Final Summary Report

FOUR 24-HOUR DNL (Ldn) MEASUREMENTS IN WEST LOUISVILLE
October-November, 2001

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As part of a continuing environmental noise assessment, the Noise Study Group at the Regional Airport Authority expressed a desire for four new 24-hour DNL (Ldn) sound measurements on the west side of Louisville (DNL is an abbreviation for the name of the measurement; Ldn refers to the number and type of decibels measured). The Airport Authority therefore contracted with VESCO Engineering to make the desired measurements. The four general sites were selected, in west Louisville, by the Noise Study Group; the specific sites within those general areas were selected by Airport Noise Officer Mr. Bob Slattery, in consultation with VESCO Engineering, and were assessed in late October and early November. These were:

- The Philip Morris Plant, located south of Broadway between Dixie Highway and the railroad adjacent to 18th Street.

- The Whayne Supply site, located at 1400 Cecil Avenue, adjacent to the Foster Traditional Academy. These facilities are not far from the Greenwood Cemetery.

- The Deaf Community Center, located at 2422 West Chestnut Street between 24th and 26th Streets.

- The Engelhard Corporation, located at 3400 Bank Street near 35th Street.

This report summarizes the background of the issue; the measurement factors to be considered; the equipment used and procedures followed; the analyses; and the results.

BACKGROUND.

The purpose for the measurements was different from that of the monitoring previously conducted during the airport noise modeling study (conducted by K. M. Chng). The previous study monitored sound levels along existing flight paths so they could be compared with predicted aircraft sound levels from new operations. The existing noise was already high at these sites since they were along flight paths which already existed, implying that existing sound levels would not be greatly increased by the new activity. By contrast, the present monitoring was conducted in areas <u>outside present</u> flight paths but along <u>proposed</u> new flight paths. This was to assist the Noise Committee in assessing whether a greater change from existing sound levels might occur under proposed new flight paths. The previous monitoring provided measurements of the total site sound environment (in a 24-hour DNL format), including both normal ambient city noise from all sources, such as industry and vehicular traffic, as well as aircraft flyovers. Therefore, the present monitoring collected data using the same metric.

Two criteria were used in selecting the four above-listed sites:

• First, the general survey areas were selected by members of the Noise Study Group representing west Louisville, using their own site selection criteria (based strictly on location) regarding urban noise environments in flight paths of interest.

• Second, specific sites within those four general areas were jointly selected by the airport Noise Officer and VESCO Engineering to provide relatively good site security (e.g., fenced, guarded, or otherwise protected against sound analyzer abuse, vandalism, or mischievous extraneous noise); to be characterized by grass or other ground cover vegetation to avoid sound reflections from hard horizontal pavement surfaces; and to be relatively far from major traffic noise generators, adjacent buildings, or other vertical sound reflecting surfaces (not always possible in an urban environment). Since the test was to capture general urban noise, not all noise sources could or should be avoided.

Specific site descriptions are given later.

No attempt was made, in site selection, to select measurement locations which were characterized by either unusually high or low ambient noise.

MEASUREMENT FACTORS

In order to assure maximum measurement accuracy, and comparability with previous airport-related urban sound measurements, it was considered to be important to have acceptable weather; use a proper recording sound analyzer and peripherals; provide a proper analyzer arrangement and electronic setup; to properly calibrate the analyzer; to measure properly; and to inspect the analyzer during each 24-hour monitoring period to assure proper operation. The following information is presented to document the care taken to assure measurement accuracy and comparability with previous data.

1. Weather.

The weather during the first of the four 24-hour measurement periods was less than ideal, but acceptable for the other three 24-hour measurement period.

During the Thursday-Friday period (October 18-19, at Philip Morris), the weather was cool and clear, with a slight wind. A windscreen was placed on the microphone at all times to reduce wind noise artifact, and it was loosely covered with a thin plastic sheet to protect it against moisture (this does not significantly affect sound measurement).

During the Wednesday-Thursday period (October 17-18, at Whayne Supply) the weather at the beginning of the period was cool and clear with no rain. During the first half of this period (afternoon and evening), the temperature began at 51ºF with light to moderate winds and a relative humidity of 34%. The next morning was cold (31.8ºF) and clear with a low fog and frost on the analyzer case; relative humidity was 51%.

Temperatures increased during the day and, at the end of the period (2:04PM), temperature was 67°F and relative humidity was 34%.

During the Monday-Tuesday period (November 5-6, at the Deaf Community Center) the weather was clear and cool-to-cold (38-56OP) with variable humidity (34-83%), no wind or precipitation.

During the Wednesday-Thursday period (November 7-8 at the Engelhard Corp.), the weather varied considerably, with temperatures from cool-to-warm (41-72ºF) and humidity varying from 12-78%. There was no precipitation, but some light frost on the instrument case during early morning hours. Wind was generally negligible, though it picked up near the end of the test. These conditions did not affect the meter function or accuracy.

Regular inspections of the analyzer, throughout all four of the 24-hour periods recorded, failed to identify any weather factor what would have altered or disrupted the sound measurements.

2. Ambient Noise Environments.

Notes were taken of various audible intrusive noise sources and events, during all 24-hour measurement periods, to assist in interpreting the measured DNLs. These were all noted during brief periods while the analyzer was being set-up or inspected and are therefore not necessarily representative of all noise sources present during the entire monitoring periods:

a. **Philip Morris Site.** Maximum recorded sound levels were as follows:

Automotive and truck noise along Maple Street: 63-73 dBA
Occasional P A system from industry across Maple Street: 65 dBA
Pure-tone industrial hum across Maple Street: 56-61 dBA
Aircraft overflights: 60-76 dBA.
Distant train whistle: 58-60 dBA

There were also pneumatic hisses (steam venting) and parking lot traffic at Philip Morris, and a fork lift back-up beeper from a site across Maple Street (these were not measured).

It was noted that the analyzer-indicated Sound Pressure Level range between 12 noon and 4:00 PM was 52-72 dB, which is in agreement with the above listed sources.

b. Whayne Supply Site. Maximum recorded sound levels were as follows:

Light traffic coming into and out of the school area: 51-58 dBA
Neighborhood dog barking: 50-62 dBA

Trucks pulling into the site: 52-54 dBA
Distant traffic on Watterson Expressway: 50 dBA
Temporary use of a chain saw: 53-55 dBA
Occasional aircraft flyovers: 50-51 dBA ,

c. <u>Deaf Community Center Site.</u>

Cars on Chestnut Street: 48 -55 dBA
Man yelling across the street: 55 dBA
Distant police siren: 47 dBA
Distant back-up beeper on unidentified vehicle: 42 dBA
Distant jet plane: 48 - 53 dBA

d. <u>The Engelhard Corp. Site.</u>

Engelhard plant noise (shielded by trailer): 55 dBA
Kids yelling: 57-60 dBA
Passing cars: 58-64 dBA
Passing mail van: 68 dBA
Passing dump truck: 69-70 dBA
Passing school bus: 65-68 dBA
Accelerating school bus: 70-73 dBA
Various vehicles accelerating away from stoplight: 71-76 dBA
Prop plane: 57-59 dBA
Helicopters: 59-64 dBA
Passing T ARC city bus: 62-65 dBA
TARC city bus accelerating: 72-76 dBA

Only one jet plane was noted during one hour of on-site inspection (not measured). A plant guard noted that most plane traffic here was on the weekends.

EQUIPMENT AND PROCEDURES

This section reviews the sound analyzer used; its preparation and calibration; the analyzer sites; analyzer arrangement and electronic settings; and the procedures used to start, inspect, and stop the analyzer measurement.

1. <u>Sound Analyzer.</u>

The sound analyzer used was a CEL model 573, upgraded to model 593 capabilities. This is a Type 1 instrument (accurate to within ± 1 dB) capable of collecting, digitizing, and electronically storing and analyzing multiple sound parameters for long periods of time. It is identical to the instrument used by other consultants during the recent airport noise study, and has been previously used by VESCO Engineering for Louisville airport area noise assessments.

2. Analyzer Preparation and Calibration.

Prior to making any measurements, the analyzer was allowed to stabilize to the environmental temperature to assure that any sudden temperature change would not cause any moisture condensation on microphone. Also, just prior to each measurement period, the analyzer was acoustically calibrated to 114.0 dB (to assure measurement accuracy).

3. Measurement Sites (see map location of all sites and photos of the analyzer setup at three of the sites in the appendix):

The Philip Morris measurement site was located at the rear of the plant, facing Maple Street. This plant was only in partial operation (some noise coming from steam pipe venting and light traffic into and out of the site). The plant site was guarded and surrounded by a security fence, providing good security for the analyzer. The analyzer was located in an island off the paved parking lot, next to the south (Maple Street) fence. This "island" was planted in a ground-cover vegetation (selected to avoid sound reflections off the pavement), and the analyzer was located between two pine trees. It was a short distance from, and visible from, the guard shack. Other industrial sites were located across Maple Street from the measurement site, including Brown Forman and a pipe storage yard. Maple street carried only light traffic.

The Whayne Supply site is a large storage facility at the southern end of Cecil Avenue, adjacent to the Foster Traditional Academy. It is the storage location for a large inventory of earthmoving and other heavy construction equipment. The only noise noted to originate from the site was truck and automobile traffic into and out of the site. This site was also guarded and surrounded by a security fence, providing good security for the analyzer. The analyzer was located about 15-feet from the fence separating the site from the school, near the school entry. It was in a grassy field (selected to avoid sound reflections off any site pavement) behind some light shrubbery. It was also visible from the guard shack. Adjacent land uses within sight, other than the school, were entirely residential. A constant, low-level noise was audible from distant Watterson Expressway.

The Deaf Community Center site is an older, multi-story brick school building located in a predominantly residential area on the south side of West Chestnut Street. A residence is located to the east, a Bell South van storage lot to the south (across an alley), and a fenced parking lot to the west. A row of residences is across Chestnut Street to the north. The dominant area noise source is street traffic. This was an unsecured site, with no fence and no guard, so the meter was located behind the Deaf Center building, in the yard in a grove of trees where it would not be easily noticed (no effect on measurement). It was thus considerably shielded from Chestnut street traffic noise, but was exposed to any noise emanating from the Bell South lot (operations only between 8:00AM and 5:00 PM), the adjacent alley (some pedestrians but little vehicular traffic), or the adjacent parking lot (little or no activity).

The Engelhard site is a heavy industry located at 3400 Bank Street, near 35th Street. This is in a mixed-use area (residential, commercial, and industrial) marked by residences, bars and small restaurants, a gas station, and a VFW building; a cemetery is located diagonally across from the site. Some plant noise emanates from the main Engelhard building during working hours (two shifts, 7:00 AM to 11:00 PM, during the measurement session) due, reportedly, to some air compressors. The analyzer was located on a grassy site between a site office trailer and Bank Street, so as to be partially shielded from the main plant noise. The primary noise sources were the plant building and heavy traffic near the busy Bank Street-35th Street intersection.

4. <u>Analyzer Arrangement.</u>

The measurement system included the following:

- CEL analyzer, mounted on a tripod with the mike about 5-feet above ground.
- Analyzer enclosed in an insulated environmental-protective case. .
- Case equipped with Plexiglas window for visual monitoring.
- Case locked so settings cannot be tempered with by outsiders.
- Microphone covered with a windscreen and, if needed, a light plastic moisture wrap.
- Acoustical-absorbing foam on case behind mike to prevent reflections.
- Tripod stabilized by a wind anchor to prevent tipping.
- 12-volt external battery to provide power for each full 24-hour period.
- Measurement system secured to tree or fence post by locked chain.

5. <u>Analyzer Electronic Settings.</u>

Prior to measurement, the analyzer was programmed with all the settings required for general 24-hour environmental sound measurement and analysis, with aircraft overflights. To assure accuracy, compatibility, and comparability with past airport noise monitoring, all settings were identical to those used in past consultant monitoring for the noise model and in past VESCO Engineering measurements for the Regional Airport Authority (except, as explained below, for aircraft-relevant thresholds). Example settings included those for hourly environmental monitoring, random microphone incidence, both A-and-C scale weightings, Leq measurement (energy-equivalent sound levels), a 3-dB exchange rate (for energy measurements); etc.

Since the analyzer was set to measure a sequence of 24 hourly Leqs (in one situation, 48 half-hour Leqs were collected), it was necessary to compute the DNL (measured as Ldn) later, as described below.

The analyzer was also set to capture (simultaneously with continuing Leq measurement) most individual transient events above a set threshold (as an indicator of aircraft overflights or other sources, such as loud truck passes, which have a similar time and intensity profile). The requirements for this project did not include detailed SEL analysis of each overflight - only general overall Ldn measurement - so no time was spent establishing the necessary threshold level and onset-rate to assure that primarily aircraft events rather than other sources were being captured. As a general indicator, however, the instrument was set with a 65 dB threshold and a 4-second onset rate (omitted for measurements at one site).

6. Analyzer Measurement Periods.

The first measurement period (Philip Morris site) ran from 2:35 PM on Thursday, October 18th to 2:35 PM on Friday, October 19th. The second measurement period (Whayne Supply site) ran from 2:05 PM on Wednesday the 17th to 2:05 PM on Thursday the 18th. The third period (Deaf Community Center) ran from 2:00 PM on Monday, November 5th to 2:00 PM on Tuesday, November 6th. The fourth period (The Engelhard Corp.) ran from 3:00 PM on Tuesday, November 6th through 3:00 PM on Wednesday, November 7th.

7. Frequent Analyzer Inspection.

During each 24-hour period, the analyzer measurement system was inspected periodically to gain confidence that there were no weather, vandalism, or other such problems with the system or its measurement. Such periodic inspection cannot guarantee against the occurrence of any mischief (shouting into the meter, etc.) -- that would have required the extra expense of a 24-hour on-site guard. But site location and procedures were selected and followed to minimize the chances of that happening.

8. Notebook Computer data Dump.

After each 24-hour run, the analyzer data were dumped into a computer for analysis. When measurements were made on two consecutive days, the first day's data were first dumped into a notebook computer, which was taken back to the office for dumping into the main computer for analysis, while the analyzer was moved to a new location.

DATA ANALYSIS

Data from the system were computer analyzed using dB2 software. The primary analyses for this project included the following:

• Printout of the Leq for each recorded hour of data.

• Printout of the number of transient events, which exceeded the 65 dBA, 4-second onset rate threshold occurring during three of the 24-hour measurements. These were taken as a rough indicator of potential aircraft overflight or other similar-profiled intrusive activity; however, since so much traffic was present, and the scope of work did not require detailed analysis of overflights, unique thresholds were not set for each site, based on long periods of previous noise-source monitoring. Therefore, the standard 65 dB threshold set for all monitoring may have a very poor ability to discriminate between aircraft overflights and similar transient events like vehicle passes.

• Calculation of the DNL (as an Ldn value) by using the energy-average equation with 10 dB added to each nighttime hourly Leq (10:00 PM - 7:00 AM). Adding 10 dB to each of the 9 nighttime hourly Leqs adjusts the Leq metric for the greater sensitivity of human receptors to nighttime noise.

RESULTS

1. <u>Philip Morris Site.</u> Data collection proceeded normally:

The calculated daytime Leq: 60.2 dBA
The calculated nighttime Leq: 56.1 dBA
The calculated DNL (Ldn value): 63.4 dBA
The number of intrusive events exceeding threshold parameters: 102
(an indicator of potential aircraft overflights or other similar intrusions)

2. <u>Whayne Supply Site.</u> Data collection proceeded normally:

The calculated daytime Leq: 56.6 dBA
The calculated nighttime Leq: 57.5 dBA
The calculated DNL (Ldn value): 63.8 dBA
The number of intrusive events exceeding threshold parameters: 7
(an indicator of potential aircraft overflights or other similar intrusions)

3. <u>Deaf Community Center Site.</u> Data collection proceeded normally (for this site, the analyzer collected 48 half-hour samples instead of24 hour samples):

The calculated daytime Leq: 52.5 dBA
The calculated nighttime Leq: 50.0 dBA
The calculated DNL (Ldn value): 57.6 dBA
Intrusive events exceeding threshold parameters were not measured at this site)

4. <u>Engelhard Corp. Site.</u>

The calculated daytime Leq: 64.8 dBA
The calculated nighttime Leq: 61.3 dBA
The calculated DNL (Ldn value): 68.4 dBA
The number of intrusive events exceeding threshold parameters: 0
(an indicator of potential aircraft overflights or other similar intrusions)

DISCUSSION AND INTERPRETATION OF RESULTS

Understanding the DNL (or Ldn numbers) measured requires some appreciation for the Leq metric, on which it is based, and the l0-dB addition for nighttime values. The purpose of this section is to provide some helpful interpretive information.

The Leq Metric.

Leq is called the "equivalent, continuous sound level", or sometimes the "energy equivalent sound level". This is a time-averaged sound level measured on an energy (logarithmic) basis. More precisely, it is the level of a steady sound which, in a stated time period and at a stated location, has the same A-weighted sound energy as the time-varying sound being measured. It is measured in decibels.

Leq is the preferred metric for measuring time-varying environmental sounds for three reasons:

- It provides a single number rating which provides a sort of "average" value over a long period of time. Single number ratings are more easily compared with each other, and with standards and limits, then wide statistical variations and ranges.

- It combines, into that single number value or rating, the three primary factors that describe a sound: intensity (as pressure), frequency, and time:

    - The intensity is a measure of the sound pressure level of the sound, in decibels. It is sound pressure which acts on the ear and creates the sensation of loudness.

    - The frequency is incorporated by using the A-scale of the sound level meter. This is a way of weighting the sound pressure, at various frequencies, in the same manner as the human ear (which hears all of a sound's medium-to-high frequencies, but filters out the low frequency sounds, increasingly as the frequency is lowered). This means that A-scale measurements are proportional to the loudness which a human being attributes to a sound. And loudness, in turn, is proportional to annoyance or health effects.

    - The time is incorporated by a kind of averaging (a special "energy-basis" kind, as explained below) of the A-scale sound level over time, to smooth out all the high and low intensities and provide an "average" value.

The Role of Energy in Sound Assessment.

The thing that can sometimes be confusing about the Leq is the way this "special averaging" procedures works. It is not a straight average of the various numbers of decibels involved: rather it is an average of the energy in a sound. It is the energy of a sound (capacity for doing work, over a time period) which does damage to (or creates annoyance in) people, not just the intensity. So environmental sound measurements seek to measure the energy in the sound.

But energy increases in a logarithmic way, not a numerical way. That's why two 50 dB sound sources do not add to make 100 dB, and they do not sound twice as loud. Rather, they add to make 53 dB and sound "a little louder". When the logarithmic character of sound energy is taken into consideration, doubling sound energy increases the number of decibels by three. It takes a 10 dB increase to sound twice as loud.

This is a great help when assessing how measured sound levels will affect people. But it makes it a little confusing when one tries to add or accumulate the effects of certain decibel sounds. To make real sense, they must be added in a logarithmic way, not a numerical way. And it also means that the higher-decibel sounds in a long-continuing sound contribute much more energy to the total sound than do the lower-decibel sounds.

The energy in a certain decibel sound goes up exponentially, as follows:

Energy is proportional to $10 \log_{10} [T \times 10^{L/10}]$
where T is the duration and L is the sound level in decibels

High energy sounds (which have a high L) add <u>disproportionately</u> high levels of energy since energy goes up as the power of 10. And the energy of an overall sound is the sum of all the component energies it contains.

This is one of the advantages of using the Leq metric for assessing environmental sounds: it is very sensitive to high decibel intrusive events, just like human beings (we often adapt to low-levels of steady sound, but intrusions like barking dogs or aircraft over-flights get our attention easily and can be very annoying - precisely because they add a great deal of energy to our total sound environment).

Consider, for example, what happens when two one-hour Leqs are added together. Suppose the Leq for one hour was 53.9 dB. Using the full energy equation (an expanded version of the above relationship) tells us that its energy is 245,470 units. And suppose the Leq for the next hour was 63.2 dB. This is just over 10 dB higher, but its energy is 2,089,296 units. It has almost 10 times the energy. The total energy is 245,470 + 2,089,296, or 2,334,766.

Now note that almost 90% of the total energy was contained in only half the data (one of the two hours).

The DNL (Ldn) Metric.

The DNL or Ldn is simply a 24-hour Leq measurement in which 10 dB is added to each Leq during nighttime hours. Extensive study has established that people are as annoyed by nighttime noises as they are by daytime noises which are 10 dB higher, because at night they are trying to rest, relax, or sleep. So we can most easily create a 24-hour annoyance scale by using numbers which are 10 dB higher at night.

This means that we calculate the value of a DNL (its Ldn) by adding 10 dB to each hourly nighttime Leq and then adding them all up on an energy (logarithmic) basis.

For example, at the Whayne Supply site, the daytime Leq was 56.6 dB and the nighttime Leq was 57.5 dB. But when 10 dB is added to the seven 57.5 dB nighttime Leqs, and the resulting energy is added to the energy of the seventeen daytime 56.6 dB Leqs, the resulting dB of the energy total is 63.8. This is because each of the nighttime Leqs act as if they were adding the energy of 67.5 dB to the energy total, not 57.5.

For purposes of evaluating community exposure to aircraft noise, FAA has established DNLs (Ldns) of 65 dBA as the boundary above which exposed people may be judged to be unduly annoyed (must be interpreted relative to existing Ldns).

It is also important to understand, also, that sound analyzers measure the Ldn of all the sounds present in a given environment, not just the contributions of overflying aircraft. Special measurements may be conducted which attempt to sort out the SEL (single exposure level of single events) of each aircraft overflight, but these were not recorded and analyzed here.

The Ldns Measured Here.

Following, for comparison, are the four DNLs (Ldns) measured:

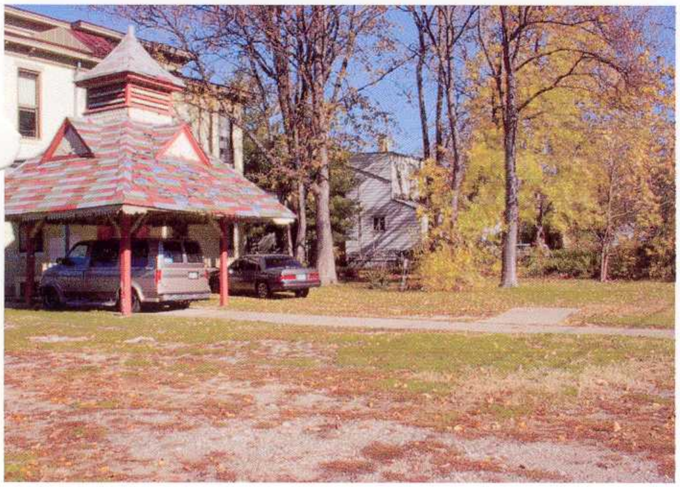
Deaf Community Center: 57.6 dBA
Philip Morris: 63.4 dBA
Whayne Supply: 63.8 dBA
Engelhard Corp.: 68.4 dBA

The Ldn at the Deaf Community Center was the lowest, first because it was in the most noise-sheltered location (not near any traffic and all intrusive Leqs were low), but more importantly, because the nighttime Leq was considerably below that of the other sites: adding 10 dB to those lower nighttime levels did not add much more energy than the daytime levels added at the other sites.

The Ldn at the Engelhard Corp. site was the highest partly because there was an almost constant audible sound from the plant, but primarily because the measurement location was not far from a busy intersection with a stop light (35th and Bank Streets) which featured virtually constant traffic, many loud vehicles (including trucks, buses, and motorcycles) and many vehicles generating higher than normal sound levels during acceleration away from the traffic light.

APPENDICES


Engelhard
Deaf Comm. Ctr.
Philip Morris
Whayne Supply
Area covered by map of Central Louisville on reverse side
SHAWNEE GOLF COURSE
SHAWNEE PARK
Ohio River
SHIVELY
CHURCHILL DOWNS
KENTUCKY FAIR AND EXPOSITION CENTER
RIVERSIDE PKWY
BROADWAY
HENRY WATTERSON EXPWY
SHAWNEE EXPWY
SOUTHERN PKWY
TAYLOR BLVD
DIXIE HY.
7TH ST. RD.
CANE RUN RD
ALGONQUIN PKWY
CAMP GROUND ROAD
WINKLER AV
BERRY BLVD.
MAIN
MARKET
JEFFERSON
MUHAMMAD ALI BLVD
CHESTNUT
OAK ST
KENTUCKY
BRECKINRIDGE
NORTH-SOUTH EXPWY
Highland Park
Lower Albany
Louisville Memorial Gardens (Cemetery)
Hazelwood Sanitorium
St. Mary and Elizabeth Hospital
Holy Rosary Acad.
Simmons University
Port of Louisville
Belle of Louisville



Deaf Community Center.
Looking toward adjacent residence.

Deaf Community Center.
Looking toward alley & Bell South.

Whayne Supply Site.
Looking toward school.

Whayne Supply site.
Looking toward Whayne Supply.

Engelhard Site.
Looking toward Bank St. residence.

Engelhard site.
Looking South East to adjacent building.