3.10 Noise and Vibration

This chapter details existing noise levels in the Study Area and describes the actions undertaken by SEA to document those conditions. It also identifies the basic acoustical concepts SEA used in its noise analysis, the Board's noise regulations, and quiet zones. Finally, this chapter presents a discussion of existing ground-borne vibration levels and related topics.

3.10.1 Human Perception Levels

Sound is what we hear when our ears are exposed to small pressure fluctuations in the air. Noise generally is considered to be unwanted or undesirable sound. In general, sound waves travel away from the source as an expanding spherical surface. The energy contained in a sound wave is spread over an increasing area as it travels, resulting in a decrease in loudness as it moves further from the source.

A sound's intensity is determined by how much its pressure fluctuates above and below that of the atmosphere and is expressed in units of decibels (dB). Sound is described in a logarithmic dB scale that takes into account the wide range of sound pressure levels in the environment. By using this scale, the range of normally encountered sound can be expressed in values between 0 and about 140 dB.

Sound-level meters measure pressure fluctuations caused by sound waves and record separate measurements for different frequency ranges; most sounds consist of a broad range of frequencies. Since the human ear does not respond equally to all frequencies (or pitches), measured sound levels (in dB at standard frequency bands) often are adjusted or weighted to correspond to the frequency response of human hearing and the perception of loudness. The A-weighted decibel (dBA) scale is most widely used for this purpose. Typical A-weighted noise levels for various types of sound sources are summarized in Table 3.10-1, below, along with the human response to these noise levels.

The Sound Exposure Level (SEL) is the cumulative exposure from a single noise event. It represents the total amount of sound energy that enters a receiver's ears (or the measurement microphone) during a noise event, such as a train pass-by. SEL is a cumulative measure, which means that louder events have greater SEL values than quiet events, and events that last longer also have greater SEL values than shorter events. SEL values are used in SEA's analysis to calculate hour equivalent sound level (Leq) and daily day-night noise level (Ldn) values associated with freight trains traveling in the Study Area.

Varying noise levels are often described in terms of Leq. Equivalent sound levels are used to develop single-value descriptions of average noise exposure over stated periods of time. The 1-hour Leq values over a 24-hour period are often used to calculate cumulative noise exposure, which can be expressed using Ldn. The Ldn is the A-weighted Leq for a 24-hour period; a 10 dBA penalty is imposed on nighttime noise (between 10 p.m. and 7 a.m.) since sleep interference could be an issue. The Ldn is a metric that is often used to characterize a community's response to noise because of the nighttime-noise penalty.

Table 3.10-1. Weighted Noise Levels and Human Response

Sound Source	dBA	Response Descriptor
Carrier deck jet operation	140	Limit of amplified speech
	130	Painfully loud
Jet takeoff (200 feet) Auto horn (3 feet)	120	Threshold of feeling and pain
Maximum train horn noise at 100 feet Riveting machine Jet takeoff (2,000 feet)	110	
Shout (0.5 foot) New York subway station	100	Very annoying
Heavy truck (50 feet) Pneumatic drill (50 feet)	90	Hearing damage (8-hour exposure)
Passenger train (100 feet) Helicopter (in flight, 500 feet) Freight train (50 feet) [a]	80	Annoying
Freeway traffic (50 feet)	70	Intrusive
Air conditioning unit (20 feet) Light auto traffic (50 feet)	60	
Normal speech (15 feet)	50	Quiet
Living room, bedroom, library	40	
Soft whisper (15 feet)	30	Very quiet
Broadcasting studio	20	
	10	Just audible
	0	Threshold of hearing

Source: CEQ, 1970, *Environmental Quality: the First Annual Report of the Council on Environmental Quality*, Washington, DC: U.S. Government Printing Office.

Note:

[a] The average measured level for EJ&E and CN trains was 85.8 dB

The logarithmic nature of dB scales is such that individual sound pressure ratings for different noise sources cannot be added directly to produce the level for the combined sources. For example, two sources that produce equal dB levels at a given location will produce a combined level that is 3 dBA greater than either sound on its own. When two sources differ by 10 dBA, the combined level will be no greater than the louder source alone.

People generally cannot detect differences of 1 dBA to 2 dBA between sources. Under ideal listening conditions, differences of 2 dBA or 3 dBA can be detected by some individuals. A 5-dBA change probably would be perceived by most people under normal listening conditions. People generally perceive a 10-dBA increase in a particular noise level as a doubling of loudness. For example, the average person will perceive a 70-dBA sound to be twice as loud as one of 60-dBA.

When distance is the only factor considered, sound levels from isolated point sources typically decrease by about 6 dBA each time the distance from the source is doubled. When the source is a continuous line (for example, vehicle traffic on a highway), sound levels decrease by about half as much (3 dBA) each time the distance from the source is doubled.

Sound levels can be affected by factors other than distance. Topographic features and structural barriers that absorb, reflect, or scatter sound waves can increase or decrease sound levels. Atmospheric conditions (wind speed and direction, humidity levels, and temperatures) also can affect the degree to which sound is attenuated over distance.

Reflections off topographical features or buildings can result in higher sound levels (lower sound attenuation rates) than normally would be expected. Temperature inversions and wind conditions can also diffract and focus a sound wave to a location at considerable distance from the source. As a result of these factors, the existing noise environment can be highly variable.

In previous proposed actions, SEA noted that a 3-dBA increase in Ldn could result from a 100 percent rise in train traffic, a substantial change in operating conditions, changed equipment, or a shift of operations from daytime to nighttime. Nighttime noise often dominates the Ldn because of the 10 dB penalty.

The Board's regulations in 49 CFR 1105.7(e)(6) require a noise analysis if rail traffic would increase by at least 100 percent as measured by annual gross ton miles, eight or more trains per day, or if carload activity at rail yards increases by at least 100 percent. Noise analyses are required at intermodal facilities if truck traffic would increase by 50 trucks per day or 10 percent of the average daily traffic. If these activity thresholds would be exceeded, the Board requires a determination as to whether the Proposed Action would cause an incremental noise-level increase of at least 3 dB on an Ldn basis, or the noise level rises to 65 dB (Ldn) or more. If either of these thresholds would be met, the Board requires sensitive receptors (e.g., schools, libraries, hospitals, residences, retirement communities, and nursing homes) in the area be identified, and the projected noise increase for these receptors determined.

What is an intermodal facility?
An intermodal facility is a facility that provides for transfer of containerized cargo or truck trailers between two or more modes of transportation, such as trucks, railroads, and cargo ships.

Typically, train activities can produce noise from a variety of sources, including operations, rail yards, increased auto and bus traffic near stations, and noise from wheels and horns. The noise a train generates when it travels along a rail line is referred to as wayside noise. Wayside train noise includes locomotive engine noise, wheel/rail contact, braking, and coupling/uncoupling operations. The noise emitted by locomotive horns is referred to as grade crossing noise because locomotive horns often are used where public roads cross rail lines at grade (except where Quiet Zones are established, as discussed below).

3.10.2 Existing Conditions

SEA performed 24-hour noise measurements at residences and other locations throughout the Study Area. SEA monitored 41 representative receptors for noise, 22 receptors along the EJ&E rail line and 19 along the five CN subdivisions that cross the EJ&E rail line. Table 3.10-2, below, shows the locations where noise measurements were taken in the Study Area and the existing noise levels (expressed as Ldn).

Table 3.10-2. 24-Hour Noise Monitoring Locations and Existing Noise Levels			
Rail Line Segment	Monitoring Site	Monitoring Location (See Figure 3.10-1)	Ldn (dBA)
CN-23B	G1	2296 182nd Place	81
CN-26	G2	12804 California Avenue	49
CN-26	G3	9209 Turner Road	59
CN-28	G4	5932 S. Stewart	75
EJ&E-16	J1	580 Market Street	61
EJ&E-11	J10	18960 Manchester Lane	72
EJ&E-11	J11	3152 Bennett Place	57
EJ&E-10B	J12	3203 Davey Court	67
EJ&E-10E	J13	13364 Blackstone Lane	70
EJ&E-9B	J14	2404 Durness Street	66
EJ&E-7B	J15	920 Spencer Road	76
EJ&E-7B	J16	1233 Andrea Drive	72
EJ&E-7B/C	J17	11470 Tea Tree Lane	73
EJ&E-7D/E	J18	420 Aberdeen Road	56
EJ&E-6	J19	81 W. 23rd Street	80
EJ&E-16	J2	29765 Bayshore Drive	49
EJ&E-5A/B	J20	394 Daren Drive	61
EJ&E-4/5B	J21	127 N. Indiana	71
EJ&E-3	J22	24th Avenue - Railroad Avenue	68
EJ&E-15	J3	27075 Northwoods Lane	52
EJ&E-14A/B	J4	18867 W. Rose Avenue	60
EJ&E-14C	J5	437 Elm Place	71
EJ&E-14C/D	J6	119 Raymond Avenue	65
EJ&E-14D	J7	11 Creekside Lane	66
EJ&E-14D	J8	195 Forrestview Drive	NA[b]
EJ&E-12	J9	31302 W. Jenlor Court	60
CN-18	JT1	110 W. 6th Street	80
CN-17	JT2	420 Talcott Road	52
CN-17	JT3	9244 Jocare Drive	72
CN-22	L1	1103 Creekview Drive	70
CN-22	L2	1336 Indigo Drive	69
CN-22	L3	1648 Chesnut	74
CN-21	L4	3637 Nichols	71
CN-1	MA1	1112 Braeburn Avenue	64
CN-3/4	MA2	13605 State Street	92
CN-6	MA3	10729 Dauphin Avenue	73
CN-7/8	MA4	6720 S. Dorchester Avenue	64
CN-13B	MU1	1216 W. Appletree Lane	61
CN-13B	MU2	1995 Flagstaff Court	63
CN-13B	MU3	2 Ridge Road	68
CN-12/11	MU5	5011 W. 26th Street	76

Note:

[a] SEA performed two measurements at this location, but the meters appear to have been tampered with both times.

> **What is SEL?**
> SEL is the total amount of sound that a person receives from a noise event, such as a train pass-by. SEA used SEL values in their noise model to predict future noise levels from increased train traffic in the Study Area.

Figure 3.10-1, below, shows where SEA performed these measurements. The measurements along the EJ&E rail line were all performed in adjacent residential backyards.

SEA also measured noise during 25 train pass-by events in different locations in the Study Area. Data collected during these events allowed SEA to determine the SEL for locomotives, locomotive horns, and rail cars. SEA then processed these SEL values and identified overall average SEL values for a single locomotive, locomotive horn, and rail car. SEA used these vehicle-specific SEL values in the models that calculated potential future train noise levels. Table 3.10-3, below, presents the average SEL values determined by SEA and used in the modeling analyses.

Table 3.10-3. Average Sound Exposure Levels (in dBA)

Ownership	Locomotive Horn	Locomotive	Rail Car (SEL)
CN	102.0	92.1	90.7
EJ&E	104.1	93.9	91.7
Other Trains	102.8	94.3	91.8

Kirk Yard is a hump yard, where locomotives push rail cars up a small incline, and gravity propels them down the other side and into the yard where they are sorted onto the tracks where they collide with existing rail cars. In this manner, trains are taken apart, resorted, and put together again. Wheel retarders, a rail-based braking system that uses friction to slow the rail cars, control the speed at which rail cars descend from the hump and minimize their speed when they collide with stationary rail cars at very low speeds. When in use, wheel retarders emit a loud squeal. Approximately 685 rail cars are handled here each day. Activities that produce noise at Kirk Yard include locomotive movements, rail car movements, wheel retarder squeal, car-to-car effects, and car-to-car coupling noise (emitted when trains begin moving from a stationary position). Kirk Yard is situated between the shore of Lake Michigan to the north, the US Steel Gary Works to the east, an interstate highway to the south, and rail lines to the west. Land use south of the interstate is residential. Noise from activities at Kirk Yard may occasionally be audible in this residential area. However, highway noise likely dominates the acoustic environment in the residential areas closest to the Kirk Yard.

East Joliet Yard is also a car classification yard, but it is not a hump yard; approximately 500 rail cars are handled here each day. Locomotives move railcars around this site, sorting them onto different rail segments. Activities that produce noise at Kirk Yard include locomotive movements, rail car movements, car-to-car effects, and car-to-car coupling noise (emitted when trains begin moving from a stationary position). The East Joliet Yard is largely surrounded by residential land use, separated by the width of a local street. Noise from activities at the East Joliet Yard is likely to be audible at residences closest to the East Joliet Yard.

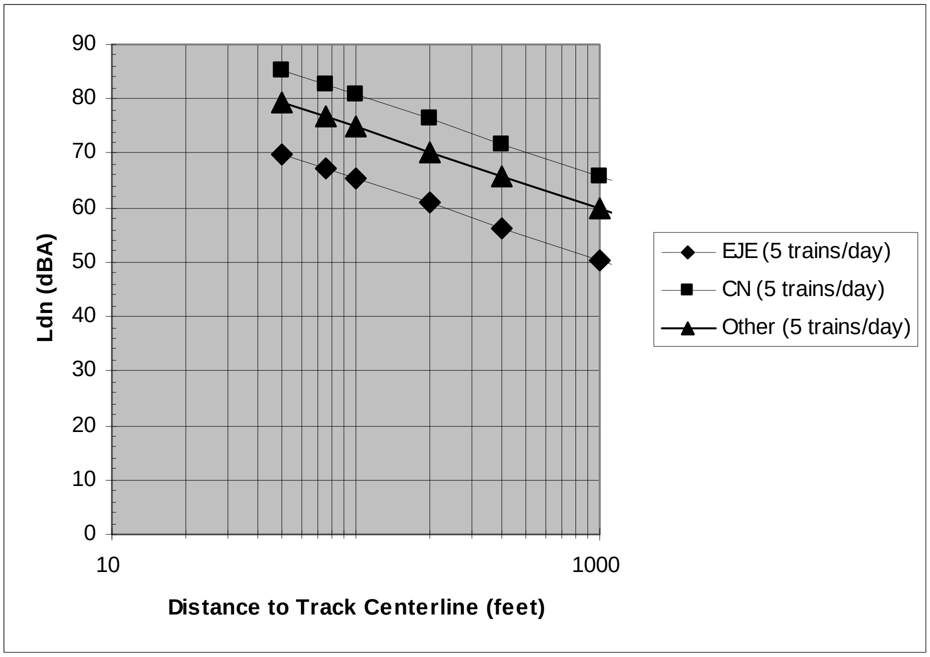
EJ&E Rail Line
CN Rail Line
Other Rail Line
Noise Monitoring Location

CN | EJ&E
Environmental Impact Statement

Figure 3.10-1
Noise Monitoring Locations

Figure 3.10-2, below, details the relationship between wayside noise (locomotive and wheel/rail noise) and the distance from the train track for CN, EJ&E, and other trains operating on the EJ&E rail line. The figure shows that train noise decreases as the distance from the track increases, assumes the same volume of trains/day for each of the three rail service types, and incorporates SEL values measured by SEA. The average number of rail cars per train varies, however, based on data provided by CN.

Figure 3.10-2 Wayside Noise vs. Distance from Track



3.10.2.1 Fermi National Accelerator Laboratory

Fermi National Accelerator Laboratory (Fermilab) occupies a 6,800-acre campus in Batavia, Illinois. Scientists at Fermilab carry out fundamental research in particle physics and astrophysics. Fermilab is home to the world's most powerful particle accelerator, the Tevatron, which is four miles in circumference and contains 1,000 superconducting magnets cooled by liquid helium to -268 degrees C (-450 degrees F).

The eastern border of the Fermilab campus shares a property line with the EJ&E right-of-way. Most of the eastern portion of the Fermilab campus is undeveloped. However, both short-term and long-term growth plans propose new research facilities on the eastern portion of the campus. SEA measured noise and ground-borne vibration on Fermilab property adjacent to the EJ&E right-of-way. SEA performed the 24-hour noise measurement near the Batavia Road entrance to Fermilab (see Monitoring Site J10 in Table 3.10-2, above), shows the results of these measurements. Figure 3.10-3, below, shows the location of the EJ&E rail line in relation to Fermilab, area roads, and the particle accelerator.

CN | EJ&E
Environmental Impact Statement

Figure 3.10-3
Fermilab

3.10.3 Quiet Zones

A quiet zone is a railroad grade crossing at which trains are generally prohibited from sounding their horns in order to minimize the noise level for nearby residents. The horns can be silenced only when other safety measures compensate for their absence.

An FRA regulation, 49 CFR 222 and 229, *Use of Locomotive Horns at Highway-Rail Grade Crossings*, took effect on June 24, 2005. This rule requires that locomotive horns be sounded upon approaching every “unsealed” public grade crossing. An unsealed public grade crossing is defined as a train and road crossing without grade separation, quad gating, or crossing guard with median barrier. At quiet zones established in accordance with the rule, trains are required to sound their horns 15 to 20 seconds before arrival at the crossing, rather than for a quarter mile (as required by most applicable state laws) regardless of speed. This results in horns sounding over a shorter distance and/or duration at many locations. The rule also prescribes both a minimum and maximum volume level for train horns, further reducing noise levels.

The Federal rule pre-empts all applicable state laws. Communities wishing to establish quiet zones must equip proposed grade crossings with adequate safety measures to compensate for the decreased safety created by horn silence. The additional safety measures are typically implemented primarily at the community’s expense and must meet Federal specifications.

As discussed in Section 3.2, Safety, above, there are three quiet zones on the EJ&E rail line, with a fourth in the establishment process. There are four quiet zones on CN’s Waukesha Subdivision. Figure 3.2-1, Existing and Proposed Quiet Zones, in Section 3.2, Safety, shows existing and proposed quiet zones along the CN and EJ&E rail lines.

3.10.4 Vibration

Train-induced ground-borne vibration is primarily caused by the interaction of steel wheels rolling along steel rails, producing energy that is transmitted outwards from the tracks. The energy (vibration) is transmitted from the wheel/rail interface through the track structure and the ground to the foundations of nearby buildings. The vibration is then transmitted into living spaces, where it may be intrusive and annoying to building occupants. Although the Board’s environmental regulations do not address train-induced, ground-borne vibration, SEA addressed this issue using guidelines and thresholds published by FTA (2006) and FRA (2005).

Vibration consists of rapidly fluctuating motions that have an average motion of zero. It can be described in terms of the displacement, velocity, or acceleration of the motion. Instantaneous vibration velocity fluctuates positively and negatively about the zero point. The maximum instantaneous positive or negative peak of the vibration signal is defined as the peak particle velocity (PPV). PPV is commonly used to characterize vibration’s potential for causing damage to buildings and other structures.

Human response to vibration is very complex. However, the general consensus is that human response to the vibration frequencies generated by freight trains is best approximated by the vibration velocity level. Therefore, SEA used vibration velocity to describe freight-train-generated vibration levels. When evaluating human response, ground-borne vibration is usually expressed in terms of dB using the root mean square (RMS) vibration velocity. RMS is the average of the squared amplitude of the vibration signal. To avoid confusion with sound dB, the abbreviation VdB is used to denote vibration dB and all vibration dB in this Draft EIS use a dB reference of 1 µin/sec.

Ground-borne vibration may be perceived as vibration of floors, rattling of dishes and other items on shelves, rattling of windows, and a low-frequency rumbling sound, which is caused by acoustic waves that radiate from vibrating room surfaces. The general consensus is ground-borne noise is more of a problem for underground trains, such as Chicago Transit Authority subways, than for at-grade rail systems. As a result, assessments of impact from ground-borne noise are typically limited to studies of proposed subway systems (FTA 2006).

Experience has shown that train-induced, ground-borne vibration is often perceivable, but does not generally reach levels where cosmetic or structural damage occurs to buildings. Consequently, assessments of potential vibration impacts from rail systems focus on annoyance to building occupants rather than structural damage (FTA 2006). The thresholds for cosmetic and structural damage to buildings are higher than the thresholds for human response to vibration. Therefore, an assessment of human response serves as a useful screening tool in the overall assessment of train-induced, ground-borne vibration. If vibration levels can not be perceived by humans, they will remain below the thresholds necessary for cosmetic and structural damage to buildings. If vibration levels exceed human perception thresholds, the next step in the analysis is a comparison with building response thresholds.

Typical community sources of ground vibration include construction equipment, passenger and freight rail operations, and motor vehicle traffic. Although motor vehicles generate ground vibration because of the vibration isolation characteristics of rubber tires and suspension systems, it is rare for motor vehicles to generate vibration that is perceptible inside nearby residences except where there are potholes, wide expansion joints, or other irregularities in the road surface.

SEA measured existing vibration at appropriate locations as shown in Figure 3.10-4, below. SEA selected the sites because they provided a good representation of existing conditions in each community along the EJ&E rail line.

SEA used three different measurement procedures:

1) SEA programmed community noise/vibration monitors to record overall vibration levels and one-third octave band spectra at 15-second intervals over the frequency range of 6.3 to 500 Hz. The results were post-processed to calculate vibration velocity levels and to extract the train vibration events. These monitors were used at Sites V1–V9 and Site V11 (see Table 3.10-4, below). For most of the tests, the monitors were left unattended for 24 hours.

2) A digital vibration recorder measured individual train vibrations at one location (Site V10 Broad Street, Griffith, Indiana) where both EJ&E and CN train traffic could be measured. Monitors (accelerometers) were placed at distances of 75 and 100 feet from the CN rail line and 120 and 140 feet from the EJ&E rail line. SEA could perform only a limited number of these measurements because of the intermittent and unpredictable freight train schedule and the limited number of trains using the EJ&E rail line.

> **What is an accelerometer?**
> An accelerometer is an electromechanical device that measures acceleration forces such as vibration.

3) Vibration propagation tests determined vibration transmission characteristics of the soil at five locations. This procedure is often used to predict ground-borne vibration from a proposed rail system. Soil types vary in their vibration transmission characteristics. FTA guidelines include a test procedure and use of the results for predictions (FTA 2006).

Figure 3.10-4
Vibration Measurement Sites

Table 3.10-4, below, is a summary of the testing performed to characterize train-induced, ground-borne vibration. The table shows SEA measured train-induced vibrations at various locations, with Site V10 recording data for both CN and EJ&E trains. Site P5 for vibration propagation is the same location as Site V10 for train vibration measurement. Table 3.10-4 also shows that SEA performed vibration propagation measurements at five locations in the project area. At these locations, SEA created a controlled vibration event and measured the vibration wave at different distances from the source.

Table 3.10-4. Summary of Vibration Testing

Description (See Figure 3.10-4)	Start Date	Start Time	End Date	End Time	Number of Trains	Comments
Train Vibration Sites						
V1. Lake Zurich	2/09/08	3:00 p.m.	2/10/08	12:30 p.m.	2 EJ&E	Equipment malfunction after first two trains because of sub-zero temperatures.
V2a. Barrington A	1/22/08	11:00 a.m.	1/23/08	11:00 a.m.	2 EJ&E	Equipment malfunction after first two trains because of sub-zero temperatures.
V2b. Barrington B	2/12/08	11:00 a.m.	2/13/08	9:00 a.m.	2 EJ&E	Additional tracks 720 feet from monitors.
V3. Hoffman Estates	2/12/08	12:30 p.m.	2/13/08	11:30 a.m.	2 EJ&E	--
V4. Batavia Rd. (Fermilab)	2/09/08	11:00 a.m.	2/10/08	1:00 p.m.	7 EJ&E	Same as Site P2.
V5. Aurora (Fermilab)	2/17/08	11:00 a.m.	2/18/08	12:30 p.m.	6 EJ&E	--
V6. Cresthill	2/14/08	6:00 p.m.	2/15/08	4:00 p.m.	13 EJ&E	--
V7. Joliet	2/13/08	6:00 p.m.	2/14/08	2:00 p.m.	30 EJ&E	There are a number of tracks in this area. It is not clear from the data which trains were on the EJ&E rail line and which were on other rail lines.
V8. Matteson	2/14/08	8:00 a.m.	2/14/08	4:00 p.m.	2 EJ&E	Same as Site P4.
V9. Chicago Heights	2/18/08	3:30 p.m.	2/19/08	3:00 p.m.	9 EJ&E	--
V10. Griffith, Broad St.	2/15/08	9:00 a.m.	2/15/08	5:30 p.m.	3 EJ&E 3 CN	Same as Site P5. Both CN and EJ&E tracks at this site.
V11. Griffith, Kennedy Ave.	2/19/08	4:30 p.m.	2/20/08	11:15 a.m.	21 CN	--
Vibration Propagation Sites						
P1. Barrington	2/09/08	--	--	--	EJ&E	
P2. Batavia Rd. (Fermilab)	2/11/08	--	--	--	EJ&E	
P3. Joliet	2/13/08	--	--	--	CN	No trains during test period.
P4. Matteson	2/14/08	--	--	--	CN	
P5. Griffith, Broad St.	2/15/08	--	--	--	CN & EJ&E	Same as Site V10.

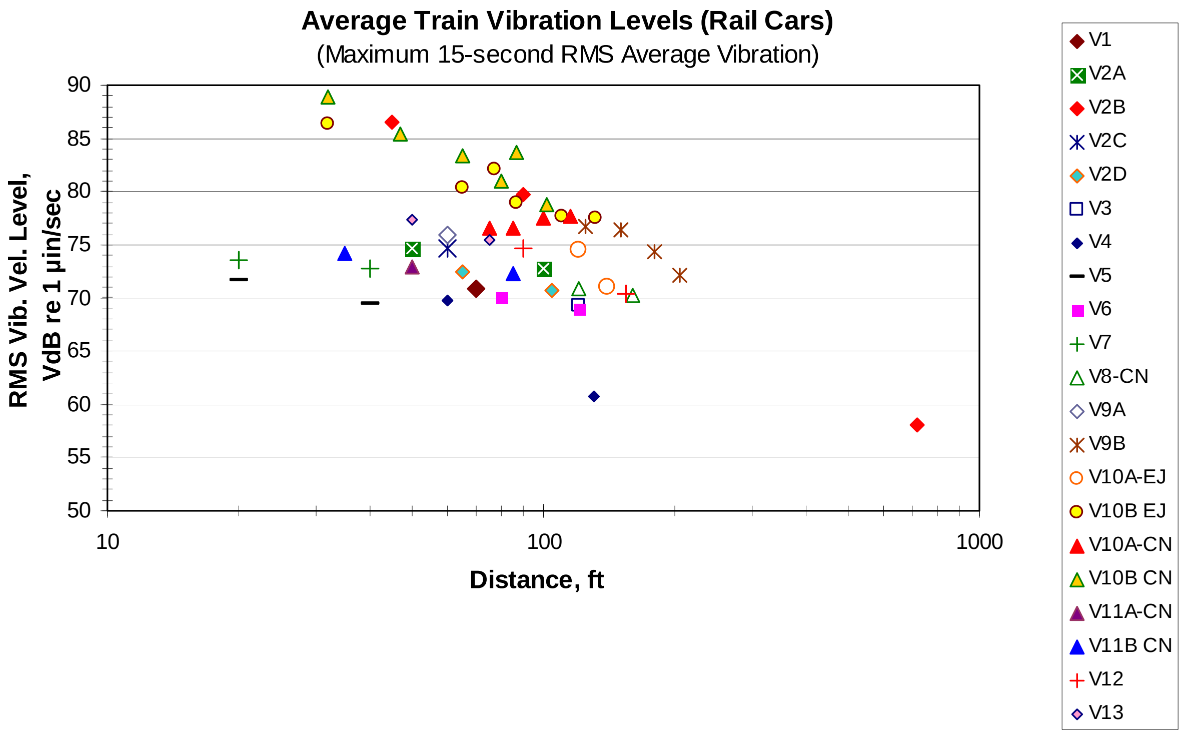
The primary goals of the vibration analysis were to characterize the levels of ground-borne vibration from existing train operations on the EJ&E rail line and to determine whether the potential increase in CN train traffic on the EJ&E rail line would have significantly different vibration levels. Following is a summary of the data analysis procedures used to achieve this goal:

- The time history of each passing train was inspected and, if there were higher vibration levels at the beginning of the event, the higher vibration levels were assumed to have been caused by the locomotives. The latter was the case for approximately half of the trains; for the remainder, the locomotive vibration was indistinguishable from the rail-car vibration. Even when the locomotive vibration was distinguishable from the rail-car vibration, the locomotive vibration was only 2 to 3 VdB higher.

- The section of the train following the locomotive was assumed to be rail cars. When the locomotives did not cause higher vibration levels, the entire event was analyzed as rail-car vibration.
- The maximum 15-second vibration velocity level was tabulated for each train. When the locomotives generated higher vibration levels, the maximum values for the locomotives and rail cars were both tabulated. The 15-second maximum levels (Lmax) were used to characterize the train vibration levels.
- Freight train-induced ground-borne vibration energy generally has a characteristic profile. Freight train pass-bys produce ground-borne vibration amplitudes that peak in the range of 40 to 100 Hz; there is very little vibration energy in the ground over 100 Hz. For each site, the one-third octave band spectra were plotted and the average one-third octave band levels were calculated. Through this step, any vibrations that were not caused by freight trains could be identified and eliminated from the analysis.
- The average Lmax at each site was calculated by averaging the one-third octave band spectra and then taking the dB sum of the one-third octave band spectra. Slow trains with low vibration levels were excluded from the average.

The average overall vibration levels for each site are summarized in Figure 3.10-5, below, which shows the average of the Lmax vibration levels (in VdB) as a function of distance from the tracks. This figure shows that measured rail car-induced vibration levels are clustered in a fairly well-defined range of between 70 and 85 VdB at distances close to 100 feet from the rail line.

Figure 3.10-5. Train Vibration Level vs. Distance from Tracks



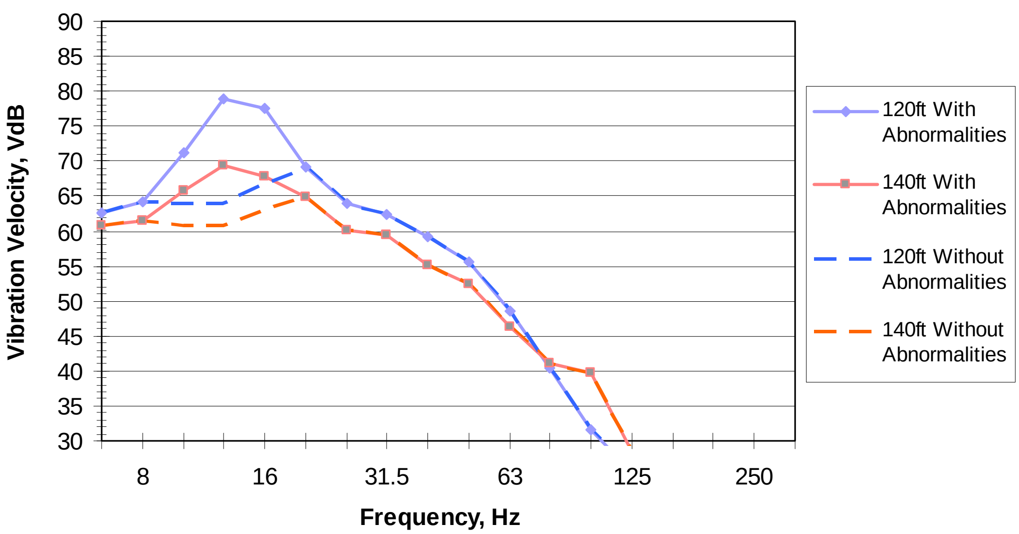
Following are descriptions of each vibration test site:

- **V1, Lake Zurich:** This site is along EJ&E Segment 14, north of Main Street in Lake Zurich, Illinois. The vibration monitor (accelerometer) was placed in the backyard of a residence on Carolyn Court. The monitor was 70 feet from the track centerline and 15 feet from the residence. Two trains, both lasting several minutes, were recorded during the 21.5 hours of the measurement.
- **V2A, Barrington A:** This site is north of Northwest Highway, along EJ&E Segment 14 in Barrington, Illinois. The monitor was placed in the backyard of a residence on Elm Road, 50 feet from the track centerline. Five trains were measured at this site over a 36-hour period.
- **V2B, Barrington B:** This site is north of Main Street, along EJ&E Segment 14 in Barrington, Illinois. The monitor was in the backyard of a residence on Grant Avenue. Accelerometers were placed at distances of 45 and 90 feet from the track centerline. Two short trains were recorded at this site during the 22-hour monitoring period. The vibration levels at this location were substantially higher than at the other sites because of a turnout near the measurement location. A turnout is a break in the rail line that enables trains to move to another track. As steel wheels cross that gap, an impact creates vibration similar to a car going over a pot hole.
- **V2C, Barrington C:** This site is north of Main Street, along EJ&E Segment 14 in Barrington, Illinois. The monitor was placed in the backyard of a residence on Raymond Avenue 60 feet from the near track centerline. Two short trains were measured at this site over a 24-hour period.
- **V2D, Barrington D:** This site is located in the backyard of a residence on West Hillside Avenue, along EJ&E Segment 14 in Barrington, Illinois. The accelerometers were at distances of 65 feet and 105 feet from the track centerline. Three short trains were recorded at this site over a 24-hour period.
- **V3, Hoffman Estates:** This site is along EJ&E Segment 14, approximately 0.6 mile south of Shoe Factory Road in Hoffman Estates, Illinois. The measurement was performed in the backyard of a residence on Mallard Lane. The accelerometer was 120 feet from the closest track. A total of two short trains were recorded at this site over a 23-hour period.
- **V4A, Fermilab, Batavia Road:** This site was located in Warrenville, Illinois, along EJ&E Segment 11 at the Fermilab site. The accelerometers were placed on the pavement of Batavia Road west of the tracks at distances of 17 feet (5 meters), 164 feet (50 meters), and 656 feet (200 meters) from the track centerline. Vibration was measured in both the vertical and horizontal directions perpendicular to the track. Three train events were recorded at this site.
- **V4B, Fermilab, Batavia Road:** This site is in Warrenville, Illinois, along EJ&E Segment 11 near the Fermilab site. The accelerometers were placed in the backyard of a residence on Maple Court, adjacent to Fermilab. The accelerometers were 60 feet and 130 feet from the track centerline. Both accelerometers were 250 feet south of Batavia Road. A total of seven trains (four long, two normal, and one short) were recorded at this site.

- **V5, Aurora:** This measurement was performed in Aurora, Illinois, at 3407 Ravinia Circle, near Ogden Avenue (US 34) and not far from Fermilab. It is along EJ&E Segment 10. The two accelerometers were 20 feet and 40 feet from the near track centerline. A total of six trains (four normal and two short) were recorded at this site.
- **V6, Cresthill:** This site is along EJ&E Segment 9 in Crest Hill, Illinois, between Gaylord and Division Streets. The residence is west of the tracks. Emlong Street is between the tracks and the residence. The accelerometers were set up in the front yard at distances of 80 feet and 120 feet from the track centerline. A total of 13 trains (six normal, four long, and three short) were recorded at this site.
- **V7A, Joliet:** This site is south of Woodruff Road, along EJ&E Segment 8 in Joliet, Illinois. There are a number of different rail lines in this area. The accelerometers were 20 feet and 40 feet from the closest tracks. Designated train speed is 10 mph on the EJ&E rail line at this site, and trains stop frequently near this location. A total of 30 trains (18 short and 12 normal) were recorded. It was not always clear whether the train causing the vibration was on the EJ&E rail line or another of the rail lines in the area.
- **V7B, Frankfort, Prestwick Dam:** This site is located at the dam near Sauk Trail Road in Frankfort, Illinois, west of South Harlem Avenue and south of Woodruff Road, along EJ&E Segment 7. The accelerometers were placed at 1600 feet and 1710 feet from the closest tracks. The distant accelerometer was located on the surface of the earthen dam. Three train events were recorded at this site. The purpose of this measurement was to determine whether post-Proposed Action vibration levels would possibly be of sufficient magnitude to damage the dam.
- **V8, Matteson:** The Matteson site is along the CN rail line, 0.4 mile south of the EJ&E alignment in Matteson, Illinois. The measurement was performed in an open area at the intersection of Cedar Road and Ridgeway Avenue, two blocks west of Main Street. The accelerometer was 50 feet from the closest track. There are six tracks at this site. Two short trains passed while the equipment was in place. The trains were on tracks that were 120 feet and 160 feet from the measurement position. Vibration propagation Site P4 is at this site over a period of just under 24 hours.
- **V9A, Chicago Heights:** This site is east of Western Avenue in Chicago Heights, Illinois, along EJ&E Segment 6. The measurement was performed in the backyard of a residence on Algonquin Street. The accelerometer was 60 feet from the track. A total of nine trains (four short, four long, and one normal) were recorded at this site.
- **V9B, Dyer:** This site is located east of Calumet Avenue in Dyer, Indiana, along EJ&E Segment 5. The measurement was performed in the backyard of a residence located on Serberger Way. The accelerometers were located at distances ranging from 125 feet to 205 feet from the track. Three train events were recorded at this site.
- **V10A, Broad Street, Griffith:** This site is west of Broad Street, along EJ&E Segment 4 in Griffith, Indiana. The measurement was performed in a parking lot on Industrial Drive. EJ&E and CN tracks intersect at this site, and measurements of both EJ&E and CN tracks were performed. The accelerometers were 120 feet and 140 feet from the closest EJ&E tracks, and 75 feet and 100 feet from the closest CN tracks. Three trains on the EJ&E tracks (two long and one normal) were recorded. Three normal length trains were recorded on the CN tracks. This is the same site as vibration propagation Site P5. The vibration spectra of the EJ&E trains at this site had a strong low-frequency component in the 12 to 16 Hz, one-third octave bands. The average vibration spectra at Site V10are shown in Figure 3.10-6, below. Because the trains on the EJ&E track at

V10A are the only ones that have this low-frequency component, this is likely a site-specific phenomenon and not representative of other sections of EJ&E track.
Figure 3.10-6 shows the low-frequency dominance, with the highest VdB levels associated with the lowest frequencies. The peak, or anomaly, appears to be site-specific and not representative of the project area. Figure 3.10-6 also shows an approximation of what the vibration levels would be without the apparent abnormality that is causing the low-frequency vibration.

Figure 3.10-6. Vibration Spectrum of EJ&E Trains at Site V10



- **V10B, Broad Street, Griffith:** This measurement was performed in April 2008 at the same area as V10A, in Griffith, Indiana, which was performed in February 2008. The accelerometers were placed at 32, 65, and 87 feet from the closest EJ&E tracks, and at 32, 65, and 87 feet from the closest CN tracks. A total of three EJ&E trains and three CN trains were recorded at this site. The primary purpose of the second set of measurements was to determine whether there is a consistent difference in the vibration generated by trains operating on the CN and EJ&E rail lines.
- **V11A, Kennedy Avenue, Griffith:** This site is located along a CN rail line to characterize the vibration of CN trains in Griffith, Indiana. The site was located at Erie Place east of Kennedy Avenue. An accelerometer was placed in the backyard of a residence at a distance of 50 feet from the tracks. There were 21 train events (16 normal and 5 short) recorded at this site.
- **V11B, Lakeside Drive, Griffith:** This site is located along a CN rail line close to V11A in Griffith, Indiana. The measurement was performed on land adjacent to a residence located on Lakeside Drive. The accelerometers were at a distance of 35 feet and 85 feet from the tracks. There were three train events recorded at this site.
- **V12, 45th Avenue, Griffith:** This site is located in the backyard of a property on North Indiana Street adjacent to the EJ&E tracks in Griffith, Indiana. The accelerometers were at distances of 90 feet and 154 feet from the tracks. There were seven train events recorded at this site.

- **V13, 15th Avenue, Gary:** This site is located in the backyard of a property on West 23rd Avenue on the west side of the EJ&E track in Gary, Indiana. The accelerometers were at distances of 50 feet and 75 feet from the tracks. There were seven train events recorded at this site.

Table 3.10-5, below, presents the results of vibration monitoring.

Table 3.10-5. Summary of Average Maximum Train Vibration Levels (Lmax)

Site Description (See Figure 3.10-4)	Number of Trains	Avg. Speed, mph	Dist[a], ft	Average Lmax Vib. Level, VdB Locos[b]	Average Lmax Vib. Level, VdB Rail Cars[c]	Comments
EJ&E Trains						
V1. Lake Zurich	2	31	70	--	70.9	--
V2A. Barrington A	5	37	50	--	74.7	--
			100	--	72.8	--
V2B. Barrington B	2	37	45	--	86.4	Measurement site was near a turnout.
			90	--	79.7	
V2C. Barrington C	2	37	60	--	74.7	1st train had substantially higher vibration levels than 2nd train
V2D Barrington D	3	37	65	--	72.5	--
			105	--	70.8	
V3. Hoffman Estates	2	36	120	--	69.3	--
V4A. Batavia Rd. (Fermilab)[d]	3	38	17	--	--	--
			164	--	--	
			656	--	--	
V4B. Batavia Rd. (Fermilab)	7	38	60	70.5	69.7	--
			130	61.2	60.8	
V5. Aurora (Fermilab)	6	35	20	73.1	71.6	--
			40	70.2	69.5	--
V6. Cresthill	13	31	80	69.5	70.1	--
			120	68.1	69.0	--
V7A. Joliet	30	9	20	74.9	73.5	--
			40	72.9	72.8	--
V7B. Frankfort (Pretswick Dam)[e]	3	40	1600	--	--	--
			1710	--	--	--
V9A. Chicago Heights	9	24	60	75.9	76.0	--
V9B. Dyer, near track	3	43	125	--	76.7	--
			180	--	76.4	
V9B. Dyer, far track	1	43	150	--	74.4	--
			205	--	72.2	
V10A. Griffith, Broad St.	3	24	120	--	82.2 74.4[f]	High vibration levels. Not clear whether trains were on near or far track. The train vibration at this site has a strong peak between 16 and 20 Hz. This is likely to be an anomaly related to a problem with the track rather than related to local geology.
			140	--	74.2 71.0[f]	
V10B. Griffith, Broad St., near track	2	24	32	--	86.3	--
			65	--	80.4	
			87	--	78.9	

Table 3.10-5. Summary of Average Maximum Train Vibration Levels (Lmax)						
Site Description (See Figure 3.10-4)	Number of Trains	Avg. Speed, mph	Dist[a], ft	Average Lmax Vib. Level, VdB		Comments
				Locos[b]	Rail Cars[c]	
V10B. Griffith, Broad St., far track	1	24	77	--	82.1	--
			110	--	77.6	
			132	--	77.5	
V12. Griffith	5	39	90	--	74.7	--
			154	--	70.4	
V13. Gary	7	40	50	--	77.3	--
			75	--	75.4	
CN Trains						
V8. Matteson, near track	1	--	120	--	70.8	--
V8. Matteson, far track	1	--	140	--	70.2	
V10A. Griffith, Broad St., near track	2	--	75	--	76.5	--
			100	--	77.5	
V10A. Griffith, Broad St., far track	1	--	90	--	76.5	--
			115	--	73.5	
V10B. Griffith Broad St., near track	1	--	32	--	88.9	--
			65	--	83.3	
			87	--	83.6	
V10B. Griffith Broad St., far track	2	--	47	--	85.4	--
			80	--	81.0	
			102	--	78.7	
V11A. Griffith, Kennedy Ave.	21	--	50	72.5	72.0	--
V11B. Griffith, Kennedy Ave.	3	--	35	--	74.1	--
			85	--	72.3	

Notes:

[a] Distance from closest track.

[b] Maximum vibration level of peak at start of train event, which is assumed to be caused by the locomotives. The locomotives vibration was higher than rail car vibration for approximately half of the train events.

[c] Railcars include entire events except the initial locomotive peaks. When the locomotives did not cause higher vibration, the entire event was analyzed as train car vibration.

[d] Train vibration at V4A was measured in two axes and the results are discussed separately.

[e] The measurements at the Prestwick Dam were substantially further from the train tracks than the other measurements. Vibration of train pass-bys were measured at the Prestwick Dam located at significantly high distances from the track. Peak particle velocity (PPV) is the relevant quantity for evaluating potential damage to the dam due to train vibration and is discussed separately.

[f] Excludes the high vibration levels between 10 and 20 Hz apparently caused by local track effects. The apparent anomaly was not observed in the vibration from CN trains or subsequent measurements in the area (Site V10B).

Table 3.10-5, above, shows the average maximum train-induced vibration levels measured in the project area. This data and the vibration transmission characteristics (line source transfer mobility) data shown below were used to determine the distance where FTA vibration impact thresholds were exceeded. Table 3.10-6, below, presents the results of vibration measurements (Lmax at 75 feet) and compares the results to threshold values as discussed further in Chapter 4, Environmental Consequences. Measured vibration levels ranged from 72.4 to 82.2 VdB. According to FTA guidance, the effect threshold varies with the surrounding land use and with the number of vibration events (trains) (FTA 2006). Vibration sensitive land uses require a lower threshold. In general, a lower threshold applies when traffic levels are higher, and vice versa. For residential and light commercial land uses, a threshold of 72 VdB applies whenever 12 or more vibration events per day are expected. Thus, the residential effect threshold was exceeded at all measurement sites under existing conditions.

Table 3.10-6. Predicted Vibration Effect Distances at Measurement Sites

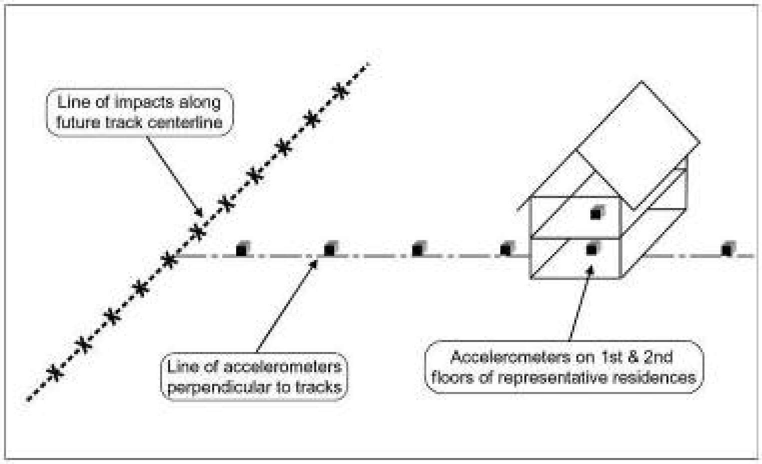
Measurement Site		EJ&E Segment	Closest Arterial Street	Trainsa	Lmax at 75 ft (VdB)b	Effect Threshold (VdB) c
				Existing		
V1.	Lake Zurich	14	Main Street	5.3	72.4	72
V2A.	Barrington A	14	Northwest Hwy.	5.3	72.4	72
V2B.	Barrington B[e]	14	Main Street	5.3	82.2	72
V2C.	Barrington C	14	Main Street	5.3	72.4	72
V2D.	Barrington D	14	West Hillside Avenue	5.3	72.4	72
V3.	Hoffman Estates	14	Shoe Factory Road	5.3	72.4	72
V4B.	Warrenville	11	Batavia Road	10.7	72.4	72
V5.	Aurora	10	Ogden Avenue	15.7	72.4	72
V6.	Cresthill	9	Gaylord Street	18.5	72.4	72
V7A.	Joliet	8	Woodruff Street	18.5	72.4	72
V8.	Matteson	7	Main Street	6.4	72.4	72
V9A.	Chicago Heights	6	Western Avenue	8.6	76.6	72
V9B.	Dyer	6	Calumet Avenue	10.2	76.6	72
V10A	Griffith[f]	4	Broad Street	7.6	82.2	72
V10B	Griffith[g]	4	Broad Street	7.6	82.2	72
V12.	Griffith	4	45th Avenue	7.6	76.6	72
V13	Gary	4	15th Avenue	9.7	76.6	72

Notes:
[a] Average number of freight trains per day under current conditions.
[b] The maximum speed of all freight trains was considered and the highest value was reported
[c] Effect threshold for maximum rail car vibration.
[d] East of Bishop Ford Freeway.
[e] West of Bishop Ford Freeway.
[f] East of Main Street.
[g] West of Main Street

In addition to train vibration measurements, vibration tests were performed at five sites to detail vibration attenuation with distance at representative sites along the EJ&E rail line.

The vibration transmission characteristics test is an experimental means for characterizing how subsurface conditions would affect rail-generated ground vibration. As illustrated in Figure 3.10-7, below, the procedure consists of dropping a weight onto the ground and measuring the vibration waves created at several distances from the point of impact. As shown in the schematic, the impacts are performed at regular intervals along a line, which is used to simulate a line vibration source such as a freight train. The transducers used to measure the vibration signals were monitors (accelerometers) attached to the ground surface and oriented in the vertical direction.

Figure 3.10-7. Schematic of Vibration Test



The test is characterized by the transfer function relationship between the impact force and the resulting vibration velocity at each accelerometer. This function is referred to as "transfer mobility." The measured transfer mobility functions for each accelerometer are combined using numerical integration to derive the line-source transfer mobility. The measured transfer mobility results for the five test sites are shown in Figure 3.10-8 and Figure 3.10-9, below.

Figure 3.10-8. Measured Line-Source Transfer Mobility at 50-Foot Impact Line

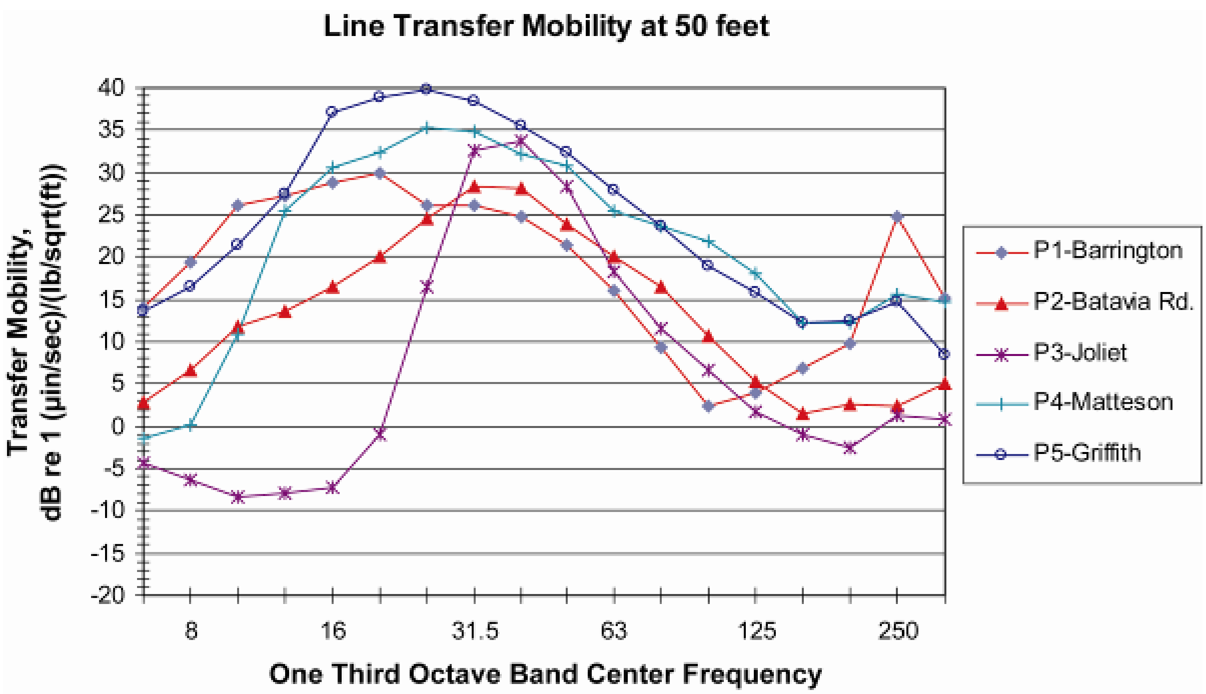
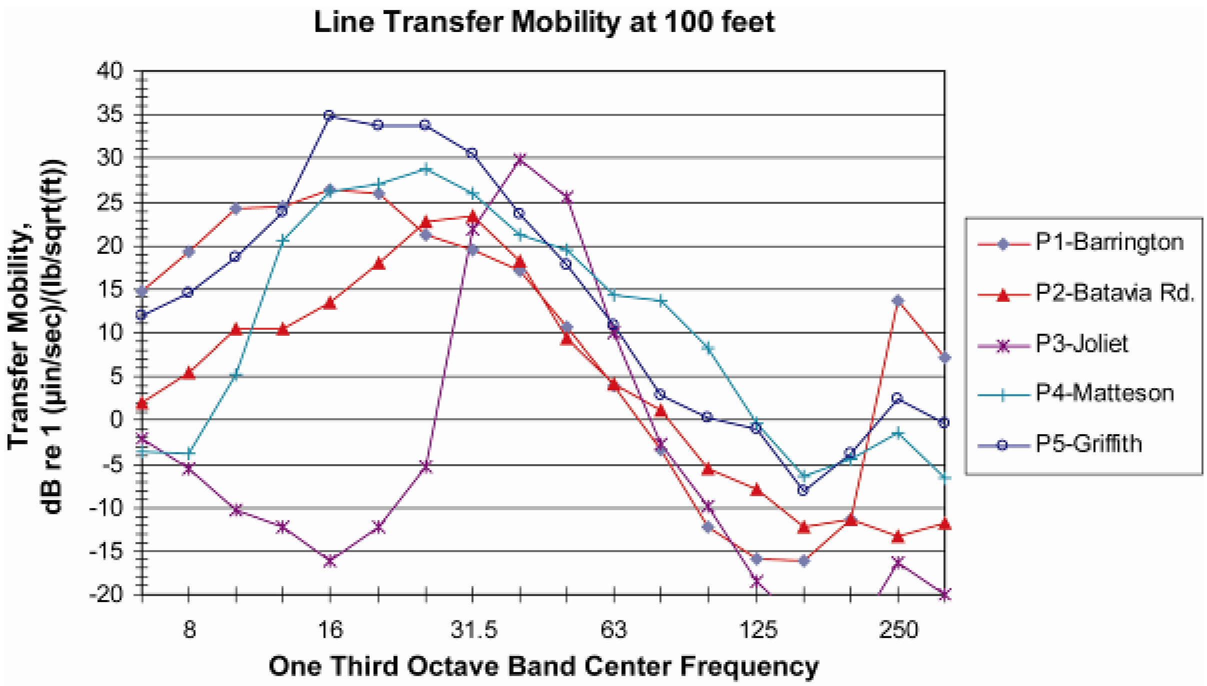


Figure 3.10-9. Measured Line-Source Transfer Mobility at 100-Foot Impact Line



Transfer mobility measured at an existing rail line is used to normalize ground-borne vibration data and remove the effects of geology. This data was used to determine the distance to the FTA vibration impact thresholds.

The sites are described below:

- **P1, Barrington:** This measurement was performed in the parking lot of the school bus company on the southwest corner of West Main Street and Raymond Avenue in Barrington, Illinois. The test site is along EJ&E Segment 14. The impact line was 20 feet from the near track (off the ROW), and transducers were 25, 37.5, 50, 75, and 100 feet from the impact line.
- **P2, Fermilab, Batavia Road:** This test was performed along Batavia Road at the eastern boundary of Fermilab. The impact line was 75 feet from the track centerline, and the transducers were 25, 50, 75, 100, 125, and 150 feet from the impact line. This site is 250 feet north of vibration site V4.
- **P3, Joliet:** This measurement was performed in an alley behind a restaurant on the southwest corner of West 10th Street and Archer Avenue (Illinois Route 171). The impact line was 10 feet from the closest CN ROW in Joliet, Illinois. Transducers were 25, 37.5, 50, 62.5, and 75 feet from the impact line. This site is along the CN rail line about 2.5 miles north of the EJ&E rail line in Joliet, and is representative of vibration propagation in the Joliet area.
- **P4, Matteson:** This site is along the CN rail line, about 0.4-mile south of the EJ&E rail line in the Matteson, Illinois, area. It is the same location as vibration site V8. The measurement was performed in an open area at the intersection of Cedar Road and Ridgeway Avenue, two blocks west of Main Street. The impact line was 10 feet from the closest CN ROW, and the transducers were 25, 50, 75, 100, and 125 feet from the impact line. This site is representative of vibration propagation in the Matteson area.

- **P5, Griffith:** This is the same location as vibration site V10 in Griffith, Indiana. The impact test was performed in a parking lot, with the impact line parallel to the CN rail line, 50 feet from the closest track. Transducers were 25, 37.5, 50, 75, and 100 feet from the impact line. This site is representative of vibration propagation in the Griffith, Indiana, area.

3.10.4.1 Fermilab

SEA measured vibration velocity in the eastern portion of the Fermilab campus. Figure 3.10-4, above, presents the vibration monitoring data. SEA's analysis also assessed rms vibration displacements at the ground surface 200 meters from the EJ&E rail line, as shown in Figure 3.10-10, below. The figure compares displacements measured with and without train pass-bys.

Data in Figure 3.10-10, below, shows that background and train-induced vibration displacements are not dramatically different at 200 meters from the EJ&E rail line.

Figure 3.10-10. Comparison of Background and Train-Induced Vibration Displacements