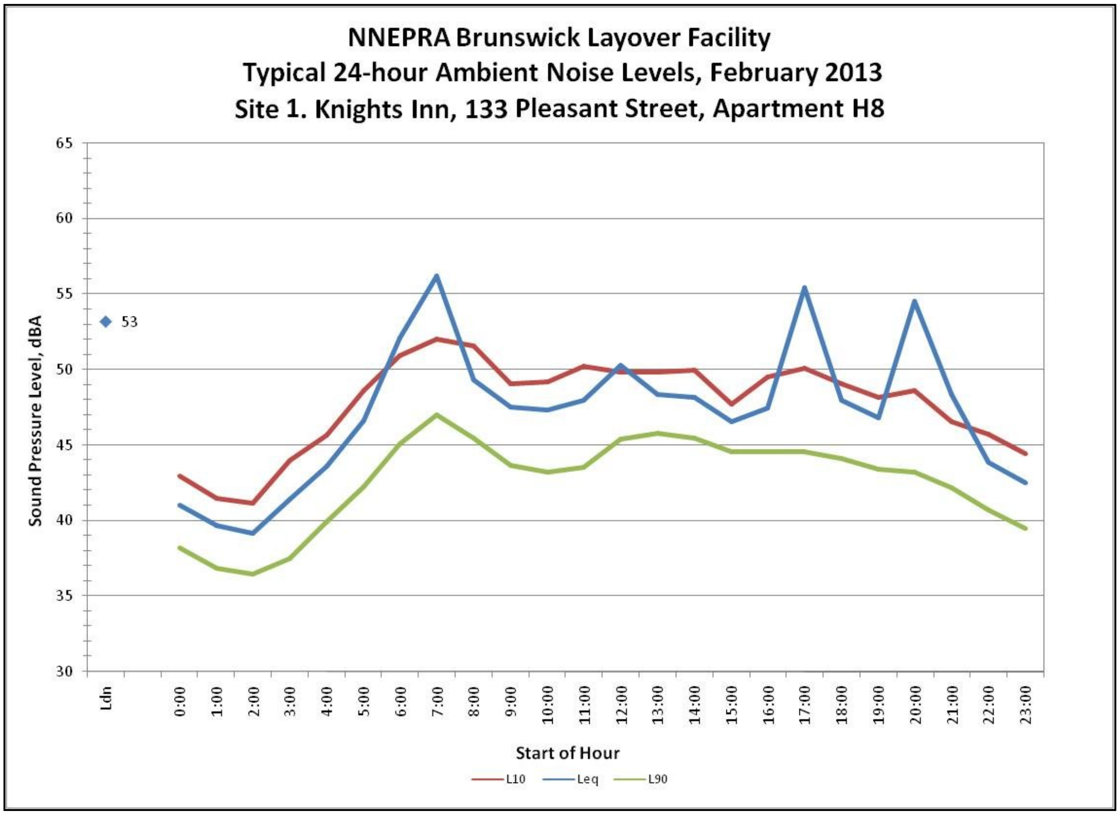


Figure 5. Ambient Noise Monitoring Data from Site 2

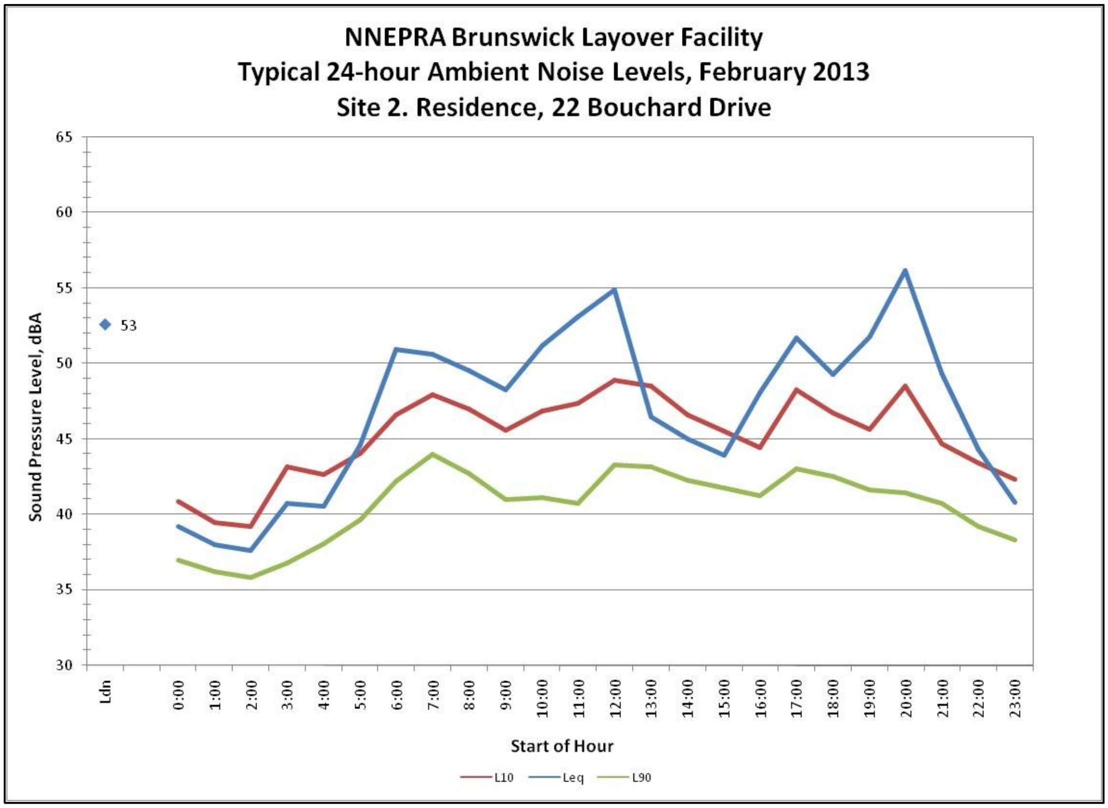
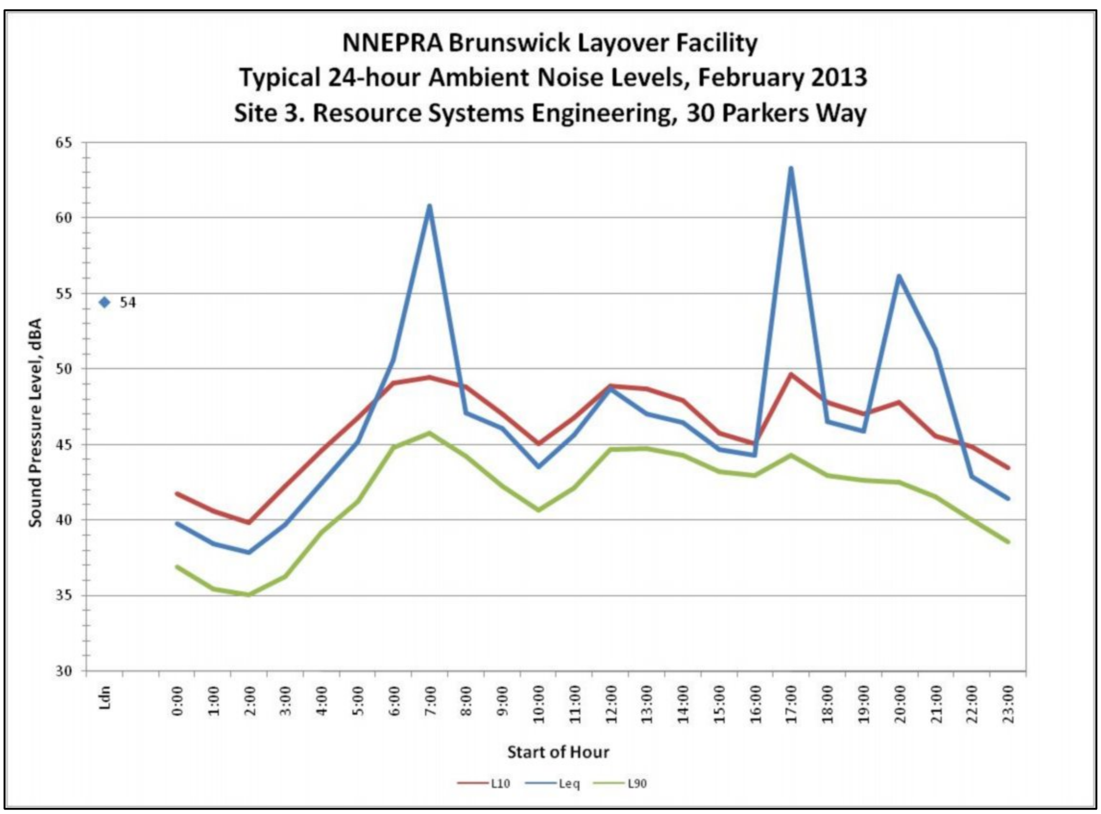


Figure 6. Ambient Noise Monitoring Data from Site 3



While considerable amounts of ambient noise data were collected, the only noise metric of interest in performing a noise assessment in accordance with FRA/FTA guidelines is the Day-Night Sound Level (Ldn) for Category 2 land-use residential receptors. Table 3 summarizes the Ldn noise levels resulting from the ambient noise measurements.

Downeaster service was fully operational during the noise monitoring period, so noise from the existing *Downeaster* service is part of the measured ambient noise levels. The existing *Downeaster* service includes four scheduled *Downeaster* trips and two non-revenue (deadhead) trips between Portland and Brunswick daily. Five of the train trips occur during daytime hours (7 AM to 10 PM) and one occurs during the nighttime period (10 PM to 7 AM), with each passing train sounding its horn at both the Stanwood Street and Church Road at-grade crossings. A typical *Downeaster* train set consists of a diesel-electric locomotive with five railcars.

While a *Downeaster* train may idle in Brunswick yard during the mid-day period, this may not occur on a consistent basis. The noise monitoring data included days where the train both was and was not idling in Brunswick yard. To be conservative, the Ldn noise levels shown in Table 3 intentionally do not include noise from the idling train because higher existing noise levels generally lead to higher noise impact criteria.

Table 3. Measured Ambient Ldn Noise Levels

Site No.	Address	FRA/FTA Land-Use Category	Measured Ambient Noise Level (Ldn, dBA)
1	Knights Inn at 133 Pleasant Street, Apartment H8	2	53
2	Residence at 22 Bouchard Drive	2	53
3	Resource Systems Engineering, 30 Parkers Way	2	54

6. Downeaster Train Set Noise Emission Measurements

Noise emission measurements of Amtrak *Downeaster* train set locomotive No. 157 were made on 2/13/13 while the train was idling in Brunswick yard. Measurements were taken at a distance of 50-feet wayside of the idling locomotive using a CEL 593 noise analyzer which complies with ANSI Standard S1.4 for Type 1 accuracy. The measurements captured steady-state idling locomotive noise as well as intermittent noise from pressure releases and compressor cycles. The results of the measurements are shown in Table 4. This noise emission data was later used to model noise from the train idling inside the proposed layover facility.

Table 4. Measured Noise Emission Level of Idling *Downeaster* Train Set at 50 feet

Broadband Leq Sound Level		Octave Band Leq Sound Level (dB)										
Linear (dB)	A-Weighted (dBA)	16	32	63	125	250	500	1000	2000	4000	8000	16000
92	73	76	83	91	77	69	65	69	62	59	59	60

7. Noise Assessment Approach

The FRA/FTA's "detailed" noise assessment procedure was followed in order to predict noise levels associated with the operation of the proposed layover facility at the three community receptor sites. Noise assessments were completed for two different *Downeaster* service level scenarios: (1) Existing Service Levels, and (2) Future Service Levels.

The Existing Service Levels scenario represents current track usage agreements and capacity constraints, which limit the number of *Downeaster* trains that can operate between Portland and Brunswick to six daily train trips (i.e. three round trips). The *Downeaster* service was operating at this service level when ambient noise measurements were made, so noise from the existing service is accounted for in the measured ambient noise levels.

This assessment intentionally does not evaluate noise or vibration impacts associated with the running of *Downeaster* trains on the mainline tracks, as that project, the *Portland North Expansion Project* (2008), was previously analyzed and approved by others. To assess potential impacts of this project, noise associated with the addition of the proposed layover facility itself was predicted and evaluated relative to appropriate FRA/FTA impact criteria. The Future Service Levels scenario represents the potential for extending all ten scheduled *Downeaster* trips (i.e. five round trips) to operate between Portland and Brunswick. For this to occur, physical track improvements unrelated to this layover facility project would need to be made. Thus, the expansion of the *Downeaster* service to ten daily trips is not part of the proposed action. However, to be conservative and assess potential impacts for the two scenarios in a consistent manner, both layover facility noise as well as noise from the expanded *Downeaster* service traveling through the project area was considered for the Future Service Levels scenario. This approach allows the same impact criteria to be used for both service level scenarios while accounting for all noise sources. To assess potential impacts, the combined noise level from the two activities (increase in *Downeaster* service and the layover facility) was predicted and evaluated relative to appropriate FRA/FTA noise impact criteria.

For each of these scenarios, an associated No-Build scenario is also discussed qualitatively. The No-Build scenario represents future conditions that could potentially occur if this project (the layover facility) is not built.

The noise impact criteria used for the assessments are shown in Table 5. In accordance with FRA/FTA methods, the impact criteria levels were determined by using the chart shown in Figure 2 to identify the thresholds for *moderate* and *severe* impact based on the existing measured ambient noise level and the land-use category of each receptor site.

Table 5. FRA/FTA Receptor Noise Impact Criteria

Site No.	Address	FRA/FTA Land-Use Category	Existing Noise Level (Ldn, dBA)	FRA/FTA Project-Generated Noise Impact Criteria (Ldn, dBA)	
				Moderate	Severe
1	Knights Inn at 133 Pleasant Street, Apartment H8	2	53	54	60
2	Residence at 22 Bouchard Drive	2	53	54	60
3	Resource Systems Engineering, 30 Parkers Way	2	54	55	61

7.1 Noise Modeling

The Cadna-A® noise model, developed by Datakustik GmbH, was used for all noise predictions. In this manner the noise contributions of train movements, staff and service vehicles, and other noise sources such as forklifts, rail switches, train horns, and rooftop ventilation fans could all be included in the same model. The Cadna-A model implements accepted methods for the propagation and prediction of outdoor noise levels in accordance with ISO Standard 9613.

A design file of the proposed layover facility overlaid on a GoogleEarth® base map of the area provided the starting point for the model. The locations of noise sources and community receptors were then added. Because the ground in the area is almost all lawn and/or wooded areas, it was modeled as being acoustically absorptive. However, to be conservative no additional shielding or absorption was assumed for leaf bearing trees.

The Cadna-A model features an FRA/FTA rail noise module that implements standard rail vehicle source emission levels and sound propagation equations in order to facilitate predictions that are consistent with FRA/FTA guidelines. The FRA/FTA's noise prediction model takes into account the number of locomotives and railcars per train set, the number of train passby events per day (7 AM to 10 PM) and night (10 PM to 7 AM), the throttle setting and speed of the trains, the distance the receptors are located from the tracks, and the intervening acoustical ground conditions. The relatively limited number of staff and service vehicles accessing the facility were also included in the model using Cadna-A's TNM module which implements FHWA's standard automotive and truck vehicle noise emission levels and propagation equations.

For other noise sources associated with the facility, the sources were modeled by inputting their respective sound power emission levels in octave band format and assembling point-, line-, or area-source components as appropriate. Sources that would be operating inside the layover facility were modeled assuming the building shell (exterior walls and roof) were made of material with a composite sound transmission class (STC) of 21.

Noise sources assumed to be operating *inside* the layover facility included small forklift type vehicles, use of hand tools with air compressors, up to three idling trains, and brief safety testing of train horns (toots) prior to departure from the building. Physical structures, such as the proposed layover facility itself, were also entered in the Cadna-A model in their three-dimensional sizes to account for the propagation of sound around and over such obstacles. Noise sources *outside* the layover facility included up to four roof top fans for ventilation, rolling service doors, employee and delivery truck vehicles, trains moving slowly (10 mph) in/out of the building, rail switch noise as trains roll over them, and train horn soundings at Church Road and Stanwood Street, as applicable. Detailed printouts of the Cadna-A model's input data tables and results tables are included in Appendix A.

8. Existing Service Levels Noise Assessment

The first noise analysis scenario assesses noise from the layover facility with existing *Downeaster* service levels, i.e. the three round trip scenario.

8.1 No-Build Scenario

Without a layover facility, the No-Build scenario would include the existing *Downeaster* service levels along with a single train idling in Brunswick yard from approximately 12:00 noon to 5:00 PM daily. The train set would return to Brunswick yard after unloading passengers at Brunswick Station and remain in the yard until the next southbound trip. The locomotive will need to idle to prevent freezing during colder months of the year.

The noise emission levels of the idling *Downeaster* train set were measured and are presented in Sections 4. Ambient noise measurements performed in February 2013 as described in Section 5 included days when the *Downeaster* was, and was not, idling in the Brunswick yard. A comparison of the two conditions revealed that noise levels at the three receptor locations were elevated by an average of 2 to 7 dBA while the train was idling in Brunswick yard. Not surprisingly, discussions with affected neighbors revealed their dislike of the noise when the *Downeaster* train set was idling outdoors. However, it should be noted that the same service level scenario with a layover facility would allow the train to move indoors year-round and remain shut down while inside the facility, thus providing a substantial degree of noise reduction for the affected community by rendering the idling trains essentially inaudible.

8.2 Project-Generated Noise Assumptions

The layover facility is expected to generate minimal sound of its own. No heavy equipment, major maintenance, or cleaning activities will be conducted at the facility. The trains and any light housecleaning equipment will be housed inside the facility building. It is assumed that two forklifts, two air compressors, and up to two pneumatic tools may be used inside the facility for a couple hours per day. At most, 70 staff and 8 service vehicles (trucks) may visit the facility in a single day. Parking will be located on the north side of the building with access from Church Road.

The assumptions for project-generated noise sources in accordance with FRA/FTA requirements are summarized below in Table 6. To compare predictions with the Maine

DEP and Town of Brunswick noise limits, both of which use the hourly equivalent sound level (Leq(h)) noise metric, the operations that would occur during a potential worst-case hour were identified. These assumptions are also included in Table 6.

Downeaster train sets will make six daily trips between Brunswick Station and the facility. All trains will enter and exit on the *east side* of the facility, so the project will cause no additional horn blows at the Church Road crossing. All trains will be traveling at 10 mph within Brunswick yard. Four train movements between Brunswick station and the facility will occur during the daytime (7 AM to 10 PM) and two will occur at night (10 PM to 7 AM), each with an associated horn sounding at the Stanwood Street crossing.

Up to three trains at a time may be housed inside the layover facility. They will remain shut-off during the night and then be powered up to allow for about a half-hour warm up period in the mornings. Train horns will then be tested briefly with a "short toot" inside the facility before exiting. The facility's walls have been specified to provide for a sound transmission class of at least STC 21. The building's roll-up doors will remain closed except to allow trains to enter and exit.

It is assumed that four rooftop mounted ventilation fans will be required to provide adequate airflow inside the facility building. It has been specified that these rooftop fans be of the low-noise emission variety, which are typically about 10 decibels quieter than standard fans.

Table 6. Project-Generated Noise Assumptions – Existing Service Levels

Source		Daytime (7 AM - 10 PM)	Nighttime (10 PM - 7 AM)	Worst Hour*
EXTERIOR	Downeaster train passbys at 30 mph	0	0	0
	Horn blows at Church Rd. crossing	0	0	0
	Horn blows at Stanwood St. crossing	4	2	1
	Trains entering or exiting Brunswick yard from Brunswick Station at 10 mph	4	2	1
	No. of rail switch events in Brunswick yard	8	4	2
	No. of fans operating continuously on roof of layover facility	4	4	4
	No. of automobiles entering or exiting layover facility	50	20	5
	No. of trucks entering or exiting layover facility	6	2	1
INTERIOR	Duration of trains idling inside layover facility (min)	70	30	30
	No. of train horn soundings inside layover facility	2	1	1
	Duration of 2 forklifts operating inside layover facility (min)	120	60	60
	Duration of 2 air impact tools operating inside layover facility (min)	60	60	60
	Duration of 2 air compressors operating inside layover facility (min)	60	60	60
	Duration of rolling service doors operating (min)	10	5	5

* Worst-hour assumptions are for comparison relative to Maine DEP and Brunswick Ordinance criteria. Assumptions only include project-generated noise associated with the introduction of the layover facility.

8.3 FRA/FTA Noise Predictions and Impact Assessment

Table 7 summarizes the predicted noise levels and noise impact assessment for Existing *Downeaster* Service Levels relative to FRA/FTA criteria. The predictions are also shown graphically in Figure 7.

The predicted project-generated noise level at Site 1 is 49 dBA Ldn where the FRA/FTA noise limits are 54 and 60 dBA Ldn for moderate and severe impact, respectively. Similarly, the project is expected to generate a noise level of 48 dBA Ldn at Site 2 where the FRA/FTA noise limits are also 54 and 60 dBA Ldn for moderate and severe impact, respectively. And due to its farther distance from trains moving in the yard, the predicted project-generated noise level at Site 3 is expected to be only 43 dBA Ldn, well below its FRA/FTA noise limits of 55 dBA Ldn and 61 dBA Ldn for moderate and severe impact, respectively.

The results show that project-generated noise levels are not predicted to exceed FRA/FTA noise criteria limits at any receptor site. The predicted noise levels are highest at Sites 1 and 2, which is primarily a result of train movements in Brunswick yard. Nevertheless, the predicted project noise levels are still five decibels or more below the threshold for moderate impact at all receptor sites.

8.4 Maine DEP and Brunswick Ordinance Noise Predictions

Table 8 compares the predicted project noise levels for Existing *Downeaster* Service relative to Maine DEP and Town of Brunswick Ordinance noise limits. The predictions are also shown graphically in Figure 8. Worst hour Leq(h) noise levels were calculated at both the facade and at the property lines for each receptor site.

It is important to note again that this project is not subject to compliance with either the Maine DEP Noise Regulation or the Town of Brunswick Noise Ordinance. Comparisons relative to these two guidelines have been included for information only and not for the evaluation of mandatory compliance with regulatory requirements.

As can be seen, project noise levels are predicted to comply with Maine DEP noise limits at all receptor sites during the daytime and at Sites 1 and 3 during the nighttime. The predicted noise levels exceed the Maine DEP nighttime limits at the property line of Site 2 by three decibels.

Project noise levels are predicted to comply with Brunswick Ordinance noise limits at all receptor sites during the daytime and at Site 1 during the nighttime. Project noise levels are predicted to exceed the nighttime noise limits at Sites 1 and 2. The nighttime exceedance at the Site 1 property line is primarily due to its close proximity to the layover facility facade. The predicted project-generated noise level at the Site 1 property line is 57 dBA Leq(h), which exceeds the Brunswick ordinance limit by seven decibels. A nighttime exceedance is not expected at the Site 2 receptor facade.

The nighttime noise exceedance at Site 2 is primarily due to a single train movement in Brunswick yard. The predicted project-generated noise level at the Site 2 receptor facade is 48 dBA Leq(h), which exceeds the Brunswick ordinance limit by three decibels. The predicted noise level at the receptor's property line is 53 dBA Leq(h), which would exceed the guideline by eight decibels.

However, it should be noted that people would generally not be using the property line location in the middle of the night, so these predicted exceedances need to be viewed in that context. The ambient noise measurements shown in Figures 4 – 6 also illustrate that existing noise levels during several nighttime hours are already higher than the worst-case noise levels the project is expected to generate.

Table 7. Summary of Predicted Noise Levels and FRA/FTA Impact Assessment for Existing Service Levels

			Measured Ambient Noise Level	FRA/FTA Project Noise Impact Criteria		Predicted Project Noise Level	Compliance or Exceedance
				Moderate	Severe		
Site No.	Receptor Address	Land-Use	Ldn, dBA	Ldn, dBA	Ldn, dBA	Ldn, dBA	
1	Knights Inn, 133 Pleasant Street, Apt. H8	Category 2	53	54	60	49	Complies
2	Residence, 22 Bouchard Drive	Category 2	53	54	60	48	Complies
3	Resource Systems Eng., 30 Parkers Way	Category 2	54	55	61	43	Complies

Table 8. Summary of Predicted Noise Levels and Maine DEP/Brunswick Ordinance Limits for Existing Service Levels

			Applicable Noise Criteria					Compliance or Exceedance
			Maine DEP		Brunswick Ordinance		Project Noise Level	
Site No.	Receptor Address	Land-Use	Daytime	Nighttime	Daytime	Nighttime	Leq(h), dBA	
1	Knights Inn, 133 Pleasant Street, Apt. H8	Mixed	70	60	60	50	50	Complies
1	Site 1 Property Line	Mixed	70	60	60	50	57	Exceeds Nighttime
2	Residence, 22 Bouchard Drive	Residential	60	50	55	45	48	Exceeds Nighttime
2	Site 2 Property Line	Residential	60	50	55	45	53	Exceeds Nighttime
3	Resource Systems Eng., 30 Parkers Way	Mixed	70	60	60	50	42	Complies
3	Site 3 Property Line	Mixed	70	60	60	50	45	Complies

Figure 7. Predicted Project Ldn Noise Levels – Existing Service Levels

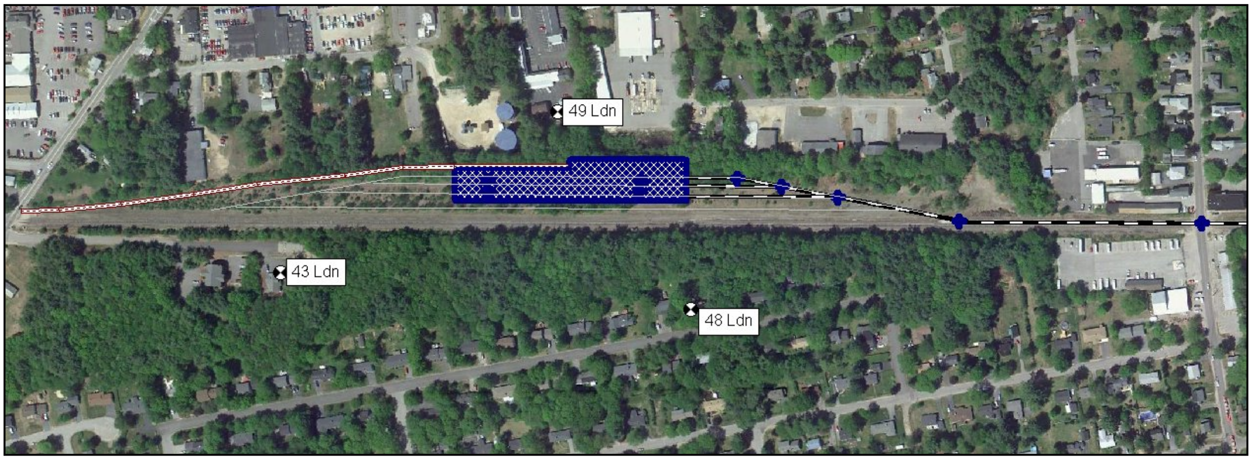
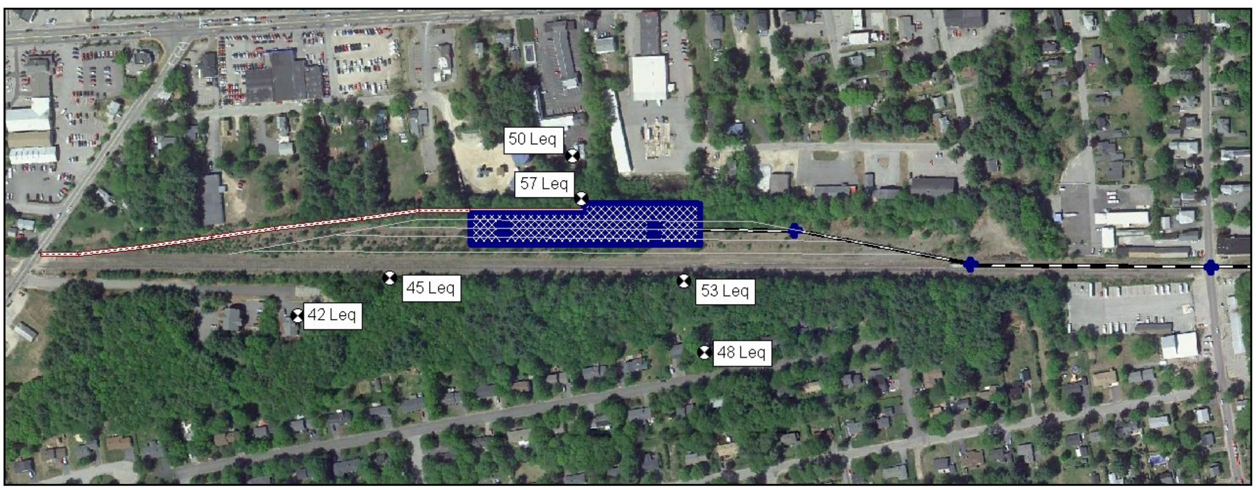


Figure 8. Predicted Project Worst-Hour Leq(h) Noise Levels – Existing Service Levels



9. Future Service Levels Noise Assessment

The second noise analysis scenario assesses noise from the layover facility with future Downeaster service levels, i.e. the five round trip scenario.

9.1 No-Build Scenario

Without a layover facility, the No-Build scenario with future *Downeaster* service levels would include sixteen daily *Downeaster* trips between Portland and Brunswick. Eleven of these trips would occur during the daytime and five would occur at night. Each passing train would be traveling at full speed and sound its horn at both the Stanwood Street and Church Road at-grade crossings. Ten of these trips (8 day, 2 night) would be scheduled *Downeaster* service, while the remaining six trips (3 day, 3 night) would be non-revenue (deadhead) trips. The deadhead trips would be necessary so that trains could layover in Portland at night and return to Brunswick in the morning to begin the trip south towards Boston.

By comparison, building the layover facility would eliminate the need for all six of the deadhead trips, as trains would be stored in Brunswick overnight. Six horn soundings at the Church Road crossing also would not occur if the layover facility were built.

9.2 Project-Generated Noise Assumptions

The project-generated noise assumptions for the Future Service Levels scenario are shown in Table 9. The assumptions include noise associated with the expanded *Downeaster* service, the layover facility itself, and any trains accessing it. As discussed in Section 7, while expansion of *Downeaster* service is not a part of the proposed action, noise associated with the expanded service has been included in the project-generated noise predictions to be conservative and allow for direct comparison to the existing service levels scenario.

The Future Service Levels scenario assumes ten daily *Downeaster* trips between Portland and Brunswick. A typical *Downeaster* train set consists of a diesel-electric locomotive with five railcars. Eight of the train trips will occur during daytime hours and two will occur during the nighttime period with trains assumed to be traveling at 30 mph. Each passing train will sound its horn at both the Stanwood Street and Church Road at-grade crossings.

Noise from the existing *Downeaster* service (6 daily trips) is already accounted for in the ambient noise measurements and factored into the noise impact criteria. The *increase* in operations associated with further expanding the *Downeaster* service to 10 daily trips would be three daytime passbys and one nighttime passby, each with an associated horn sounding at the Stanwood Street and Church Road at-grade crossings.

Downeaster train sets will make ten trips between Brunswick Station and the facility daily. Seven trips will occur during the daytime (7 AM to 10 PM) and three will occur at night (10 PM to 7 AM), each with an associated horn sounding at the Stanwood Street crossing. All trains will enter and exit on the east side of the facility and travel at 10 mph within Brunswick yard.

The layover facility is expected to generate minimal sound of its own. No heavy equipment, major maintenance, or cleaning activities will be conducted at the facility. The trains and any light housecleaning equipment will be housed inside the facility building. It is assumed that two forklifts, two air compressors, and up to two pneumatic tools may be used inside the facility for a couple hours per day. At most, 70 staff and 8 service vehicles (trucks) may visit the facility in a single day. Parking will be located on the north side of the building with access from Church Road.

Up to three trains at a time may be housed inside the layover facility. They will remain shut-off during the night and then be powered up to allow for about a half-hour warm up period in the mornings. Train horns will then be tested briefly with a "short toot" inside the facility before exiting. The facility's walls have been specified to provide for a sound transmission class of at least STC 21. The building's roll-up doors will remain closed except to allow trains to enter and exit.

It is assumed that four rooftop mounted ventilation fans will be required to provide adequate airflow inside the facility building. It has been specified that these rooftop fans be of the low-noise emission variety, which are typically about 10 decibels quieter than standard fans.

To evaluate compliance with the Maine DEP and Town of Brunswick noise limits, both of which use the hourly equivalent sound level (Leq(h)) noise metric, the operations that would occur during a potential worst-case hour were identified. To be consistent with the regulations, only noise associated with the introduction of the layover facility was predicted. These assumptions are also listed in Table 9.

Table 9. Project-Generated Noise Assumptions – Future Service Levels

	Source	Daytime (7 AM - 10 PM)	Nighttime (10 PM - 7 AM)	Worst Hour*
EXTERIOR	Downeaster train passbys at 30 mph	3	1	0
	Horn blows at Church Rd. crossing	3	1	0
	Horn blows at Stanwood St. crossing	10	4	1
	Trains entering or exiting Brunswick yard from Brunswick Station at 10 mph	7	3	1
	No. of rail switch events in Brunswick yard	14	6	2
	No. of fans operating continuously on roof of layover facility	4	4	4
	No. of automobiles entering or exiting layover facility	50	20	5
	No. of trucks entering or exiting layover facility	6	2	1
INTERIOR	Duration of trains idling inside layover facility (min)	70	120	30
	No. of train horn soundings (1 sec duration) inside layover facility	1	2	1
	Duration of 2 forklifts operating inside layover facility (min)	120	60	60
	Duration of 2 air impact tools operating inside layover facility (min)	60	60	60
	Duration of 2 air compressors operating inside layover facility (min)	60	60	60
	Duration of rolling service doors operating (min)	10	5	5

9.3 FRA/FTA Noise Predictions and Impact Assessment

Table 10 summarizes the predicted noise levels and noise impact assessment for future *Downeaster* service levels relative to FRA/FTA criteria. The predictions are also shown graphically in Figure 9.

* Worst-hour assumptions are for comparison relative to Maine DEP and Brunswick Ordinance criteria. Assumptions only include project-generated noise associated with the introduction of the layover facility.

The predicted project-generated noise level is 51 dBA Ldn at Site 1 where the FRA/FTA noise limits are 54 and 60 dBA Ldn for moderate and severe impact, respectively. Similarly, the project-generated noise level is expected to be 51 dBA Ldn at Site 2 where the FRA/FTA noise limits are also 54 and 60 dBA Ldn for moderate and severe impact, respectively. The predicted project-generated noise level at Site 3 is expected to be 50 dBA Ldn where the FRA/FTA noise limits are 55 and 61 dBA Ldn for moderate and severe impact, respectively.

The results show that project-generated noise levels are not predicted to exceed FRA/FTA noise criteria limits at any receptor site. The predicted noise levels are highest at Sites 1 and 2, which is primarily a result of train movements in Brunswick yard. Nevertheless, the predicted noise levels are still three decibels or more below the threshold for moderate impact at all receptor sites.

9.4 Maine DEP and Brunswick Ordinance Noise Predictions

Table 11 compares the predicted project noise levels for Future *Downeaster* Service relative to Maine DEP and Brunswick Ordinance noise limits. The predictions are also shown graphically in Figure 10. Worst hour Leq(h) noise levels were calculated at both the facade and at the property lines for each receptor site.

It is important to note again that this project is not subject to compliance with either the Maine DEP Noise Regulation or the Brunswick Noise Ordinance. Comparisons relative to these two guidelines have been included for information only and not for the evaluation of mandatory compliance with regulatory requirements.

As can be seen, project noise levels are predicted to comply with Maine DEP noise limits at all receptor sites during the daytime and at Sites 1 and 3 during the nighttime. The predicted noise levels exceed the Maine DEP nighttime limits at the property line of Site 2 by three decibels.

Project noise levels are predicted to comply with Brunswick Ordinance noise limits at all receptor sites during the daytime and at Site 1 during the nighttime. Project noise levels are predicted to exceed the nighttime noise limits at Sites 1 and 2. The nighttime exceedance at the Site 1 property line is primarily due to its close proximity to the layover facility facade. The predicted project-generated noise level at the Site 1 property line is 57 dBA Leq(h), which exceeds the Brunswick ordinance limit by seven decibels. A nighttime exceedance is not expected at the Site 2 receptor façade.

The nighttime noise exceedance at Site 2 is primarily due to a single train movement in Brunswick yard. The predicted project-generated noise level at the Site 2 receptor facade is 48 dBA Leq(h), which exceeds the Brunswick ordinance limit by three decibels. The predicted noise level at the receptor's property line is 53 dBA Leq(h), which would exceed the guideline by eight decibels.

However, it should be noted that people would generally not be using the property line location in the middle of the night, so these predicted exceedances need to be viewed in that context. The ambient noise measurements previously shown in Figures 4, 5 and 6 also illustrate that existing noise levels during several nighttime hours are already higher than the worst-case noise levels the project is expected to generate.

Table 10. Summary of Predicted Noise Levels and FRA/FTA Impact Assessment for Future Service Levels

			Measured Ambient Noise Level	FRA/FTA Project Noise Impact Criteria		Predicted Project Noise Level	Compliance or Exceedance
				Moderate	Severe		
Site No.	Receptor Address	Land-Use	Ldn, dBA	Ldn, dBA	Ldn, dBA	Ldn, dBA	
1	Knights Inn, 133 Pleasant Street, Apt. H8	Category 2	53	54	60	51	Complies
2	Residence, 22 Bouchard Drive	Category 2	53	54	60	51	Complies
3	Resource Systems Eng., 30 Parkers Way	Category 2	54	55	61	50	Complies

Table 11. Summary of Predicted Noise Levels and Maine DEP/Brunswick Ordinance Limits for Future Service Levels

			Applicable Noise Criteria					Compliance or Exceedance
			Maine DEP		Brunswick Ordinance		Project Noise Level	
Site No.	Receptor Address	Land-Use	Daytime	Nighttime	Daytime	Nighttime	Leq(h), dBA	
1	Knights Inn, 133 Pleasant Street, Apt. H8	Mixed	70	60	60	50	50	Complies
1	Site 1 Property Line	Mixed	70	60	60	50	57	Exceeds Nighttime
2	Residence, 22 Bouchard Drive	Residential	60	50	55	45	48	Exceeds Nighttime
2	Site 2 Property Line	Residential	60	50	55	45	53	Exceeds Nighttime
3	Resource Systems Eng., 30 Parkers Way	Mixed	70	60	60	50	42	Complies
3	Site 3 Property Line	Mixed	70	60	60	50	45	Complies

Figure 9. Predicted Project-Generated Ldn Noise Levels – Future Service Levels

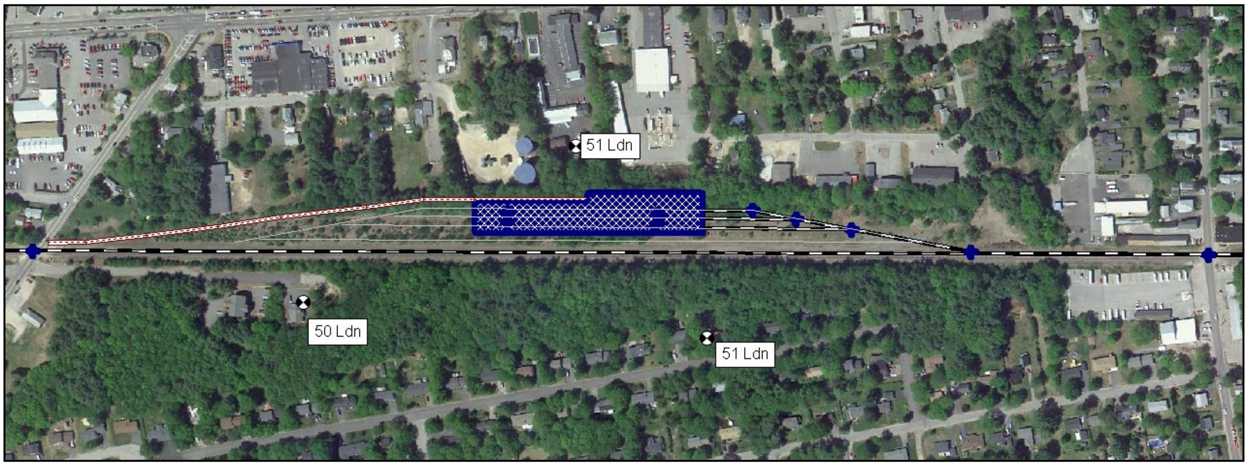
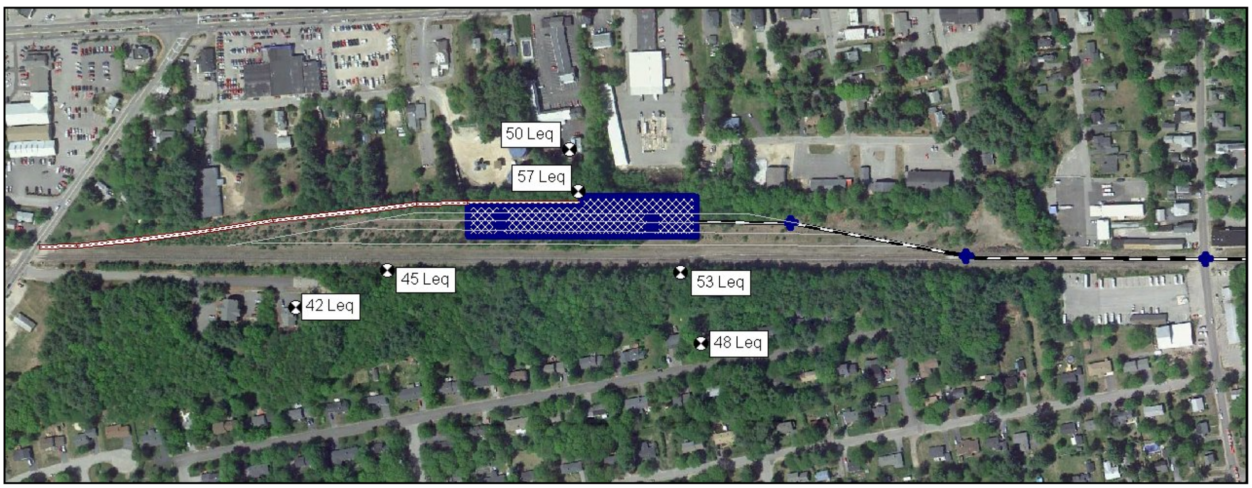


Figure 10. Predicted Project Worst-Hour Leq(h) Noise Levels – Future Service Levels



10. Train Horn Noise

Horns are a necessary and proven-effective warning device used on trains of all types in service in the United States. For *Downeaster* trains, Amtrak uses a Nathan 5 Air Chime K5LA horn mounted on the top middle of the locomotive. All five "bells" face forward and produce a B major 6th chord (220 to 554 Hertz) measuring 104 dBA at a reference distance of 100 feet. The K5LA five-chime assembly's musical chord helps the horn to be heard and lessens complaints. However, to serve its intended purpose the horn must be loud relative to its surrounding background noise condition.

The use and loudness of train horns are dictated in the United States by 49 CFR Parts 222 and 229, as administered by the FRA. Train horns must produce a minimum of 96 dBA at a distance of 100 feet, but should not exceed 110 dBA at 100 feet. Train horns are required to be sounded ¼ mile ahead of a street crossing as the train is approaching. The approach distance can be even greater if the train is moving at higher speeds. The warning should consist of two-long – one-short – one-long horn blows. The horn is also used at the engineer's discretion and judgment in the event of pedestrians, vehicles or obstacles on the tracks.

Of particular significance to this project, per FRA regulations the horn does <u>not</u> need to sound as the train moves around the yard or in and out of the layover facility to merge with the mainline track. Thus, the only location associated with this project where trains would need to sound their horn would be at the Stanwood Street crossing as trains move to and from Brunswick Station and the layover facility.

Train horn noise was assessed for this project in the same manner as other facility and rail noise sources through use of the Cadna-A model. The model's FRA/FTA module has train horn noise emissions in its database. Horn soundings at Stanwood Street and Church Road were included as point sources in the model; however, there are no train horn soundings expected at Church Road attributable to this project. The noise prediction results, as shown in Tables 7 and 10 for the Existing and Future *Downeaster* Service Levels scenarios, respectively, confirm that compliance with FRA/FTA noise limits is easily demonstrated even with the effects of trains horns included in the predicted levels.

10.1 Horn Noise Mitigation

If reduction of from train horn noise were to be desired then noise barriers are generally not feasible at street crossings due to driver visibility. Residential soundproofing only addresses interior noise levels and is also fraught with issues involving access and liability on private property. Therefore, the only horn noise mitigation measure approved by FRA/FTA would be the establishment of a *Quiet Zone*.

By adopting approved Supplemental Safety Measures (SSM) at each public grade crossing, a Quiet Zone of at least a half-mile long can be established. These measures are in addition to the standard safety devices required at most public grade crossings (e.g. stop signs, reflective cross bucks, flashing lights with gates that do not completely block travel over the tracks). Below are six SSM's which have been predetermined by the FRA to fully or in tandem compensate for the lack of a locomotive horn:

- *Reconstruct the street crossing into an under-over pass.* This measure, while expensive, would completely eliminate the need for a train to sound its horn.

- *Temporary closure of a public highway-rail grade crossing.* This measure requires closure of the grade crossing one period for each 24 hours, and must be closed the same time each day.

- *Four-quadrant gate system.* This measure involves the installation of at least one gate for each direction of traffic to fully block vehicles from entering the crossing.

- *Gates with medians or channelization devices.* This measure keeps traffic in the proper travel lanes as it approaches the crossing. This denies the driver the option of circumventing the gates by traveling in the opposing lane.

- *One-way street with gates.* This measure consists of one-way streets with gates installed so that all approaching travel lanes are completely blocked.

- *Pole-mounted wayside warning horns.* This measure places warning horns on signal poles directly at the street crossing in question. The wayside horns are still relatively loud (92 dBA at 100 feet) but can be effectively aimed directly down the affected street to minimize disturbance to adjacent neighborhoods.

The lead agency in designating a Quiet Zone is the local public authority responsible for traffic control and law enforcement on the roads crossing the tracks. In order to satisfy the FRA regulatory requirements, the public transit agency must work closely with the highway/traffic agency while also coordinating with any freight or passenger railroad operator sharing the right-of-way.

Renovating a street crossing in accordance with the SSM's above can be expensive. It could easily cost $250,000 per crossing to complete all the necessary modifications to keep the street crossing at grade, and reconstructing the crossing into an under-over pass would cost millions of dollars.

11. Vibration Assessment

11.1 Vibration Fundamentals

Environmental vibration can be generated by transportation systems such as trains, subways, trucks, automobiles; construction activities such as heavy earth moving equipment, blasting, pile driving; power generation or other large mechanical systems; or by actual seismic motion. While vibratory motion can be generated in all directions, only the vertical component is addressed in environmental studies. Vertical vibration typically contains more energy than either the longitudinal or latitudinal directions.

Due to human perception of vibration, ease of quantifiable measurement, and predictability within the low frequencies of interest (1 Hz to 100 Hz), *vibration velocity* has been standardized as the metric for evaluating environmental vibration impacts. As such, vibration results can be expressed in linear units of inches per second. However, due to the very large velocity range over which vibration energy can be found (.0001 to 1.0 inch/sec), a more convenient decibel scale has also been adopted. The Vibration Velocity Level, or VdB, expressed in decibels relative to 1 micro-inch/sec, allows for the compression of this large velocity range into a more practical scale of about 40 to 120 VdB.

According to FRA/FTA guidelines, the frequency range over which to examine human annoyance from vibration ranges from about 1 Hz to 100 Hz. The broadband VdB level is typically summed over this frequency range. However, the frequency spectrum range over which vibration levels are measured can be filtered to examine the amount of vibration energy within a finite bandwidth. Octave band and third-octave band filters serve this purpose.

Vibration magnitude can be described using various quantities depending on the intent of the analysis and type of sensitive receptor being evaluated. In accordance with FRA/FTA procedures, all vibration measurements and predictions in this study are in the form of energy-averaged *Root Mean Square (RMS)* levels. RMS represents a mathematically averaged level which is more proportional to the energy-of-motion generated by a vibrating surface. The RMS vibration velocity level has been shown to correlate better with the human body's sensitivity to vibration when computed with a one-second response time (i.e. RMS ‘slow’). Train passby vibration events are typically expressed in VdB levels using the *maximum* RMS levels within each frequency band in order to evaluate worst-case potential consequences.

A related vibration metric would be the *Peak Particle Velocity (PPV)* which is a measure of the vibration signal’s absolute highest instantaneous magnitude. Being a measure of vibration velocity, the PPV is also expressed in linear units of inches/second. Human annoyance is generally not a function of instantaneous PPV levels, however potential damage to buildings and structures can be, so an analysis of PPV levels is only used to assess potential cosmetic or major damages to structures. For example, PPV levels are used to describe potential building damages from impact sources such as construction.

11.2 Vibration Criteria

As shown in Figure 11, FRA/FTA’s vibration criteria are intended to avoid human annoyance and are based on root-mean-squared (RMS) vertical vibration velocity levels expressed in decibel units of VdB relative to one micro-inch per second (VdB re: 1 micro-inch/second). The vibration criteria limits are absolute levels, not relative increases above existing conditions, and thus do not require ambient vibration levels to be established.

The FRA/FTA’s vibration limits vary based on a receptor’s categorized land-use and frequency of vibration events (i.e. train passbys). Residential receptors are considered as Category 2 receptors, while institutional land-uses are placed in Category 3. Most general purpose commercial buildings are not included in any category. "Frequent" events are defined as more than 70 vibration events per day, “Occasional” events range from 30 to 70 per day, and "Infrequent" events are defined as fewer than 30 per day. Most commuter and inter-city rail systems fall into this latter category.

In addition, vibration criteria for special buildings such as concert halls, TV and recording studios, auditoriums and theaters have been established, as have criteria limits for ground-borne vibration-induced interior noise levels, although these criteria are only applied in special cases involving particularly sensitive receptors and are not expected in the current study.

For the current project, the three receptors were considered to be Category 2 or Category 3 receptors, as appropriate, exposed to “infrequent” events (i.e. less than 30 per day). This will be the case for the both the Existing and Future *Downeaster* Service Levels scenarios being evaluated in this study.

Therefore, based on the relatively limited number of future vibration events per day associated with the subject layover facility, the vibration impact limits for this project per FRA/FTA's criteria approach are shown in Table 12 for the three receptor locations.

Figure 11. FRA/FTA Criteria for Ground-Borne Vibration Impact

Land Use Category	GBV Impact Levels (VdB re 1 micro-inch /sec)			GBN Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[1]	**Occasional Events[2]**	**Infrequent Events[3]**	**Frequent Events[1]**	**Occasional Events[2]**	**Infrequent Events[3]**
Category 1: Buildings where vibration would interfere with interior operations.	65 VdB[4]	65 VdB[4]	65 VdB[4]	N/A[4]	N/A[4]	N/A[4]
Category 2: Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

Notes:

1. "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.
2. "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.
3. "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.
4. This criterion limit is based on levels that are acceptable for most moderately sensitive equipment such as optical microscopes. Vibration-sensitive manufacturing or research will require detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the HVAC systems and stiffened floors.
5. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

Table 12. FRA/FTA Criteria Limits for Vibration Impact

Site No.	Receptor Address	Land-Use (FRA/FTA Category)	Vibration Velocity Limit for Infrequent Events (VdB)
1	Knights Inn, Apt. H8, 133 Pleasant Street	Residential (Category 2)	80
2	Residence, 22 Bouchard Drive	Residential (Category 2)	80
3	Commercial Business, 30 Parkers Way	Commercial (Category 3)	83

11.3 Ambient Vibration Measurements

Even though ambient vibration measurements are not required in accordance with FRA/FTA procedures, ambient vibration levels were measured in September 2011 with no train activity, and again in February 2013 to document the levels with *Downeaster* train service on the mainline. Both of these conditions are considered to represent ambient or existing vibration conditions as they are not generated by the current project. Measurements were conducted at the three receptor locations identified in Section 4 in order to provide a better frame of reference for understanding vibration levels and relative differences with and without the project. The vibration monitoring instrumentation used in this study is listed in Table 13.

A highly sensitive (10 V/g) PCB 393B05 Accelerometer was used on a 35 pound mounting mass to measure vibration levels in the vertical direction a few inches outside the foundation at each receptor building. The accelerometer's signal was passed through a PCB 480E09 Power Supply Amplifier and into a CEL Instruments 593 Analyzer via a Bruel & Kjaer ZR0020 Input Adaptor. The CEL 593 allowed for optimization of the signal's dynamic range prior to its being output and permanently stored as a digital wav file in a Marantz PMD670 Recorder. The digital wav file was later analyzed using SpectraPLUS computer-based FFT software to allow analysis of the low frequency third-octave band range of 1Hz to 100 Hz using an RMS 'slow' response. The resulting acceleration spectra were then exported to Excel spreadsheets in order to convert and calculate the resulting measured RMS vertical vibration velocity level into decibel units of VdB re: 1 micro-inch/second.

The PCB 393B05 accelerometer is too sensitive to be calibrated by a typical hand-held field calibrator. Therefore, its published sensitivity was used in a comparison calibration method with the results obtained from a less-sensitive Endevco 7703A-1000 accelerometer mounted on a PCB 394C06 vibration calibrator which produces 1 g RMS. This method allowed for proper calibration of the entire vibration data collection and analysis system.

Table 13. Vibration Monitoring Instrumentation

Manufacturer	Model	Description
CEL Instruments	CEL593.C1T/2M	Noise and Vibration Analyzer, ANSI Type 1
Bruel & Kjaer	ZR0020	Accelerometer Input Adaptor for SLM
PCB Piezotronics	394C06	Vibration Calibrator, 1.0 g at 159.2 Hz
PCB Piezotronics	480E09	Signal Conditioner, x1, x10, x100 gain

PCB Piezotronics	422E13	Charge Amplifier Converter, 1pC to 1mV
PCB Piezotronics	393B05	Accelerometer, 9870 mV/g
Endevco	7703A-1000	Accelerometer, 981.3 pC/g, 981.3 mV/g
Marantz	PMD670	Solid State Data Recorder (wav files)
Pioneer Hill Software	SpectraPLUS 5.0	FFT & RTA Spectral Analysis PC Software

The results of the ambient vibration monitoring exercises are shown in Figures 12, 13 and 14 for receptor Sites 1, 2 and 3, respectively. As shown, vibration levels exterior to the buildings ranges from 44 to 48 VdB during non-event time periods, and can be as high as 63 to 65 VdB during passbys of the Downeaster train. The speeds at which the Downeaster passed the receptors during the vibration measurements ranged from 10 to 50 mph as measured with a radar gun. These ambient vibration results are also summarized in Table 14 as they relate to predicted future project-generated vibration levels and FRA/FTA vibration criteria limits.

Figure 12. Ambient Vibration Levels at Site 1

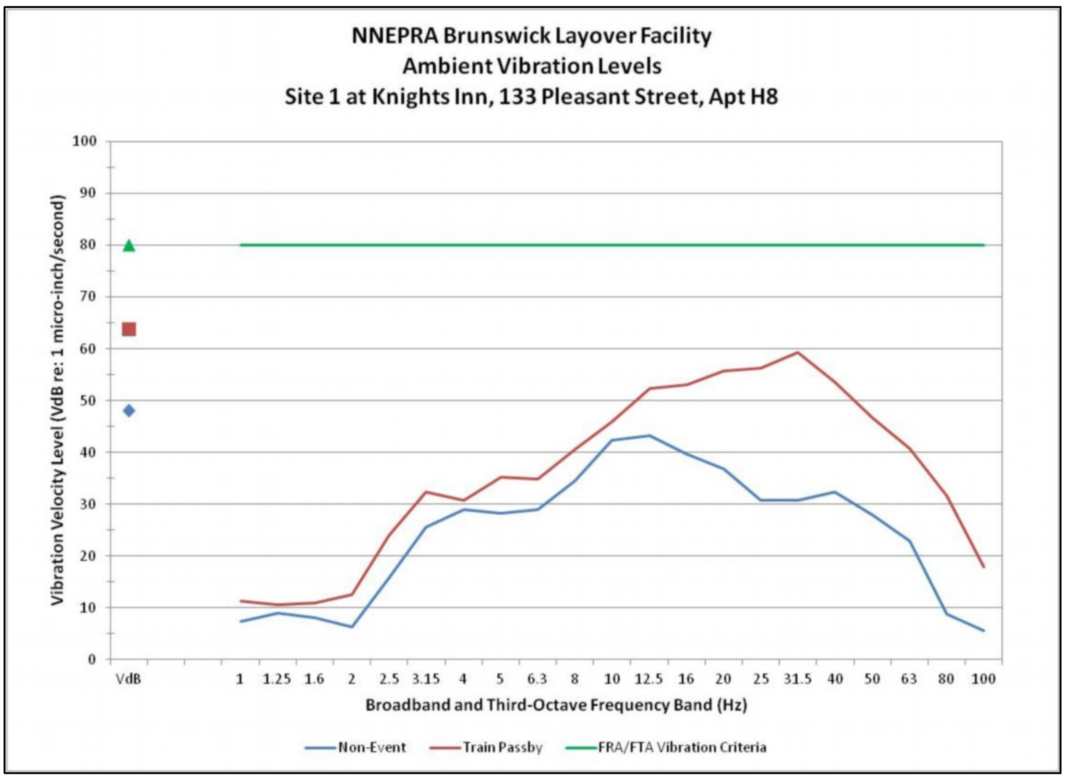


Figure 13. Ambient Vibration Levels at Site 2

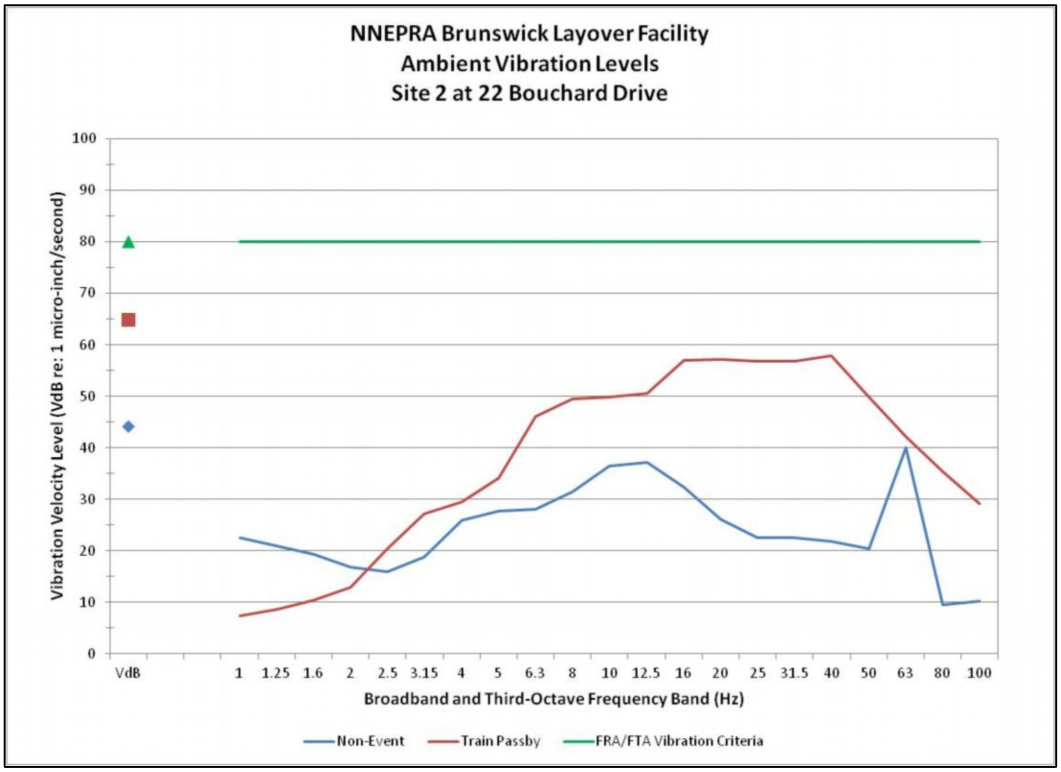
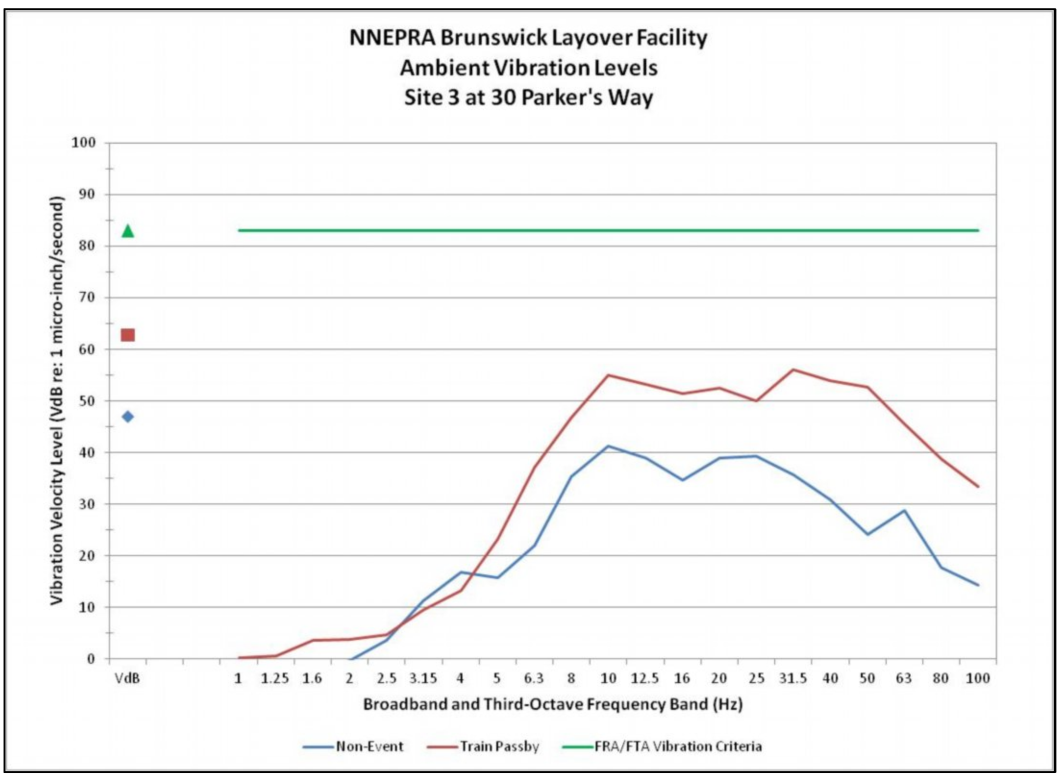


Figure 14. Ambient Vibration Levels at Site 3



11.4 Project-Generated Vibration Levels

The subject layover facility is expected to generate negligible vibration of its own. No heavy earth-moving equipment will be used at the facility, nor will any drilling, blasting or impact-type work be performed. As such the only notable potential vibration generating source to consider is the movement of Amtrak Downeaster trains in/out of the layover facility's eastern end moving at a very slow speed.

In this case the FRA/FTA's "general method" ground-borne vibration model was used to predict train movement vibration levels potentially affecting the three receptor locations. The model predicts vibration velocity levels in units of VdB based on a train's speed, distance to the receptor (i.e. from the center of the future layover facility area, not from the closest point at which the mainline tracks pass the receptors), number of events per day, coupling efficiency of the receptor's foundation to the ground, and any special track or ground conditions that may accentuate or diminish vibration.

It was assumed that future tracks will be continuous welded rail (CWR), and that the trains would be moving as fast as 10 mph in and out of the eastern end of the layover facility. Once trains merge back onto the mainline tracks they are no longer considered part of this project for either the Existing Service Level or the Future Service Level. The applicable vibration adjustment of +10 VdB was selected in the model for trains moving over switches in the yard.

To estimate the vibration levels *inside* each receptor building per FRA/FTA procedures, a foundation coupling efficiency adjustment of -5 VdB for wooden framed structures was assumed for all three receptors. In contrast, the ambient vibration level measurements were performed *outside* of each receptor's building. Vibration levels inside a building will always be less than those measured outside the building. And based on a report that there may be a high water table in the area, a penalty of +10 VdB was applied in the model to account for potentially more effective vibration transmission through soil. These assumptions and adjustments were applied in order to yield conservative or worst-case vibration predictions at the receptors' locations.

The results of the train movement-induced ground-borne vibration velocity level predictions can be seen in Table 14 for each receptor location. As can be seen, even with the relatively conservative assumptions for efficient vibration generation and propagation, the results are expected to be orders of magnitude below applicable FRA/FTA vibration criteria limits. It can therefore easily be concluded that this project represents no ground-borne vibration-related impacts of any kind for any of the receptors.

Table 14. Ambient and Predicted Vibration Levels

Site No.	Receptor Address	Land-Use (FRA/FTA Category)	Modeled Distance from Train to Receptor (feet)	Measured Exterior Ambient Vibration Level Non-Event/ Downeaster (VdB)	Predicted Interior Train Movement Vibration Level (VdB)	FRA/FTA Vibration Criteria (VdB)
1	Knights Inn, Apt. H8, 133 Pleasant Street	Residential (Category 2)	200	48 / 64	73	80
2	Residence, 22 Bouchard Drive	Residential (Category 2)	490	44 / 65	66	80
3	Commercial Business, 30 Parkers Way	Commercial (Category 3)	870	47 / 63	61	83

12. Conclusions

A comprehensive noise and vibration assessment was performed for the Brunswick Layover Facility project. Two scenarios with differing levels of *Downeaster* train service were evaluated: (1) Existing Service Levels, and (2) Future Service Levels. For each scenario, predicted noise and vibration levels were evaluated at three community receptor locations in accordance with Federal Railroad Administration and Federal Transit Administration guidelines. Project-generated noise levels were also assessed for information only relative to Maine Department of Environmental Protection and Town of Brunswick Ordinance noise guidelines.

The results conclude that the project will easily comply with all relevant FRA/FTA noise and vibration impact criteria. Additional noise and vibration mitigation measures beyond those assumed in this study will <u>not</u> be required for this project.

Moreover, the construction of an indoor layover facility in the Brunswick yard will provide a notable reduction in community noise level relative to the No-Build scenario in which a *Downeaster* train set is allowed to idle outdoors during the afternoon hours.