DATE, 20XX

To: Project Manager (HRSD)
Real Estate Manager (HRSD)
Chief of Design & Construction/SWIFT/Special Projects (HRSD)

From: Design Engineer, PE (FIRM)

Re: Insert Project Name
Preconstruction Assessment and Damage Mitigation Memorandum

Preconstruction Assessment and Damage Mitigation

DRAFT STATUS

Introduction

In recent years, HRSD has received an increasing number of complaints from residents and locality staff regarding the condition of roads, sidewalks, drainage ditches, private property, damage to buildings, etc. within close proximity to active construction. This assessment provides evaluation of the potential construction related impacts to the surrounding area as well as monitoring and potential remediation strategies.

Project Background

The Providence Road Off-Line Storage Facility (PROLSF) is a partially buried 5.2-million-gallon storage tank to be constructed within the City of Virginia Beach's Woodstock Park. that will divert flow during peak events, store flow until system pressures subside, and return stored flows back into the HRSD system. This facility is critical to the successful diversion of CETP flow to ATP during wet weather conditions and therefore, must be fully operational by June 2021. The PROLSF will include a storage tank, pump station, control room and dry well. Specific work includes demolition of the existing site facilities, construction of buried and above grading piping, tank foundation and associated pile supports, incidental concrete work, site work and stormwater system improvements, instrumentation and control systems, HVAC systems, odor control systems, potable water systems, flushing/cleaning systems and all other incidental electrical, I&C ,structural work, park improvements and new skate park. The Design-Build team of Crowder Construction & Hazen and Sawyer were selected for this project.

1. Construction Impact Research and Evaluation

For the PROLSF, Preconstruction Assessment and Damage Mitigation evaluation was based upon Section 11 of HRSD's Design and Construction Standards dated January 2019. The design-build team utilized a 4-phase construction activity approach as shown in Table 1. Specific equipment assigned to each phase of work is further detailed in the phased construction tables provided in Appendix A – Figure 1.1 through Figure 2

Table 1

PHASE	ACTIVITY	DESCRIPTION
1	Excavation	Activities consist of installation of erosion and sediment control elements, sediment traps, tree removal, demolition of existing onsite structures, tank excavation and dewatering.
2	Pile Driving	Activities consist of pile driving for the tank foundation and continuous dewatering operations.
3	Tank & Utility Construction	Activities consist of concrete placement for the tank, installation of below ground utilities, restroom facilities and playground components.
4	Backfill & Grading	Activities consist of backfilling of soils for tank and final grading.

Construction impact research and investigations for this design-build project and related activities on the Woodstock Park site considered means and methods of the proposed work and was based on direct input from the Crowder team in combination with Hazen's design team's analysis of the following anticipated construction related impacts:

- Noise Generation and Impacts from construction equipment such as dewatering pumps, excavators, dump trucks, dozers, compactors and pile driving.
- Vibration Impacts from construction equipment such as excavators, dump trucks, dozers, compactors and pile driving.
- Dewatering Impacts on Ground Structures and Settlement as they relate to the extents of the cone of depression for the ground watering operations.

2. Risk Mitigation Analysis and Recommendations

2.0 Noise Generation and Impacts

Noise Generation and Impacts were calculated using the Federal Highway Administration's (FHWA) Roadway Construction Noise Model (RCNM) version 1.1. The model predicts the noise generated at the identified receptors by applying related historic noise data associated with each piece of equipment. See Appendix B for detailed information related to the RCNM. Each

construction phase was modeled based on the proximity of the construction activity identified in Table 1. Specific equipment for each phase/activity were provided by Crowder and combined within their respective areas of application to predict the noise generated for each phase. See Appendix A Figure 1.1 – Figure 1.4 for phase maps and tabular results of the noise generation and impact analysis. Noise Levels for this analysis were calculated for L_{10} and L_{max}. L_{10} is the noise level exceeded for 10% of the time of the measurement duration. This is often used to give an indication of the upper limit of fluctuating noise, such as that from road traffic. L_{max} is the highest noise level for the measuring period.

2.0.1 Noise Reduction

While the distance between each noise source and receptor was considered, an additional estimated noise shielding of 3 dBA was utilized in the calculations to account for noise reduction associated with existing vegetation and change in topography. Understanding that existing site vegetation and soil stockpile(s) will provide additional shielding, 3 dBA is considered conservative (less than a whisper). Typical Threshold of Hearing comparisons are shown in Figure 1.

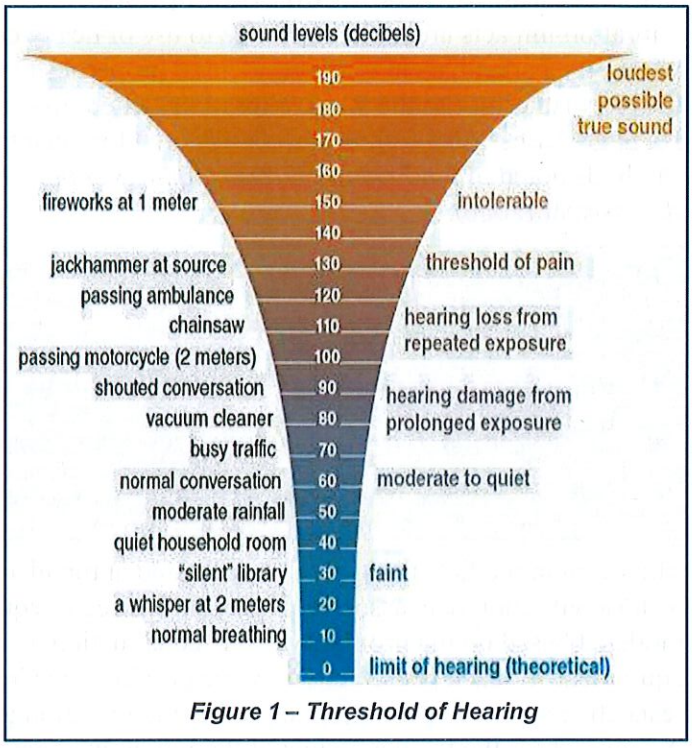


Figure 1 – Threshold of Hearing

2.0.2 Time of Day Considerations

Acceptable noise levels are compared with Daytime, Evening and Nighttime Baseline noise levels with relative decreasing baselines and exceedance limits. The PROLSF project will limit construction work hours to 7 a.m. to 5 p.m. Monday-Friday, therefore, Daytime Noise Limits were used as the exceedance metric. The only exception to the time of day consideration is use of dewatering pumps. The dewatering pumps will run constantly to maintain the necessary ground water levels required for the project. Therefore, noise related to dewatering pumps was compared to nighttime baseline noise levels and measured relative to the nighttime noise exceedance limits.

2.0.3 Noise Analysis Results

A summary of the predicted noise levels indicates that individual and combined calculated noise levels for the subject project exceed the noise limits (L_{10} and L_{max}) in some instances ranging from 0 (dBA) – 22.9 (dBA). The predicted exceedance(s) are considered minimal as 30 dBA is considered "faint". See Figure 1 for various noise level characterizations. See Appendix A Figure 1.1 – Figure 1.4 for phase maps and tabular results of the noise generation and impact analysis.

2.0.4 Noise Mitigation Recommendations

- Monitor and document baseline noise levels at three or more locations near the identified receptor boundary during non-working periods.
- Monitor and document noise levels at the same receptor locations during the peak activity period.
- Use a Type 2 / Class 2 sound level meter that meets or exceeds IEC 61672

2.1 Vibration Generation and Impacts

Vibration impacts are anticipated due to use of heavy equipment and pile driving activities within the park adjacent to the residential properties to the East, Dominion Energy facilities to the North and I-64 to the West. Vibration Generation and Impacts were analyzed based upon the Damage Assessment formula (*shown below*) for Quantitative Construction Vibration Assessment Methods noted in the *Federal Transit Administration (FTA), Transit Noise and Vibration Impact Assessment (2006).*

$PPV_{equip} = PPV_{ref} x\ (25/D)^{1.5}$

where:

- *PPV(equip) is the peak particle velocity in in/sec of the equipment adjusted for distance*
- *PPV(ref) is the reference vibration level in in/sec at 25 feet*
- *D is the distance from the equipment to the receiver.*

The formula predicts the vibration generated at the identified distance by applying related historic vibration data associated with each piece of equipment. Each construction phase was modeled based on the proximity of the construction activity identified in Table 1. Specific equipment for each phase/activity were provided by Crowder and combined within their respective areas of application to predict the vibration generated for each activity. See Appendix A Figure 2 for the tabular results of the vibration generation and impact analysis.

2.1.1 Projected Vibrations Associated with Pile Driving

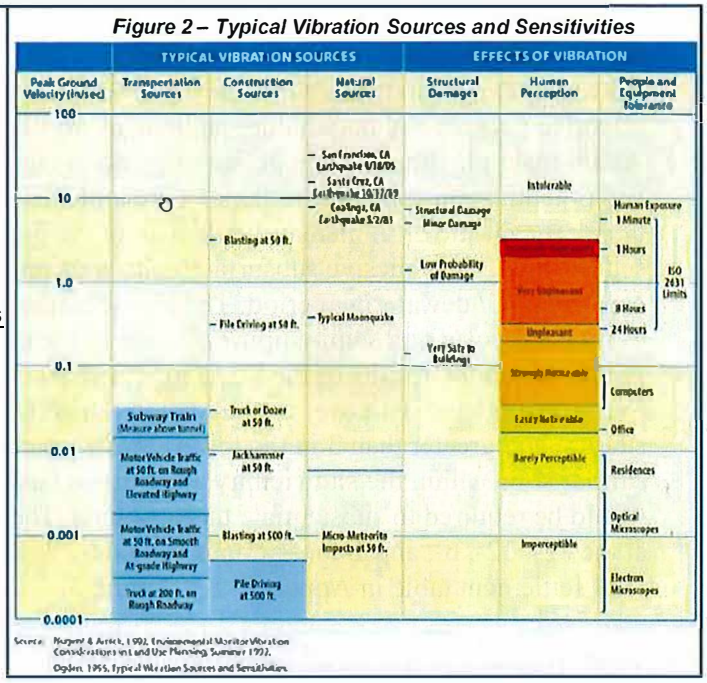
When considering the suitability of a driven pile foundation, consideration should be given to the integrity of nearby structures. Due to the large amount of energy required to install driven deep foundations, vibrations of considerable magnitude are generated. These vibrations may affect nearby structures. These structures can, due to their proximity, be detrimentally affected by the construction unless proper protection measures are taken. In addition, experience has shown that these construction features will often lead adjacent property owners to conclude that damage to their property has taken place, even though none has occurred. Geotechnical analysis for the project site indicates that vibrations should only be considered an issue for structures within 200 ft. of the pile driving activity. This conclusion is further supported by the vibration projections provided herein. Appendix A Figure 2 shows the extents of the 200 ft offset that represents the

area of projected impacts. See Section 2.1.3 for specific recommendations associated with the vibration analysis.

2.1.2 Vibration Analysis Results

A summary of the predicted vibration levels indicates that individual calculated vibration levels for the subject project range from 0.0001 PPV to 0.0677 PPV. The high-end vibration predictions are generated from the utility installation along the Eastern boundary of the project site and are primarily influenced by the proximity to the receptor. While considered to be "strongly noticeable", vibrations at this level are considered to be "very safe to buildings". See Figure 2 for Typical Vibration Sources and Sensitivities.

Figure 2 – Typical Vibration Sources and Sensitivities



2.1.3 Vibration Mitigation Recommendations

- Prepare a vibration monitoring plan per specification section 02367. The plan shall include the following:
  - Photo documentation of the condition of all site structures that will remain during construction, in particular documentation of the Dominion Energy structures.
  - Monitor and document baseline vibration levels at three or more locations near the identified receptor boundary during non-working periods.
- Monitor and document vibration levels at the same receptor locations during the peak activity period.

2.2 Groundwater Dewatering Impacts

Excavations within the footprint of the PROLSF storage tank and pump station will extend to depths of up to 29 feet below existing site grades, corresponding to ELEV -9 for a duration of approximately 12 months. Considering the depth of the excavation and the observed groundwater levels within the proposed tank and pump station footprint, significant dewatering operations are expected. Lowering the groundwater table during dewatering activities will result in an increase in effective stresses and may induce settlements of the soils underlying adjacent structures/pavements. Additionally, hydraulic compaction of predominately granular soils (e.g. SP, SP-SM, SM soils) and potential consolidation settlement is anticipated as a result of lowering the groundwater table.

2.2.1 Dewatering Analysis

Griffin Dewatering, LLC (Griffin) was selected to analyze, design and provide the necessary dewater system for the PROLSF site. Griffin analyzed the dewatering for the excavations utilizing a series of analytical equations for estimating the flow from radial source in an unconfined aquifer (Thiem Equation). The radius of influence of the system was estimated using an empirical relationship developed by Sichart and Kryieleis. Results of the radius of influence analysis are depicted in Appendix A – Figure 3 as drawdown contour lines.

2.2.2 Dewatering/Settlement Analysis

Lowering the groundwater table during dewatering activities will result in an increase in effective stresses and may induce settlements of the soils underlying adjacent structures. Additionally, hydraulic compaction of predominately granular soils (e.g. SP, SP-SM, SM soils) and potential consolidation settlement are anticipated as a result of lowering the groundwater table. The elastic or immediate settlement of the granular subsurface soils, and consolidation settlement of the cohesive subsurface soils were analyzed for the projected 12-month construction / dewatering period. The elastic settlement of the subsurface granular soils was evaluated by use of a semi-empirical strain influence factor proposed by *Schmertmann and Hartman* and the results of the Standard Penetration Tests. The cohesive soils are estimated to be over-consolidated with over consolidation ratios (OCR) of approximately 1.5 in the upper CLAY stratum and greater than 3 in the lower CLAY stratum. These OCR's were estimated based on similar soils within the site vicinity and limited laboratory testing (additional laboratory testing would be required to substantiate these values). The total settlement magnitudes were calculated at the 18-, 12-, 6-, and 2-foot groundwater drawdown contour lines depicted in the estimated total settlement table in Appendix A – Figure 3.

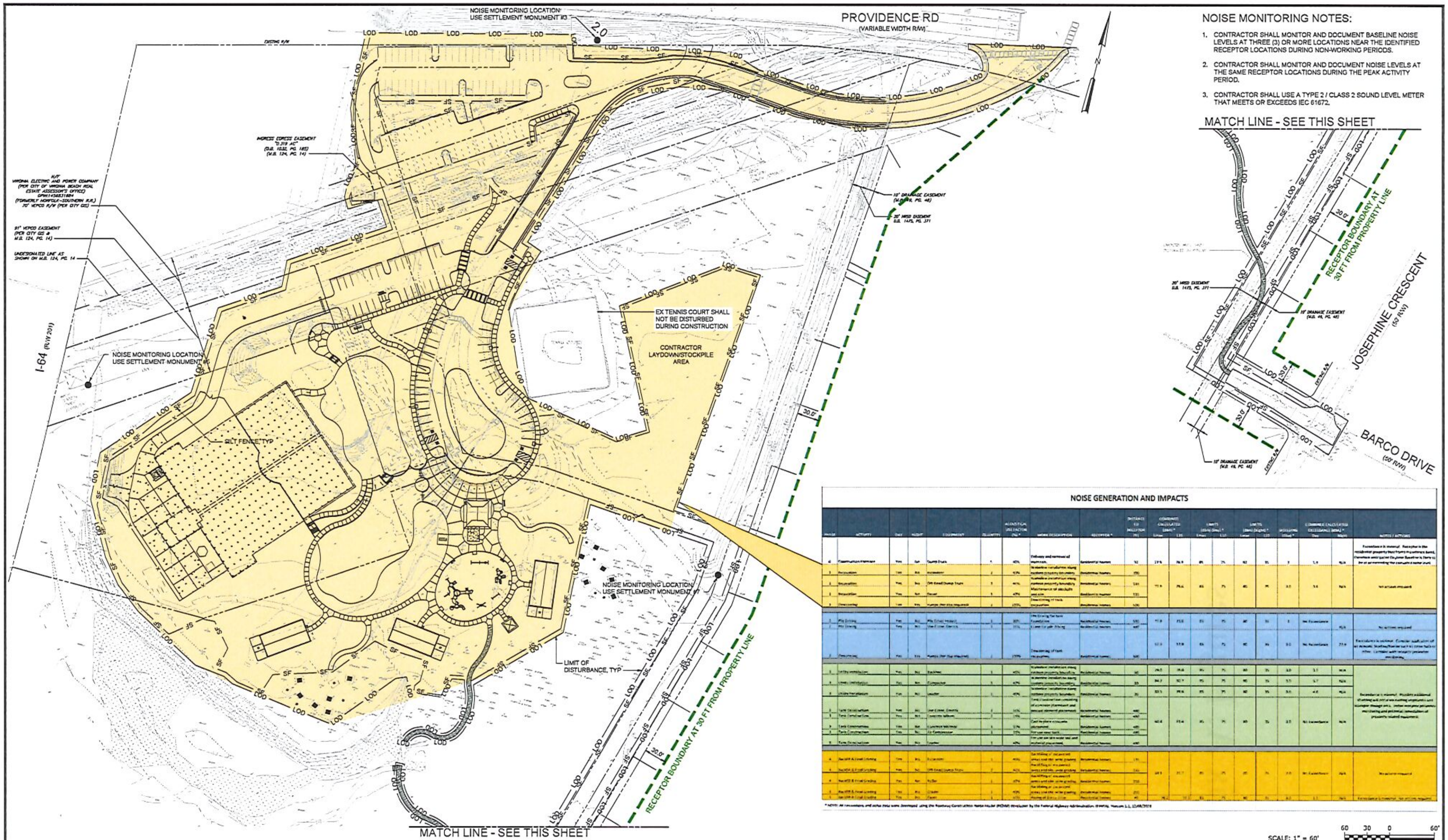
2.2.3 Dewatering Mitigation Recommendations

- Place settlement monuments for tracking elevation changes and monitor/document at regular intervals.
- Should settlement become evident contractor should develop a plan for remediation of estimated total settlement related to dewatering.

2.3 Odor Impacts - Insert finding and recommendations

2.4 Dust Impacts - Insert finding and recommendations

Appendix A: Figures



NOISE MONITORING NOTES:

1. CONTRACTOR SHALL MONITOR AND DOCUMENT BASELINE NOISE LEVELS AT THREE (3) OR MORE LOCATIONS NEAR THE IDENTIFIED RECEPTOR LOCATIONS DURING NON-WORKING PERIODS.
2. CONTRACTOR SHALL MONITOR AND DOCUMENT NOISE LEVELS AT THE SAME RECEPTOR LOCATIONS DURING THE PEAK ACTIVITY PERIOD.
3. CONTRACTOR SHALL USE A TYPE 2 / CLASS 2 SOUND LEVEL METER THAT MEETS OR EXCEEDS IEC 61672.

PROJECT ENGINEER:	T. McPHERSON
DESIGNED BY:	T. McPHERSON / C. LINK
DRAWN BY:	M. BRANDT
CHECKED BY:	T. McPHERSON
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE	

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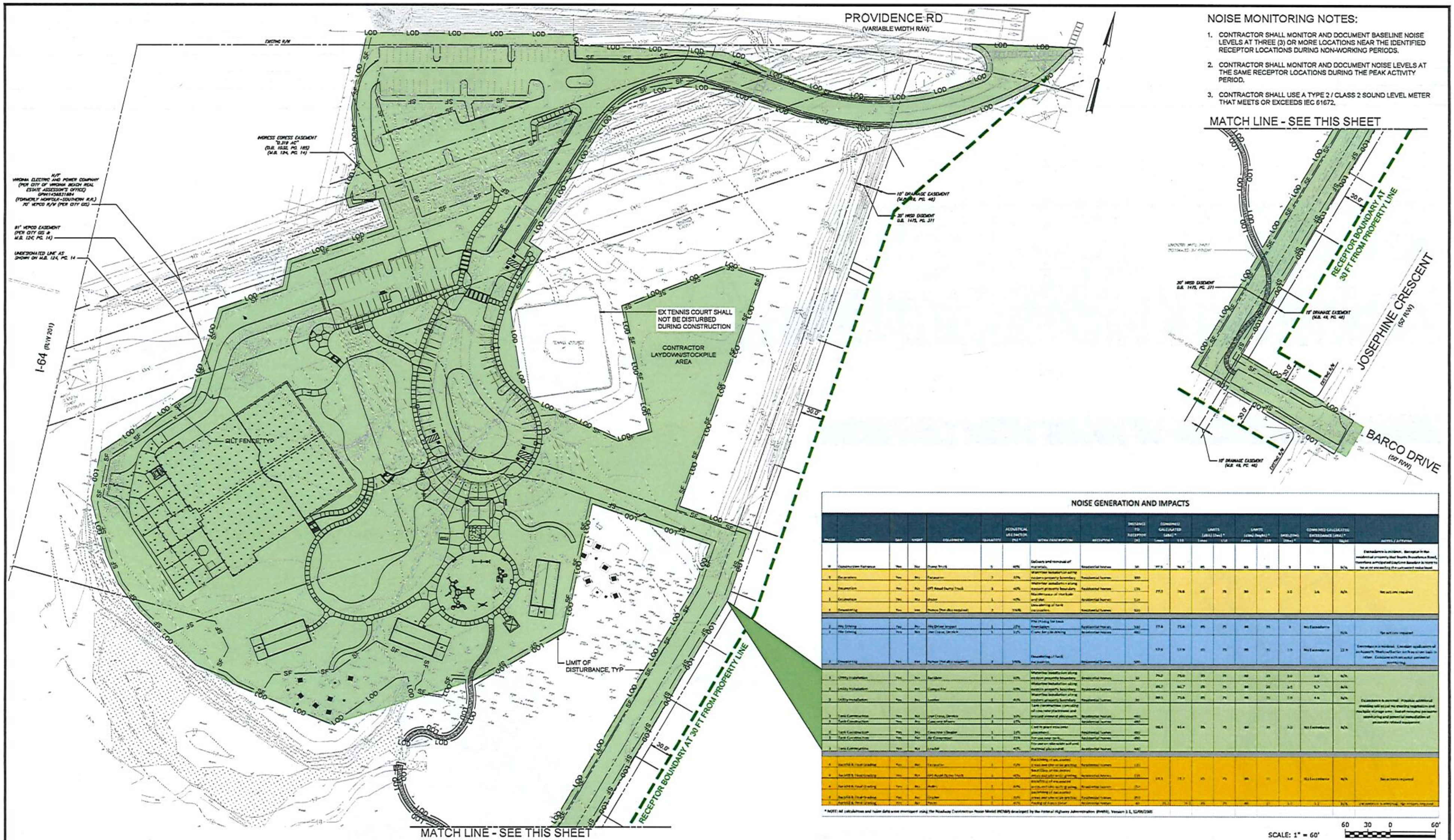
City of Virginia Beach

HRSD

PROVIDENCE ROAD OFF-LINE STORAGE FACILITY AND WOODSTOCK PARK IMPROVEMENTS

PRECONSTRUCTION ASSESSMENT AND DAMAGE MITIGATION PLAN
NOISE GENERATION AND IMPACTS
PHASE 1
EXCAVATION AND DEWATERING

DATE:	AUGUST 2019
HAZEN NO.:	31419-000
FIGURE NO.	1.1



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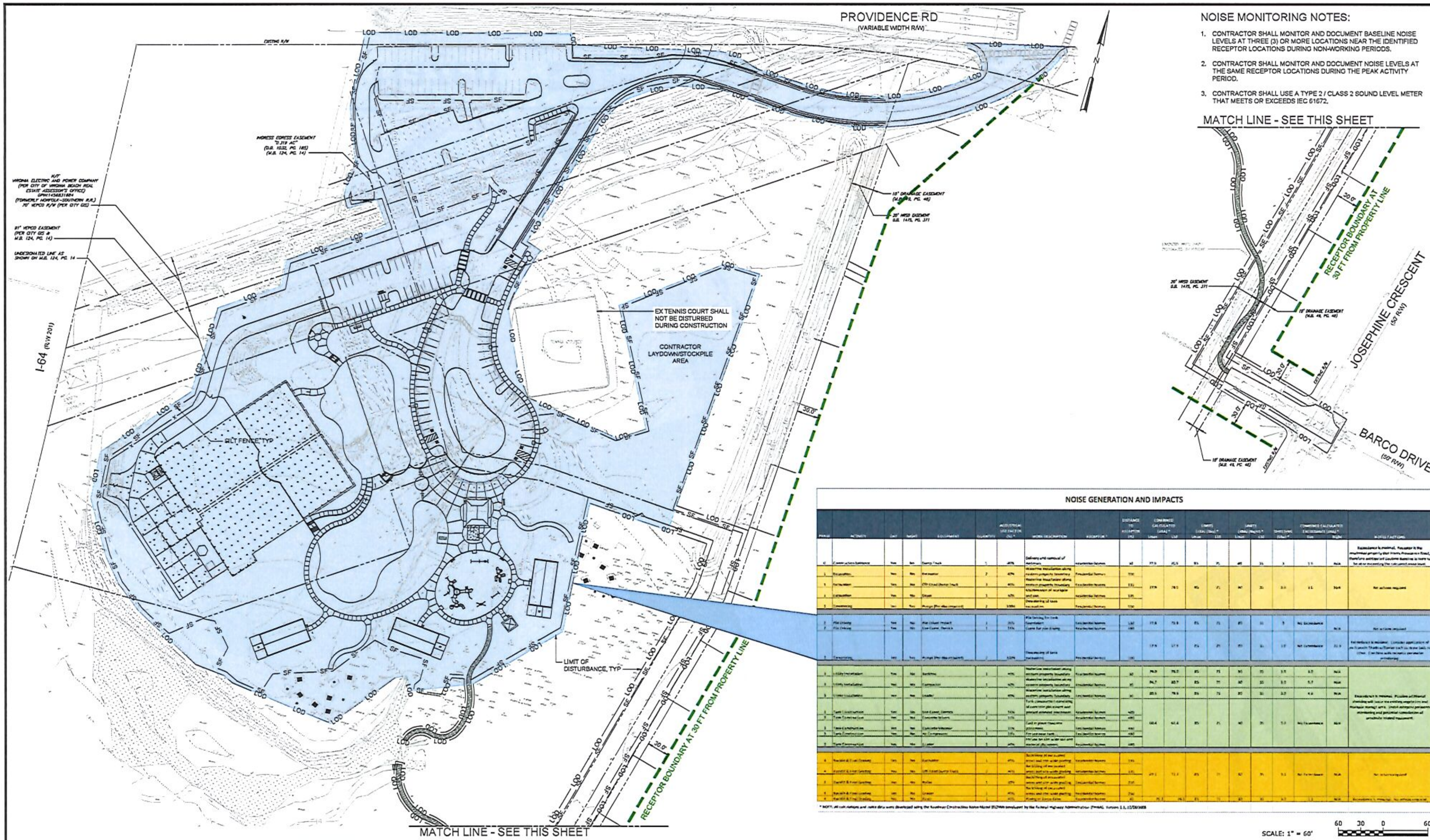
PRECONSTRUCTION ASSESSMENT AND DAMAGE MITIGATION PLAN
NOISE GENERATION AND IMPACTS
PHASE 3
UTILITY AND TANK CONSTRUCTION

DATE:	AUGUST 2019
HAZEN NO.:	31419-000
FIGURE NO.	1.3



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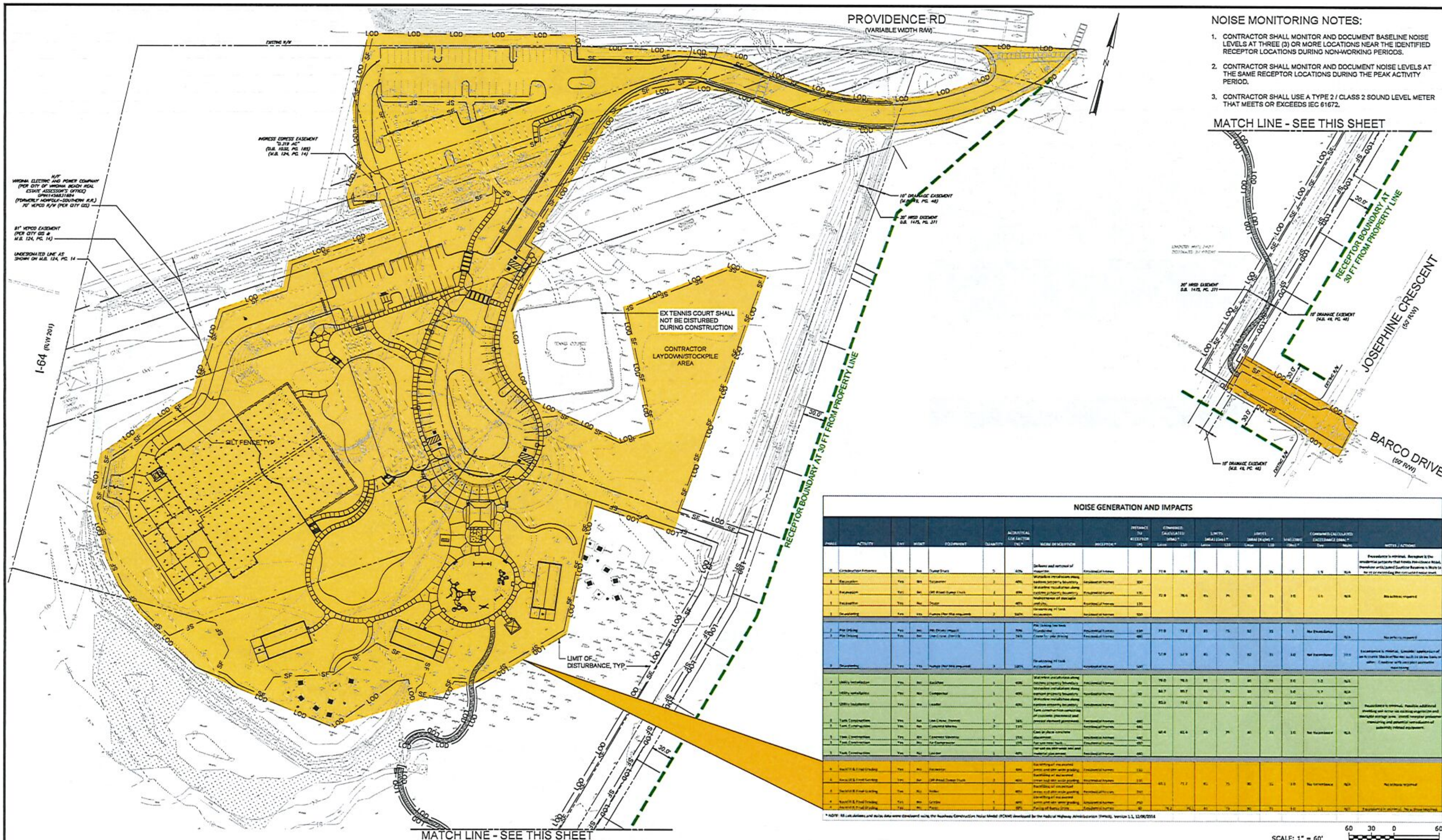
PRECONSTRUCTION ASSESSMENT AND DAMAGE MITIGATION PLAN
NOISE GENERATION AND IMPACTS
PHASE 2
PILE DRIVING

DATE:	AUGUST 2019
HAZEN NO.:	31419-000
FIGURE NO.	1.2



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2. CONTRACTOR SHALL MONITOR AND DOCUMENT NOISE LEVELS AT THE SAME RECEPTOR LOCATIONS DURING THE PEAK ACTIVITY PERIOD.
3. CONTRACTOR SHALL USE A TYPE 2 / CLASS 2 SOUND LEVEL METER THAT MEETS OR EXCEEDS IEC 61672.

NOISE GENERATION AND IMPACTS

PHASE	ACTIVITY	DAY	NIGHT	EQUIPMENT	QUANTITY	ACOUSTICAL USE FACTOR (%)*	WORK DESCRIPTION	RECEPTOR*	DISTANCE TO RECEPTOR (FT)	COMBINED CALCULATED (dBA)* Lmax	L10	LIMITS (dBA) (Day)* Lmax	L10	LIMITS (dBA) (Night)* Lmax	L10	SHIELDING (dBA)*	COMBINED CALCULATED EXCEEDANCE (dBA)* Day	Night	NOTES / ACTIONS
0	Construction Entrance	Yes	No	Dump Truck	[illegible]	40%	Delivery and removal of material	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	[illegible]
1	Excavation	Yes	No	Excavator	[illegible]	40%	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	No actions required
1	Excavation	Yes	No	Off Road Dump Truck	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
1	Excavation	Yes	No	Dozer	[illegible]	40%	[illegible]	Residential Homes	[illegible]										
1	Dewatering	Yes	Yes	Pumps [illegible]	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
2	Pile Driving	Yes	No	Pile Driver (Impact)	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No Exceedance	N/A	No actions required
2	Pile Driving	Yes	No	[illegible]	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
2	Dewatering	Yes	Yes	Pumps [illegible]	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Not Exceedance	[illegible]	[illegible]
3	Utility Installation	Yes	No	Backhoe	[illegible]	40%	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	[illegible]
3	Utility Installation	Yes	No	Compactor	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	
3	Utility Installation	Yes	No	Loader	[illegible]	40%	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	
3	Tank Construction	Yes	No	[illegible]	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No Exceedance	N/A	
3	Tank Construction	Yes	No	Concrete Mixers	[illegible]	[illegible]		Residential Homes	[illegible]										
3	Tank Construction	Yes	No	[illegible]	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
3	Tank Construction	Yes	No	Air Compressor	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
3	Tank Construction	Yes	No	Loader	[illegible]	40%	[illegible]	Residential Homes	[illegible]										
4	Backfill & Final Grading	Yes	No	Excavator	[illegible]	40%	[illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	No Exceedance	N/A	No actions required
4	Backfill & Final Grading	Yes	No	Off Road Dump Truck	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
4	Backfill & Final Grading	Yes	No	Roller	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
4	Backfill & Final Grading	Yes	No	Grader	[illegible]	[illegible]	[illegible]	Residential Homes	[illegible]										
4	Backfill & Final Grading	Yes	No	Paver	[illegible]	[illegible]	Paving of [illegible]	Residential Homes	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	N/A	[illegible]

* NOTE: All calculations and noise data were developed using the Roadway Construction Noise Model (RCNM) developed by the Federal Highway Administration (FHWA), Version 1.1, 12/08/2006

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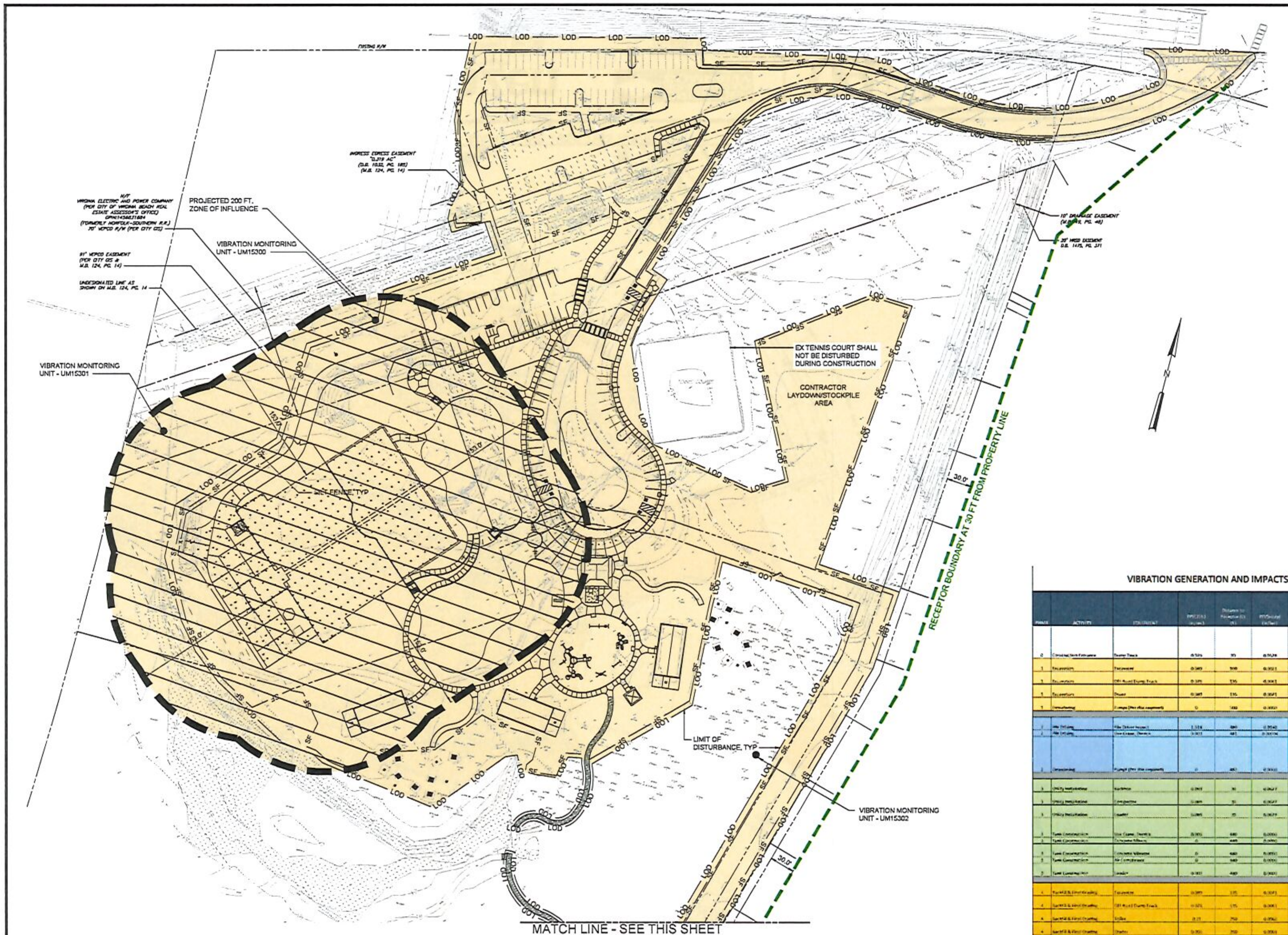
PROVIDENCE ROAD OFF-LINE STORAGE FACILITY AND WOODSTOCK PARK IMPROVEMENTS

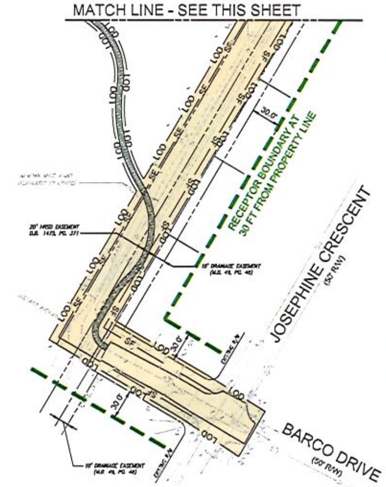
PRECONSTRUCTION ASSESSMENT AND DAMAGE MITIGATION PLAN
NOISE GENERATION AND IMPACTS
PHASE 4
BACKFILL & FINAL GRADING

DATE:	AUGUST 2019
HAZEN NO.:	31419-000
FIGURE NO.	1.4

VIBRATION MONITORING NOTES:

CONTRACTOR SHALL PREPARE A VIBRATION MONITORING PLAN PER SPECIFICATION SECTION 02367. THE PLAN SHALL INCLUDE:
- PHOTO DOCUMENT THE CONDITION OF ALL SITE STRUCTURES WITHIN THE PROJECTED 200 FT. ZONE OF INFLUENCE THAT WILL REMAIN DURING CONSTRUCTION IN PARTICULAR DOCUMENTATION OF THE EXISTING DOMINION ENERGY STRUCTURES.
- MONITOR AND DOCUMENT BASELINE VIBRATION LEVELS AT THREE (3) OR MORE LOCATIONS NEAR THE IDENTIFIED RECEPTOR BOUNDARY DURING NON-WORKING PERIODS.
- MONITOR AND DOCUMENT VIBRATION LEVELS AT THE SAME RECEPTOR LOCATIONS DURING THE PEAK ACTIVITY PERIOD.





VIBRATION GENERATION AND IMPACTS

PHASE	ACTIVITY	EQUIPMENT	PPV(25ft) (in/sec)	Distance to Receptor (D) (ft)	PPV(equip) (in/sec)	NOTES / ACTIONS
0	Construction Entrance	Dump Truck	[illegible]	[illegible]	[illegible]	Noticeable but very safe to buildings
1	Excavation	Excavator	[illegible]	[illegible]	[illegible]	Barely perceptible
1	Excavation	Off-Road Dump Truck	[illegible]	[illegible]	[illegible]	Barely perceptible
1	Excavation	Dozer	[illegible]	[illegible]	[illegible]	Barely perceptible
1	Dewatering	Pumps (Per site equipment)	0	[illegible]	[illegible]	Imperceptible
2	Pile Driving	Pile Driver Impact	[illegible]	[illegible]	[illegible]	Strongly Noticeable but very safe to buildings
2	Pile Driving	Tire Crane, Derrick	[illegible]	[illegible]	[illegible]	Imperceptible
2	Dewatering	Pumps (Per site equipment)	0	[illegible]	[illegible]	Imperceptible
3	Utility Installation	Backhoe	[illegible]	[illegible]	[illegible]	Easily noticeable but very safe to buildings
3	Utility Installation	Compactor	[illegible]	[illegible]	[illegible]	Easily noticeable but very safe to buildings
3	Utility Installation	Loader	[illegible]	[illegible]	[illegible]	Easily noticeable but very safe to buildings
3	Tank Construction	Tire Crane, Derrick	[illegible]	[illegible]	[illegible]	Imperceptible
3	Tank Construction	Concrete Mixers	0	[illegible]	[illegible]	Imperceptible
3	Tank Construction	Concrete Vibrator	0	[illegible]	[illegible]	Imperceptible
3	Tank Construction	Air Compressor	0	[illegible]	[illegible]	Imperceptible
3	Tank Construction	Loader	[illegible]	[illegible]	[illegible]	Barely perceptible
4	Backfill & Final Grading	Excavator	[illegible]	[illegible]	[illegible]	Barely perceptible
4	Backfill & Final Grading	Off-Road Dump Truck	[illegible]	[illegible]	[illegible]	Barely perceptible
4	Backfill & Final Grading	Roller	[illegible]	[illegible]	[illegible]	Barely perceptible
4	Backfill & Final Grading	Grader	[illegible]	[illegible]	[illegible]	Imperceptible
4	Backfill & Final Grading	Paver	[illegible]	[illegible]	[illegible]	Imperceptible

SCALE: 1" = 60'

60 30 0 60'

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DRAWN BY:	M. BRANDT
CHECKED BY:	T. McPHERSON

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE 0 1/2" 1"

Hazen
HAZEN AND SAWYER
4500 MAIN STREET, SUITE 500
VIRGINIA BEACH, VIRGINIA 23462
PHONE: 757 497-0490

CROWDER CONSTRUCTION COMPANY
1111 BURMA DRIVE
APEX, NORTH CAROLINA 27530
PHONE: 800-849-5449

City of Virginia Beach

HRSD

PROVIDENCE ROAD OFF-LINE STORAGE FACILITY AND WOODSTOCK PARK IMPROVEMENTS

PRECONSTRUCTION ASSESSMENT AND DAMAGE MITIGATION PLAN
VIBRATION IMPACTS

DATE: AUGUST 2019
HAZEN NO.: 31419-000
FIGURE NO. 2

NOTES:

1. DEWATERING CONTOURS ARE SHOWN IN RED AND REPRESENT GROUND WATER DRAW DOWN IN FEET FROM EXISTING GROUNDWATER LEVELS.
2. CONTRACTOR SHALL PLACE SETTLEMENT MONUMENTS FOR TRACKING ELEVATION CHANGES AND MONITOR/DOCUMENT AT REGULAR INTERVALS.
3. SHOULD DEWATERING RELATED SETTLEMENT BECOME EVIDENT, CONTRACTOR SHALL PROVIDE A PLAN FOR REMEDIATION.

CONTOUR LINE	ESTIMATED TOTAL SETTLEMENT (IN.)
18 FEET	3 TO 5 INCHES
12 FEET	2 TO 3 INCHES
6 FEET	1 TO 2 INCHES
2 FEET	LESS THAN 1 INCH

SCALE: 1" = 90'

90 45 0 90'

REV	ISSUED FOR	DATE	BY

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE 0 1/2" 1"

PROJECT ENGINEER:	T. McPHERSON
DESIGNED BY:	T. McPHERSON / C. LINK
DRAWN BY:	M. BRANDT
CHECKED BY:	T. McPHERSON

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PROVIDENCE ROAD OFF-LINE STORAGE FACILITY AND WOODSTOCK PARK IMPROVEMENTS

PRECONSTRUCTION ASSESSMENT AND DAMAGE MITIGATION PLAN
DEWATERING IMPACTS

DATE: AUGUST 2019
HAZEN NO.: 31419-000
FIGURE NO. 3

Appendix B: Figures

U.S. Department
of Transportation

**Federal Highway
Administration**

FHWA
Roadway Construction Noise Model
User's Guide

FHWA-HEP-05-054
DOT-VNTSC-FHWA-05-01

Final Report
January 2006

Prepared for
U.S. Department of Transportation
Federal Highway Administration
Office of Environment and Planning
Washington, DC 20590

Prepared by
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13. ABSTRACT (Maximum 200 words)

The Roadway Construction Noise Model (RCNM) is the Federal Highway Administration's (FHWA) national model for the prediction of construction noise. Due to the fact that construction is often conducted in close proximity to residences and businesses, construction noise must be controlled and monitored to avoid impacts on surrounding communities. In addition to community issues, excessive noise can threaten a construction projects' progress. Each project needs to balance the community's need for peace and quiet with the contractor's need to progress the work.

During the Central Artery/Tunnel (CA/T) project in Boston, Massachusetts, the project's noise control program developed the Construction Noise Control Specification 721.560, the most comprehensive noise specification ever developed in the United States. As part of the CA/T project noise control program, a construction noise prediction spreadsheet was developed. Because the CA/T prediction tool can benefit other state and local governments, the FHWA developed the RCNM, which is based on the noise prediction calculations and equipment database used in the CA/T prediction spreadsheet. The RCNM provides a construction noise screening tool to easily predict construction noise levels and determine compliance with noise limits for a variety of construction noise projects of varying complexity.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in) = 2.5 centimeters (cm)
1 foot (ft) = 30 centimeters (cm)
1 yard (yd) = 0.9 meter (m)
1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)

MASS – WEIGHT (APPROXIMATE)

1 ounce (oz) = 28 grams (gm)
1 pound (lb) = 0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp) = 5 milliliters (ml)
1 tablespoon (tbsp) = 15 milliliters (ml)
1 fluid ounce (fl oz) = 30 milliliters (ml)
1 cup © = 0.24 liter (l)
1 pint (pt) = 0.47 liter (l)
1 quart (qt) = 0.96 liter (l)
1 gallon (gal) = 3.8 liters (l)
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F = y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm) = 0.04 inch (in)
1 centimeter (cm) = 0.4 inch (in)
1 meter (m) = 3.3 feet (ft)
1 meter (m) = 1.1 yards (yd)
1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres

MASS – WEIGHT (APPROXIMATE)

1 gram (gm) = 0.036 ounce (oz)
1 kilogram (kg) = 2.2 pounds (lb)
1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

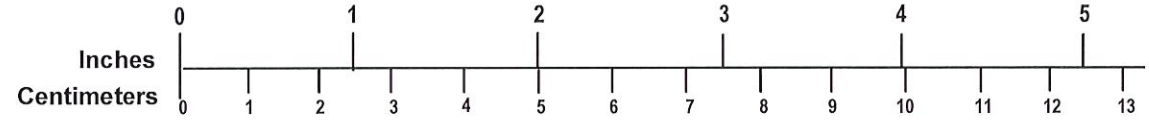
VOLUME (APPROXIMATE)

1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 liter (l) = 2.1 pints (pt)
1 liter (l) = 1.06 quarts (qt)
1 liter (l) = 0.26 gallon (gal)
1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)

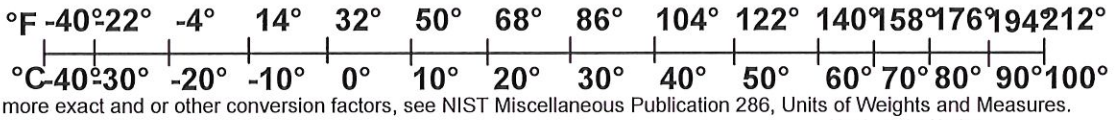
TEMPERATURE (EXACT)

[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures.
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Updated 6/17/98

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1 Introduction

The Roadway Construction Noise Model (RCNM) is the Federal Highway Administration's (FHWA) national model for the prediction of construction noise. Due to the fact that construction is often conducted in close proximity to residences and businesses, construction noise must be controlled and monitored to avoid impacts on surrounding communities. In addition to community issues, excessive noise can threaten a construction project's progress. Each project needs to balance the community's need for peace and quiet with the contractor's need to progress the work.

The Central Artery/Tunnel (CA/T) project in Boston, Massachusetts, which began in the early 1990s, is the largest urban construction project ever conducted in the United States. Its noise control program developed the Construction Noise Control Specification 721.560, the most comprehensive noise specification ever developed in the United States [1]. As part of the CA/T project noise control program, a construction noise prediction spreadsheet was developed [2]. Because the CA/T prediction tool can benefit other state and local governments, the FHWA developed the RCNM, which is based on the noise prediction calculations and the equipment database used in the CA/T prediction spreadsheet. The RCNM provides a construction noise screening tool to easily predict construction noise levels and to determine compliance with noise limits for a variety of construction noise projects of varying complexity.

2 Background

The RCNM is a national model based on the noise calculations and extensive construction noise data compiled for the CA/T Project. The basis for the national model is a spreadsheet tool developed in support of the CA/T project [2]. The CA/T predictions originated from Environmental Protection Agency (EPA) noise level work [3] and an Empire State Electric Energy Research Corp. Guide [4] which utilizes an "acoustical usage factor" to estimate the fraction of time each piece of construction equipment is operating at full power (i.e., its loudest condition) during a construction operation. Table 1 presents a construction equipment noise database compiled through the CA/T project [2]. This database is used to predict construction noise within the RCNM. The noise levels listed represent the A-weighted maximum sound level (Lmax), measured at a distance of 50 feet from the construction equipment.

Table 1. CA/T equipment noise emissions and acoustical usage factors database.

CA/T Noise Emission Reference Levels and Usage Factors					
filename: EQUIPLST.xls					
revised: 7/26/05	Impact	Acoustical Use Factor	Spec 721.560 Lmax @ 50ft	Actual Measured Lmax @ 50ft	No. of Actual Data Samples
Equipment Description	Device ?	(%)	(dBA, slow)	(dBA, slow)	(Count)
				(samples averaged)	
All Other Equipment > 5 HP	No	50	85	-- N/A --	0
Auger Drill Rig	No	20	85	84	36
Backhoe	No	40	80	78	372
Bar Bender	No	20	80	-- N/A --	0
Blasting	Yes	-- N/A --	94	-- N/A --	0
Boring Jack Power Unit	No	50	80	83	1
Chain Saw	No	20	85	84	46
Clam Shovel (dropping)	Yes	20	93	87	4
Compactor (ground)	No	20	80	83	57
Compressor (air)	No	40	80	78	18
Concrete Batch Plant	No	15	83	-- N/A --	0
Concrete Mixer Truck	No	40	85	79	40
Concrete Pump Truck	No	20	82	81	30
Concrete Saw	No	20	90	90	55
Crane	No	16	85	81	405
Dozer	No	40	85	82	55
Drill Rig Truck	No	20	84	79	22
Drum Mixer	No	50	80	80	1
Dump Truck	No	40	84	76	31
Excavator	No	40	85	81	170
Flat Bed Truck	No	40	84	74	4
Front End Loader	No	40	80	79	96
Generator	No	50	82	81	19
Generator (<25KVA, VMS signs)	No	50	70	73	74
Gradall	No	40	85	83	70
Grader	No	40	85	-- N/A --	0
Grapple (on backhoe)	No	40	85	87	1
Horizontal Boring Hydr. Jack	No	25	80	82	6
Hydra Break Ram	Yes	10	90	-- N/A --	0
Impact Pile Driver	Yes	20	95	101	11
Jackhammer	Yes	20	85	89	133
Man Lift	No	20	85	75	23
Mounted Impact Hammer (hoe ram)	Yes	20	90	90	212
Pavement Scarafier	No	20	85	90	2
Paver	No	50	85	77	9
Pickup Truck	No	40	55	75	1
Pneumatic Tools	No	50	85	85	90
Pumps	No	50	77	81	17
Refrigerator Unit	No	100	82	73	3
Rivit Buster/chipping gun	Yes	20	85	79	19
Rock Drill	No	20	85	81	3
Roller	No	20	85	80	16
Sand Blasting (Single Nozzle)	No	20	85	96	9
Scraper	No	40	85	84	12
Shears (on backhoe)	No	40	85	96	5
Slurry Plant	No	100	78	78	1
Slurry Trenching Machine	No	50	82	80	75
Soil Mix Drill Rig	No	50	80	-- N/A --	0
Tractor	No	40	84	-- N/A --	0
Vacuum Excavator (Vac-truck)	No	40	85	85	149
Vacuum Street Sweeper	No	10	80	82	19
Ventilation Fan	No	100	85	79	13
Vibrating Hopper	No	50	85	87	1
Vibratory Concrete Mixer	No	20	80	80	1
Vibratory Pile Driver	No	20	95	101	44
Warning Horn	No	5	85	83	12
Welder / Torch	No	40	73	74	5

3 The RCNM

The RCNM is a computer program used to assess construction noise impacts. The computer on which it is installed should be equipped with the Microsoft Windows 98 or newer operating system (OS) and 192 MB or more of random access memory (RAM). The display should be set to 1024 x 768 pixels or greater, and the computer should carry the Adobe Acrobat 4.0 or newer software.

The RCNM allows the estimation of three key metrics of interest: Lmax, Leq, and L10 at receptor locations for a construction operation that can include up to 20 pieces of equipment. RCNM allows for user-defined construction equipment and user-defined noise limit criteria. The two main uses of the RCNM are to allow typical computer users to: 1. easily predict noise emissions from construction equipment, and 2. determine a construction work plan's compliance with noise criteria limits. A variety of construction work scenarios can be created quickly, allowing the user to determine the impact of changing construction equipment and adding/removing the effects of shielding due to noise mitigation devices such as barriers.

3.1 RCNM Main Page

The RCNM consists of one main display page with Input Data and Results sections, shown in Figure 1.

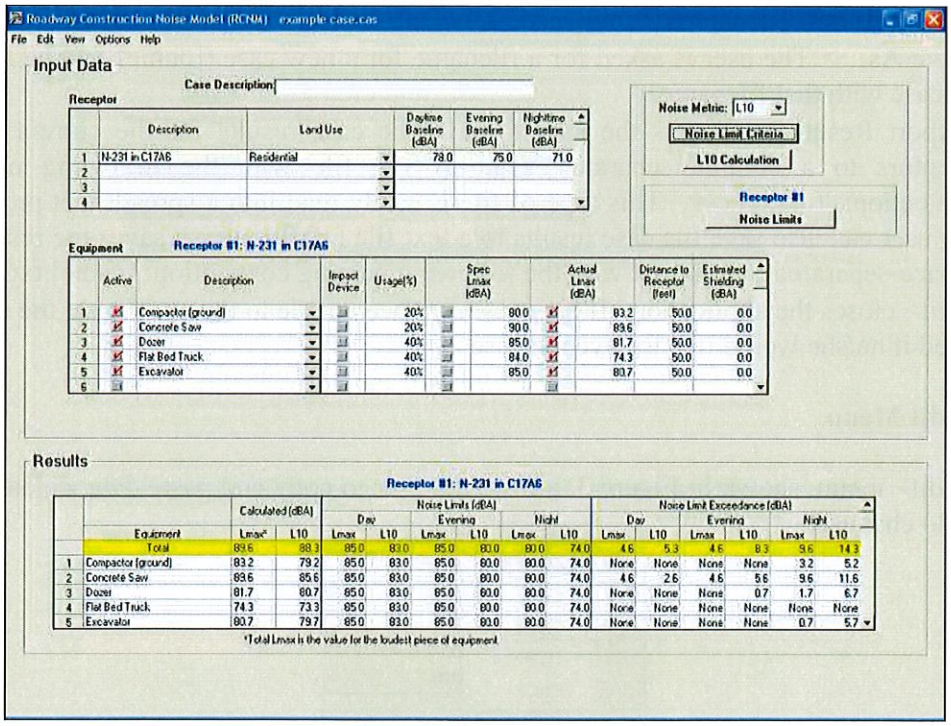

Figure 1. The RCNM main page

Several command buttons and pull-down menus allow the user to modify the input data before results are calculated by the model.

3.1.1 File Menu

The <File> menu, shown in Figure 2, contains items that allow the user to create, open, and save a case, export the results of a case, and exit the program.

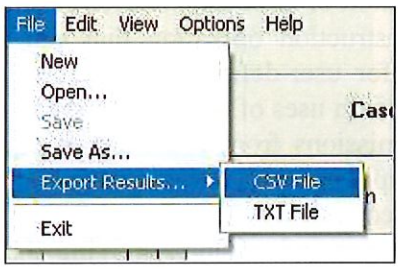

Figure 2. <File> Menu

- <New> creates a new case. If a case is currently open, the user is prompted to save it before closing.
- <Open…> allows the user to open an existing case file ([name].cas).
- <Save> saves the case with the current filename. If this is a new case, the user is asked for a new filename ([name].cas).
- <Save As…> The user is asked for a filename for a new case ([name].cas) and saves the case with that filename.
- <Export Results> prompts the user to save the case results for the current or all receptors to a comma separated value (CSV) file with the following naming convention: [name].csv. This type of file is easily read into a spreadsheet program. The user can also save the case results to a text file (TXT), which saves the results to a space-separated text format with the following naming convention: [name].txt.
- <Exit> closes the application. If changes have been made to the open case, the user is asked if he/she would like to save the case.

3.1.2 Edit Menu

The <Edit> menu, shown in Figure 3, allows the user to copy and paste data, delete data, and undo changes.

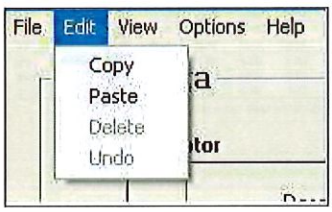

Figure 3. <Edit> Menu

- <Copy> lets the user copy into a clipboard the contents of a single cell or an entire line from an RCNM dialogue box.
- <Paste> lets the user copy the contents of the clipboard into a single cell or an entire line of an RCNM dialogue box.
- <Delete> lets the user delete from the case a receptor or piece of equipment selected in the receptor or equipment dialogue box.
- <Undo> lets the user revert the RCNM one step to where it was before the latest change was made.

3.1.3 View Menu

The <View> menu, shown in Figure 4, allows the user to focus in <Zoom +> on either the Input Data or Results section of the RCNM's main page. To activate Zoom +, click on Zoom + and guide the spyglass + icon to either Input Data or Results and single-click.

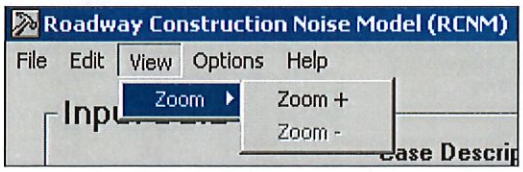

Figure 4. <View> Menu

To deactivate Zoom + and go back to the full RCNM screen, click on Zoom – and guide the spyglass – icon to the Input Data or Results section that has been maximized on the screen.

3.1.4 Options Menu

The <Options> menu, shown in Figure 5, allows the user to modify the equipment list and change the case's units of measure from feet to meters.

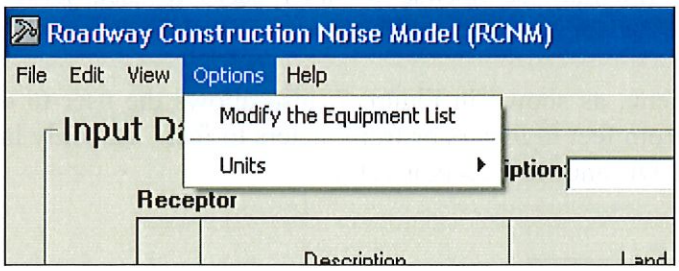

Figure 5. <Options> menu

The <Options> menu allows the user to add new types of equipment to the equipment list. The equipment list modification dialogue box, shown in Figure 6, allows the user to specify a user-defined piece of equipment and add it. The user can specify the following

data: whether the equipment is an impact device, the equipment's usage factor[1], and the equipment's Lmax level (spec and/or actual[2]). The user can also delete equipment that's been added by selecting it and clicking the delete button. The default equipment cannot be modified, but it may be deleted entirely from the case by selecting it and clicking the delete button. Selecting the default button restores the default equipment list (from the CA/T Project) and eliminates any user-defined equipment.

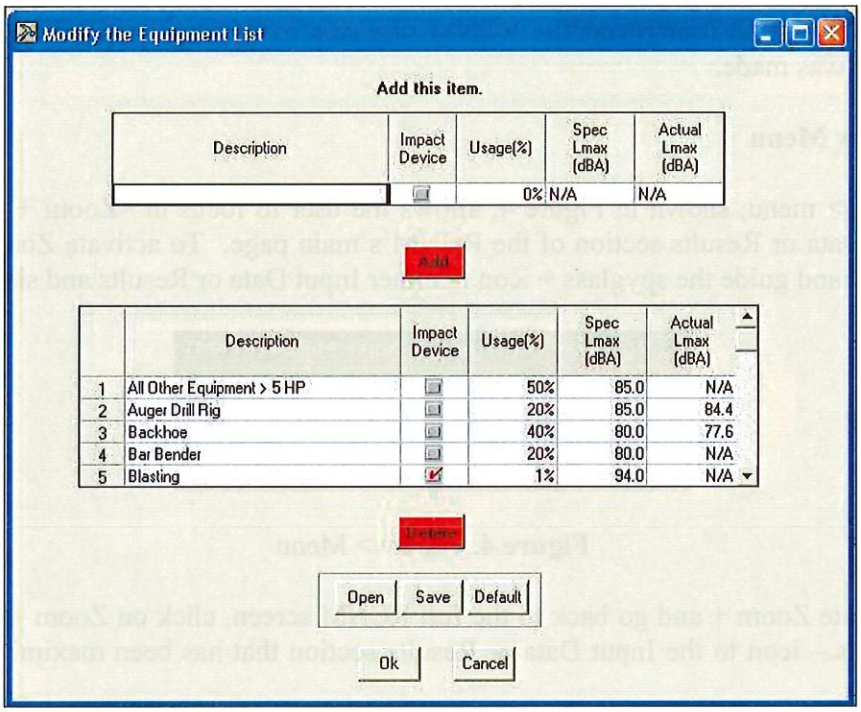

Figure 6. Equipment list modification dialogue box

Data for user-defined pieces of equipment may be saved to an equipment file ([name].equ), along with all other equipment in the current list, including default equipment. This file may be opened in other cases to incorporate these pieces of equipment.

The <Options> menu, as shown in Figure 7, also allows the user to change the case's units of measure from feet to meters or from meters to feet. The only input data affected by this tool are the Distance to Receptor values.

[1] Usage factor is the percentage of time during a construction noise operation that a piece of construction equipment is operating at full power. In the case of construction blasting, the equipment gives a very short duration blast, and can be quantified by using a 1% usage factor in the RCNM to allow for some prediction. Never use a usage factor of zero because the log of zero causes a mathematical impossibility. The usage factor term only affects the computation of Leq and L10. The usage factor does not enter into the equation when calculating the more important term for blasting, that being the Lmax.

[2] "Spec" refers to noise levels stated in noise specifications, and "Actual" refers to Lmax values measured at 50 ft from the equipment.

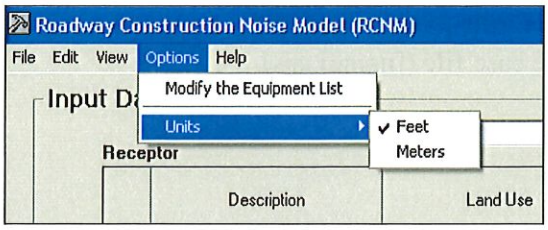

Figure 7. Units modification pull-down menu

3.1.5 Help Menu

The <Help> Menu loads for the user the RCNM User's Guide in Portable Document Format (PDF). This PDF is searchable by key word using the Adobe Acrobat Edit / Find search tool.

3.2 Input Data

The user is required to input receptor data and equipment data before a case can be processed. The user is advised to type in some summary comments about the case in the Case Description dialogue box before inputting data. Also, in order to determine noise limit exceedance values, the user can input noise limit criteria.

3.2.1 Receptors

Multiple receptors may be input for a case, but only one receptor may be processed at a time. The name of the highlighted receptor chosen for processing appears in blue type above the Equipment input dialogue box and the Noise Limits command button (see Figure 1). The user specifies the receptors for a study by entering information into the Receptors input box in the main window of the RCNM. The user is required to enter the receptor name, land use, daytime baseline L10 or Leq, evening baseline L10 or Leq, and nighttime baseline L10 or Leq. The baseline levels indicate the sound level at a receptor before any construction noise contributions. Baseline levels are only necessary if the desired noise criteria limits are based on *relative* increases in noise level. If the desired noise criteria limits are *absolute* noise levels, then the user should insert a placeholder number other than zero.

When entering information for more than one receptor, it may be desirable to copy information already entered. An entire receptor row may be highlighted and copied to another row, where copying multiple rows requires the selection of the same number of rows when pasting (this same functionality also applies to editable cells). Note: Entire rows may be selected by clicking on the row number.

Again, the RCNM will only calculate results for the receptor displayed in blue type in the Input Data portion of the main page. The results for other receptors may be displayed by selecting the desired receptor in the Receptor window; to select a receptor, click in any

cell in the row. Up to 100 receptors may be included in any case. Information for receptors is saved in the case file ([name].cas).

3.2.2 Equipment

Core equipment noise data are stored in the RCNM and are accessible by a pull-down menu in the main page, as in Figure 8.

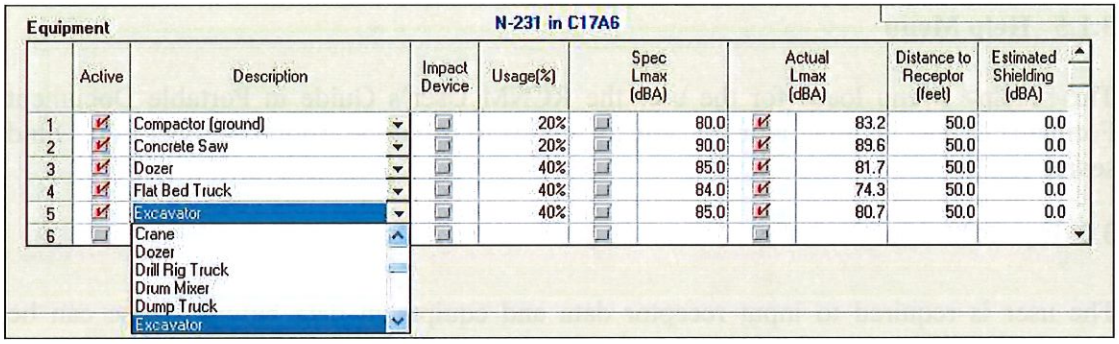

Figure 8. Equipment dialogue box, with pull-down menu shown

As discussed in Section 3.1.4, new pieces of equipment may be added to a case and saved in an equipment file ([name].equ). When the user-defined equipment file is opened through the <Options> / <Modify the Equipment List> menu, user-defined equipment will appear in the equipment pull-down menu. The user activates and inactivates chosen equipment types by ticking and unticking the "Active" checkbox. The user is required to specify:

1. The type of reference emission levels to use ("Spec", if applicable, or "Actual", [the default is "Actual"]);
2. Distance to Receptor – that is, the distance between each type of equipment and the receptor being analyzed (the default distance is 50 feet); and
3. Estimated Shielding (in dBA) associated with each type of equipment (can leave the default value of 0.0 when not considering shielding). **NOTE: A Best Practices document is presented in Appendix A showing how to determine Estimated Shielding using several Rules of Thumb developed from experience at the CA/T project.**

When entering information for more than one piece of equipment, it may be desirable to copy information already entered. An entire equipment row may be highlighted and copied to another row, where copying multiple rows requires the selection of the same number of rows when pasting (this same functionality also applies to editable cells). Note: Entire rows may be selected by clicking on the row number.

The user may analyze up to 20 pieces of equipment at one time, and they may be included in any combination of different or identical equipment types.

3.2.3 Noise Metric and Noise Limit Criteria

While a case is open, the user can choose a noise metric (for baseline levels, noise limits, and calculated results) and enter the noise limit criteria for a local area. The user may edit the Lmax and L10 or Leq day, evening, and night noise limit criteria for a residential, commercial, or industrial area. Daytime, evening, and nighttime may represent any time periods the user wishes, but they are typically defined as 7 AM to 6 PM, 6 PM to 10 PM, and 10 PM to 7 AM, respectively. The criteria, used together with the baseline sound levels, define the noise limits for each receptor. CA/T Noise Limit Criteria are used as a default [1], but users may input their own criteria. The RCNM offers a metric pull-down menu and two or three command buttons to the right of the Receptor input dialogue box.

- Metric Pull-Down Menu

A pull-down menu allows the user to choose between the L10 or Leq metric, as in Figure 9. The chosen metric represents that used for the baseline levels, noise limits, and calculated results. For the noise limits and calculated results, Lmax values are also included.

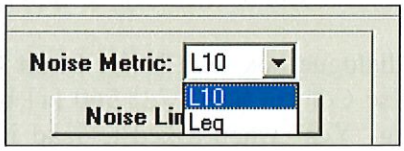

Figure 9. Noise Metric pull-down menu

- Noise Limit Criteria Pop-up Dialogue Box

A pop-up dialogue box allows the user to specify Noise Limit Criteria information for an area being studied in a case, as in Figure 10. The flexibility of the Noise Limit Criteria allows RCNM users to incorporate criteria based on local noise ordinances and baseline levels measured for each receptor.

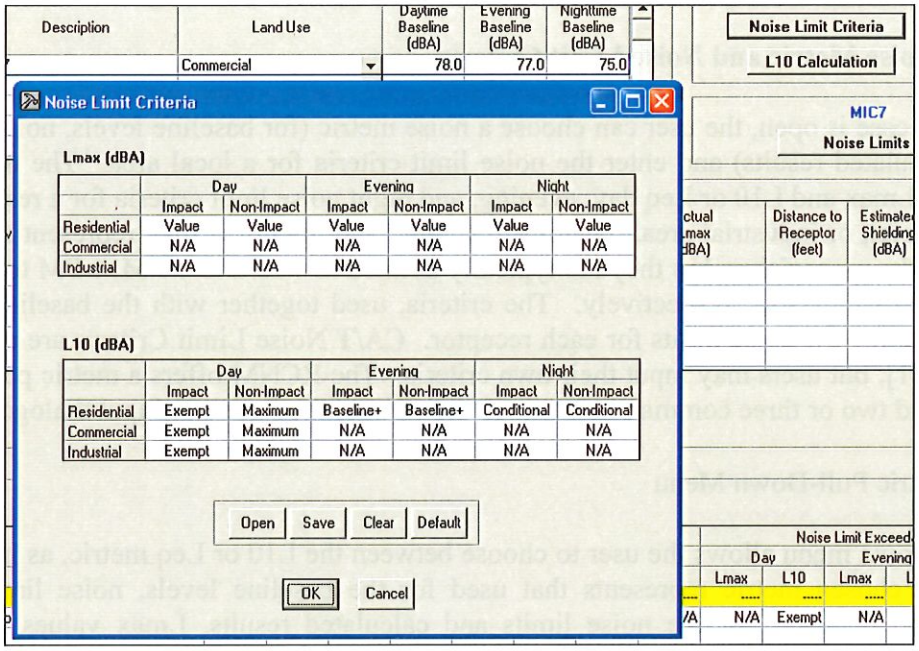

Figure 10. Noise Limit Criteria pop-up dialogue box

The user may populate this dialogue box with Noise Limit Criteria information derived from CA/T Construction Noise Control Spec. 721.560 [1] by clicking on the "Default" command button and clicking "Yes" when asked to load information from the default file, which is stored in the RCNM (see Table 2).

Table 2. Default Noise Limit Criteria

	Daytime (7 AM to 6 PM)		Evening (6 PM to 10 PM)		Nighttime (10 PM to 7 AM)	
Land Use	**L10 Limit (dBA)**	**Lmax Limit (dBA)**	**L10 Limit (dBA)**	**Lmax Limit (dBA)**	**L10 Limit (dBA)**	**Lmax Limit (dBA)**
Residential	maximum of 75 and baseline + 5 for non-impact* and exempt for impact**	85 for non-impact and 90 for impact	baseline + 5	85	if baseline <70 then baseline +5; if baseline ≥70 then baseline + 3	80
Commercial	maximum of 80 and baseline + 5 for non-impact and exempt for impact	N/A	N/A	N/A	N/A	N/A
Industrial	maximum of 85 and baseline+5 for non-impact and exempt for impact	N/A	N/A	N/A	N/A	N/A

* Non-impact equipment is equipment that generates a constant noise level while in operation.

** Impact Equipment is equipment that generates impulsive noise. Impulse Noise is defined as noise produced by the periodic impact of a mass on a surface, of short duration (generally less than one second), high intensity, abrupt onset and rapid decay, and often rapidly changing spectral composition.

Otherwise, the user may clear any information present in the dialogue box and specify new data in each cell. Clicking on the "Clear" command button will prompt the user to set all the cells in the dialogue box to Not Applicable (N/A), as in Figure 11. By clicking "Yes," the user will populate all cells with N/A; by clicking "No," the dialogue box will return to the data present before the user clicked "Clear."

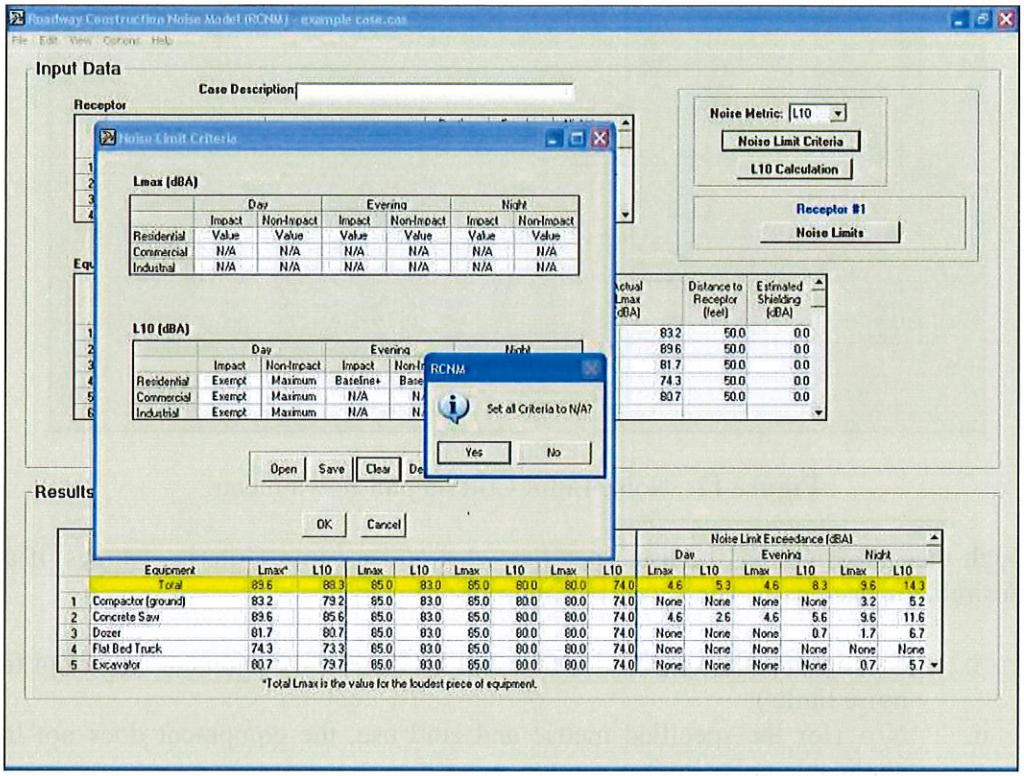

Figure 11. The Noise Limit Criteria "Clear" command button

Clicking on any cell in the Noise Limit Criteria dialogue box reveals a Noise Limit Criteria pull-down menu. Click on this pull-down menu to access the six options, as in Figure 12.

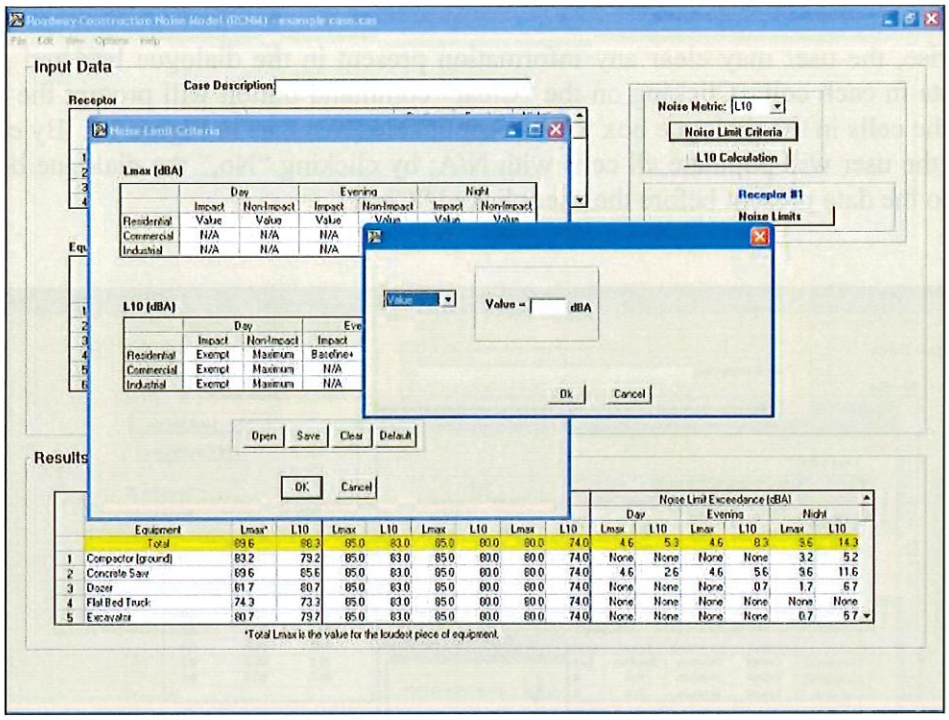

Figure 12. Noise Limit Criteria pull-down menu

Through these six options, the user specifies what Noise Limit Criteria changes, if any, are desirable in each cell. The six cell options are:

i. Exempt (for the specified metric and land use, the equipment is exempt from noise limits)
ii. N/A (for the specified metric and land use, the equipment does not have applicable noise limits)
iii. Value (user is prompted to enter a value for which the noise level should not exceed), as in Figure 13:

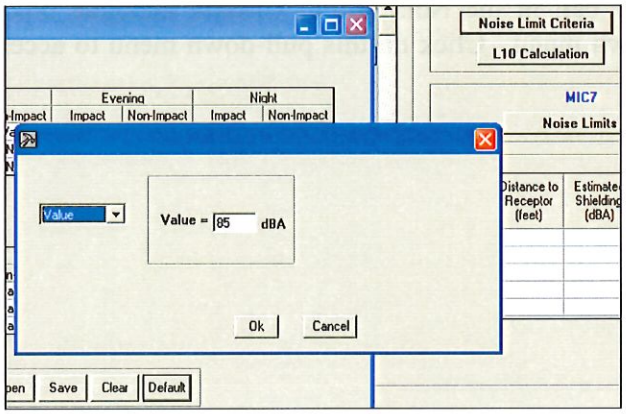

Figure 13. Noise Limit Criteria "Value" dialogue box

iv. Maximum (set value for which a noise level should not exceed to the maximum of two possible levels: A user-defined level or the Baseline level plus some user-defined increment), as in Figure 14:

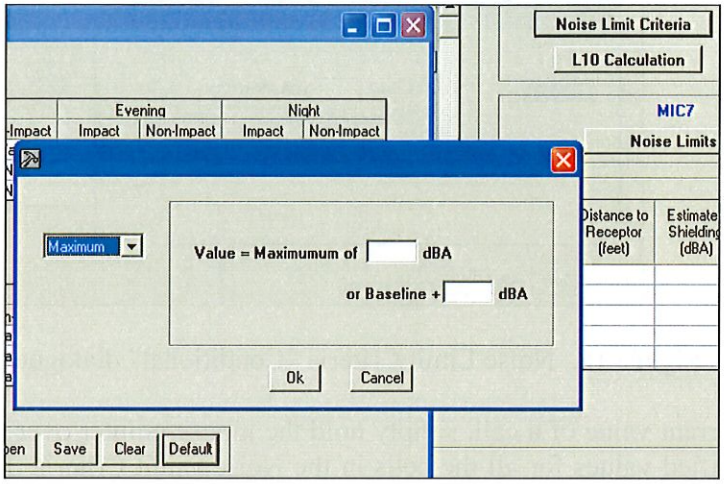

Figure 14. Noise Limit Criteria "Maximum" dialogue box

v. Baseline + (set value for which a noise level should not exceed to the Baseline level plus some user-defined increment), as in Figure 15:

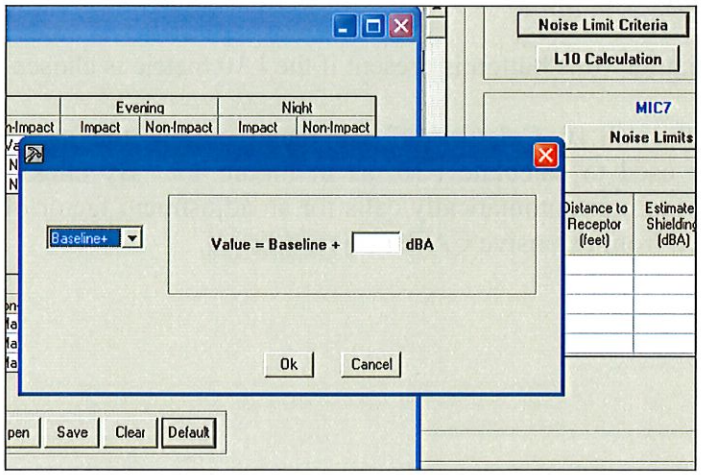

Figure 15. Noise Limit Criteria "Baseline +" dialogue box

vi. Conditional (set conditional value for which a noise level should not exceed; the user is prompted to enter the following information: 1. a comparison value, i.e., "If Baseline < [value], then …"; 2. an increment value to add to the baseline level if the baseline level is *less than* the comparison value; 3. an increment value to add to the baseline level if the baseline level is *greater than or equal to* the comparison value), as in Figure 16:

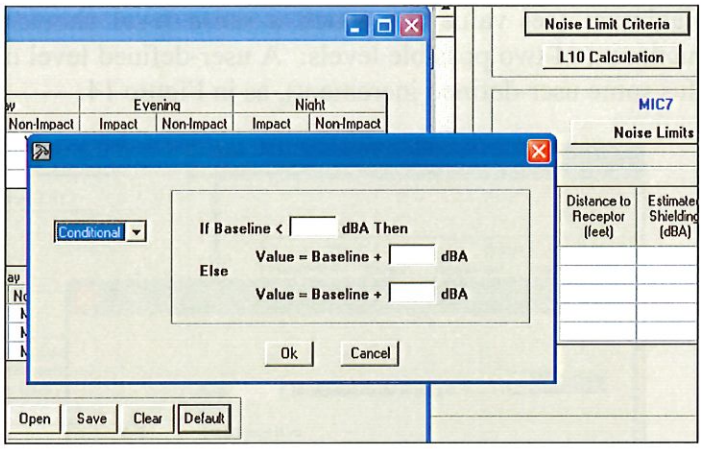

Figure 16. Noise Limit Criteria "Conditional" dialogue box

To see the current value of a cell, simply hold the mouse pointer over the cell. Once the user has specified values for all the cells in the Noise Limit Criteria dialogue box, these criteria can be saved in a criteria file ([name].cri) by clicking on the "Save" command button. The user will be prompted to give the criteria file a name. These criteria can thereafter be loaded into any case by clicking on the "Open" command button.

The user returns to the Noise Limit Criteria dialogue box by clicking "Ok", and returns to the case by clicking "Ok" again.

- L10 Calculation (this button is present if the L10 metric is chosen)

By clicking on the "L10 Calculation" command button, the user can specify the adjustment factor used to calculate L10, as in Figure 17. By clicking the "Default" command button, the user automatically calls for an adjustment factor of 3 dBA, a value empirically derived from extensive CA/T Project data [2].

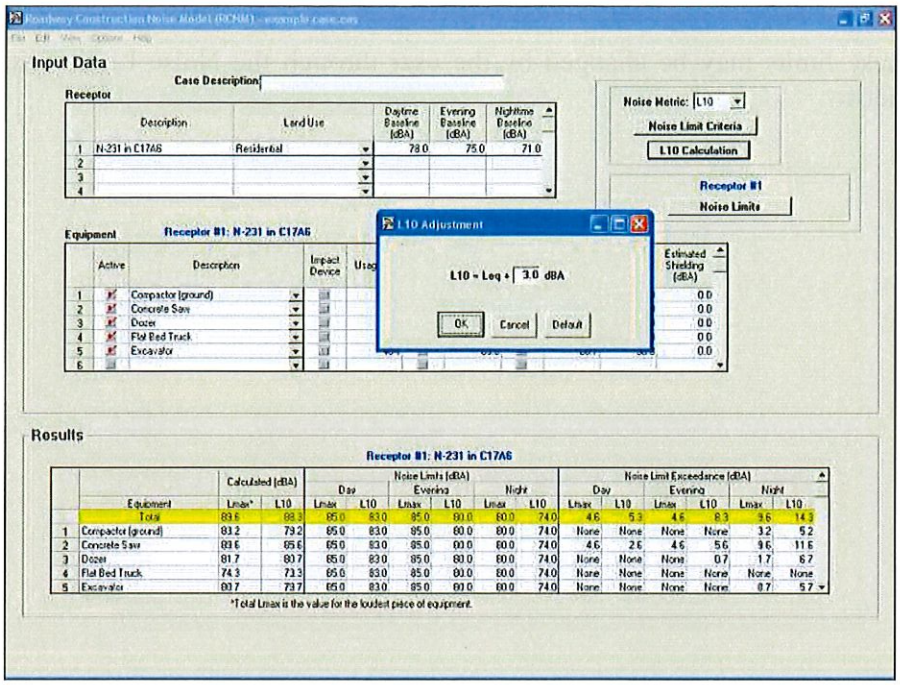

Figure 17. L10 Adjustment dialogue box

- Noise Limits

The "Noise Limits" command button opens a display window that looks exactly like the "Noise Limit Criteria" dialogue box, except that it is not editable, and the only button in the opened window is "Ok". The values in the cells are based on the criteria set in the Noise Limit Criteria window and the baseline levels for the selected receiver, as in Figure 18. (If a receiver is not selected, the dialogue box is unavailable for viewing.)

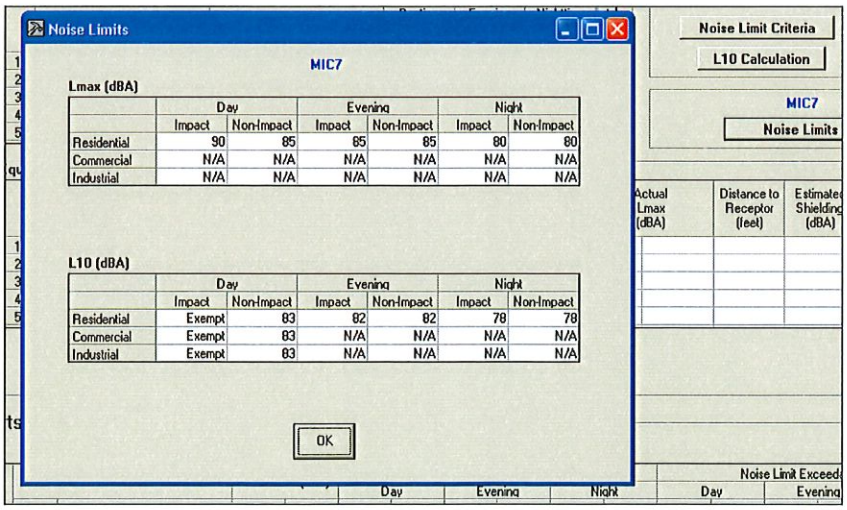

Figure 18. Noise Limits display window

Again, these limits may be changed by the user through the Noise Limit Criteria data entry window.

4 Results

Once the data for one receptor and up to 20 pieces of equipment have been specified in the Input Data portion of the main screen, the RCNM will automatically calculate the Results readout displayed in the bottom portion of the main screen, as in Figure 19. Any changes to the Input Data will automatically cause the RCNM to update the Results. The results for only one receptor will be displayed at a time; results for other receptors can be displayed by selecting the desired receptor in the Receptor window (click in any cell in the desired receptor row). Results for up to 100 receptors can be saved in a case. If Noise Limit Criteria information has been specified, the corresponding results (limits and exceedance values) will be updated as well.

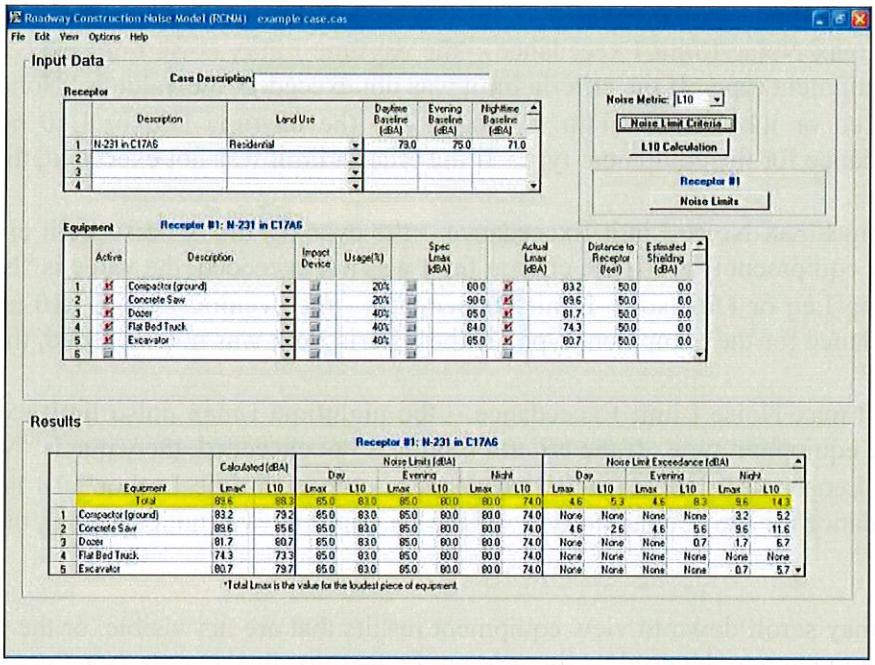

Figure 19. The RCNM main-page Results display

If there is insufficient input data for RCNM to compute a result, then a "Check Input Data" button will appear in the middle of the screen. Clicking on this button will provide the user with an indication of what additional input data are required.

The Results are presented in a read-only spreadsheet that contains the following fields, all applicable to the selected receptor:

- Equipment – the name/description of the equipment type
- Calculated Lmax – the calculated Lmax value for the equipment type. This is calculated from the "Spec" or "Actual" equipment Lmax, distance, and estimated shielding.

- Calculated Leq or L10 – the calculated Leq or L10 value (depending on what is selected in the Noise Metric pull-down menu) for the equipment type. This is calculated from the Calculated Lmax values, equipment usage factors, and selected adjustment factor.
- Day Lmax Noise Limit – the daytime Lmax noise limit for the equipment type.
- Day Leq or L10 Noise Limit – the daytime Leq or L10 noise limit for the equipment type.
- Evening Lmax Noise Limit – the evening Lmax noise limit for the equipment type.
- Evening Leq or L10 Noise Limit – the evening Leq or L10 noise limit for the equipment type.
- Night Lmax Noise Limit – the nighttime Lmax noise limit for the equipment type.
- Night Leq or L10 Noise Limit – the nighttime Leq or L10 noise limit for the equipment type.
- Day Lmax Noise Limit Exceedance – the daytime Lmax noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Day Leq or L10 Noise Limit Exceedance – the daytime Leq or L10 noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Evening Lmax Noise Limit Exceedance – the evening Lmax noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Evening Leq or L10 Noise Limit Exceedance – the evening Leq or L10 noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Night Lmax Noise Limit Exceedance – the nighttime Lmax noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".
- Night Leq or L10 Noise Limit Exceedance – the nighttime Leq or L10 noise limit exceedance for the equipment type. If the criteria limit was not exceeded, the value is "None".

The user may scroll down to view equipment results that are not visible, or the <View> / <Zoom +> menu may be used to zoom in on the Results display only (see Section 3.1.3). There is a row at the top of the Results display, highlighted in yellow, that calculates the total for all equipment combined. This row is always visible during scrolling of the Results spreadsheet. (Calculations for totals are explained in Section 5.3.)

Again, users may export a case's input information and results to a comma separated value (CSV) report file ([name].csv) by choosing the <Export Results> option from the <File> menu. The user can also save the case results to a text file (TXT), which saves the results to a space-separated text format ([name].txt). Results may be saved for a single receptor or all receptors in the case.

5 Calculations in the RCNM

The RCNM uses the primary equation described in the CA/T Construction Noise Control Specification 721.560 [1] for the construction noise calculations.

5.1 Metric Calculation

LmaxCalc = selected_Lmax – 20log(D/50) - shielding (1)

where

selected_Lmax is the "Spec" or "Actual" maximum A-weighted sound level at 50 ft., listed in Table 1 for all pieces of equipment, in dBA,
D is the distance between the equipment and the receptor, in feet,
shielding is the insertion loss of any barriers or mitigation, in dBA (see Appendix A).

Leq = LmaxCalc + 10log(U.F.%/100) (2)

where

U.F.% is the time-averaging equipment usage factor, in percent (see footnote 1 on p 7).

L10 = Leq + 3 dBA adjustment factor (3)

The RCNM calculates L10 by adding 3 dBA to the Leq, where the 3 dBA default L10 adjustment factor was empirically derived by comparing extensive CA/T construction noise data. This adjustment factor may be changed in the RCNM at the user's discretion.

5.2 Exceedance Calculation

Daytime Lmax Exceedance = LmaxCalc – Daytime Lmax Limit (4)

Daytime Leq or L10 Exceedance = Leq or L10 – Daytime Leq or L10 Limit (5)

Evening Lmax Exceedance = LmaxCalc – Evening Lmax Limit (6)

Evening Leq or L10 Exceedance = Leq or L10 – Evening Leq or L10 Limit (7)

Nighttime Lmax Exceedance = LmaxCalc – Nighttime Lmax Limit (8)

Nighttime Leq or L10 Exceedance = Leq or L10 – Nighttime Leq or L10 Limit (9)

5.3 Totals Calculation

The Total values in the Results section are determined in the following manner:

1) Total Leq = 10*log(Σ (individual equipment Leq values[3]))
2) Total L10 = 10*log(Σ (individual equipment L10 values[3]))
3) Total Lmax = Maximum among individual equipment Lmax values
4) Total noise limits and limit exceedances:
    a. Determine whether or not total is impact or non-impact
        i. If all the equipment is non-impact, label the total as non-impact.
        ii. If all the equipment is impact, label the total as impact.
        iii. If the equipment is mixed non-impact and impact, label the total as non-impact.

    b. Determine total noise limits and limit exceedances the same way as with individual pieces of equipment (see Section 5.2), only use the calculated total sound levels (Total Leq or Total L10) and the impact or non-impact label according to the criteria specified in i through iii.

[3] The Leq and L10 levels are energy averages.

6 References

[1] Construction Noise Control Specification 721.560, Central Artery/Tunnel Project, Massachusetts Turnpike Authority, Boston, MA, 2002.

[2] Thalheimer, Erich. "Construction Noise Control Program and Mitigation Strategy at the Central Artery/Tunnel Project". Noise Control Engineering Journal, Vol. 48, No. 5, pp 157-165, September - October 2000.

[3] "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety", Environmental Protection Agency, ONAC 550/9-74-004. Washington, DC, March 1974.

[4] "Power Plant Construction Noise Guide". Bolt, Beranek, and Newman Inc. and Empire State Electric Energy Research Corp., Report No. 3321. New York, NY May 1977.

Appendix A: Best Practices for Calculating Estimated Shielding for Use in the RCNM

This Appendix presents some simplified shielding factors for use in the RCNM. These suggestions are "rules of thumb" based on experience gathered by CA/T construction noise experts working in the field [2].

1) If a noise barrier or other obstruction (like a dirt mound) just barely breaks the line-of-sight between the noise source and the receptor, use 3 dBA.

2) If the noise source is completely enclosed OR completely shielded with a solid barrier located close to the source, use 8 dBA. If the enclosure and/or barrier has some gaps in it, reduce the effectiveness to 5 dBA.

3) If the noise source is completely enclosed AND completely shielded with a solid barrier located close to the source, use 10 dBA.

4) If a building stands between the noise source and receptor and completely shields the noise source, use 15 dBA.

5) If a noise source is enclosed or shielded with heavy vinyl noise curtain material (e.g., SoundSeal BBC-13-2" or equivalent), use 5 dBA.

6) If dilapidated windows are replaced with new acoustical windows, or quality internal or exterior storm sashes, use an incremental improvement of 10 dBA for an overall Outside-to-Inside Noise Reduction (OINR) of 35 dBA.

7) If work is occurring deep inside a tunnel using the "top-down" construction method (i.e. cover the tunnel work with concrete roadway decks to allow surface traffic and then excavate underneath the roof deck), use 12 dBA.