# *ACOUSTICAL STUDY*

# *HOUGHTON TRANSFER STATION SITE MITIGATION AND ROOF REPLACEMENT PROJECT*

Prepared for:

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## INTRODUCTION

The intent of this document is to record and compile the various analyses regarding noise issues at Houghton Transfer Station at 11724 NE 60th St. in Kirkland, Washington. The goal of each study was to propose mitigation approaches to reduce sound exposure levels in the adjacent residential neighborhood and/or to address staff exposure noise levels at the facility.

The current study was undertaken to revisit property line exposure levels and barrier construction in light of the recently identified wetland buffer, which encroaches on the western site boundary through the mid-section of fencing. Wetland buffer impact requirements allow the fence at this point to be repaired or replaced in kind, but that section of fence may be no higher than the existing barrier.

The following Greenbusch studies have been completed regarding the noise characteristics of Houghton Transfer Station. The current study draws on the data collected during and conclusions drawn from these previous studies.

- ***"Houghton Transfer Station Safety Improvements-Noise Study", June 2000.*** This study evaluated the effectiveness of the existing barriers along the west property line of the facility. Noise measurements were made inside the fence line on the plant property and outside of the fence line to determine the level of sound reduction provided by the fencing.

- "***Houghton Transfer Station Roof Replacement Project", October 2001***. This study evaluated the noise characteristics in the existing shelter at the tipping floor and the effectiveness of the existing structure to mitigate sound along the property line. In addition, the study evaluated proposed modifications to the roof and predicted resulting noise exposure at the property line, given the new geometry at the tipping floor. This study also considered staff noise exposure in the shelter and proposed mitigation to reduce exposure levels.

Clayton Group Services completed an additional study for King County Solid Waste.

- ***"Transfer Station Noise Surveys A Comparison to Applicable Noise Ordinance Levels Criteria 13," February 4, 2005.*** This study documented existing sound exposure levels along property lines at several King County facilities.

## SUMMARY

The dominant source of sound at Houghton Transfer Station is the on-site truck traffic on the surface roads. Current noise levels along the west property line exceed permissible Code exposure levels. In order to reduce sound exposure levels at the west property line to within Code limits, mitigation will be required. A replacement wall at the existing fence line will need to also comply with height restrictions imposed by the wetland buffer regulations. The mitigation treatment should consist of a new solid barrier, not less than 12 feet in height, for the entire length of the western property line, exclusive of the wetland buffer impact zone. Within the wetland buffer impact zone, the wall may be reduced to 6 feet in height.

The added height and change of configuration to the tipping floor roof is not predicted to significantly increase the noise exposure levels at the adjacent residential property lines.

However, the replacement of the roof structure does afford an opportunity to include an absorptive surface within the shelter. Reverberant build-up within the current shelter due to reflected sound is on the order of 5-7 dBA. The increased height of the new shelter is likely to increase this build-up to 7 to 9 dBA. Adding absorption to the roof surface would reduce this effect significantly.

Measured noise levels inside of the existing shelter showed maximums of 85-90 dBA. An 8-hour period is limited by the State of Washington Industrial Safety and Health Act (WISHA) to a continuous exposure level of 85 dBA. General long-term noise levels within the facility are within compliance of WISHA limits. However, impact sound from waste dropping into empty trailers and the clanging of metal truck gates can be quite high. It is our recommendation that staff wear hearing protection while working in the tipping floor area.

The addition of absorption to the ceiling surface will not reduce exposure to near field sound levels nor will it reduce the intensity of impact sounds. However, potential improvement in overall noisiness and staff communication conditions could be accomplished with an absorptive ceiling surface.

## NOMECLATURE

The auditory response to sound is a complex process that occurs over a wide range of frequencies and intensities. Decibel levels, or "dB," are a form of shorthand that compresses this broad range of intensities with a convenient numerical scale. The decibel scale is logarithmic. For example, using the decibel scale, a doubling or halving of energy causes the sound level to change by 3 dB; it does not double or halve the sound loudness as might be expected.

The minimum sound level variation perceptible to a human observer is generally around 3 dB. A 5-dB change is clearly perceptible, and an 8 to 10 dB change is associated with a perceived doubling or halving of loudness. Common sound pressure levels are reported below in Table 1.

- **A-weighted Sound Pressure Level, dBA**

The human ear is less sensitive to higher and lower frequency sounds falling outside the range of speech and has a frequency response that is dependent on the overall level of the listening environment. Sound level meters and monitors utilize weighting systems to approximate human perception of sound. Measurements made utilizing this weighting system are referred to as "A-weighted" and are called "dBA".

- **Equivalent Sound Pressure Level, $L_{eq}$**

An energy-averaged sound pressure level, where acoustical energy within a defined time period is logarithmically averaged to produce a single descriptor level.

**Table 1.** Common Noise Sources

| Typical Sound | Sound Pressure Level, dBA | Subjective Impression |
|---|---|---|
| Jet Takeoff | 140 | Potential Hearing loss |
| Siren at 100 ft. | 120 | Threshold of pain |
| Accelerating Motorcycle | 110 | Threshold of discomfort |
| Power Lawnmower | 100 | Very Loud |
| Train Whistle | 90 | |
| Busy Street | 80 | Communication Difficult |
| Average Street Noise | 70 | Loud |
| Normal Conversation | 60 | Usual Background |
| Quiet Street Noise | 50 | |
| Private Office | 40 | Noticeably Quiet |
| Empty Auditorium | 30 | Very Quiet |

*Source: Various*

## REGULATORY CRITERIA

In the City of Kirkland, sound is regulated by Section 115.95 of the Kirkland zoning code. The Kirkland code adopts the State noise control act of 1974 as reflected in Chapter 173-60 of the Washington Administrative Code (WAC). These maximum allowable noise levels, as outlined in WAC 173-60, are summarized below. Permissible noise levels are established by the environmental designation for noise abatement (EDNA) of the area. The EDNA is based upon zoning. The transfer station is zoned "Public Use." In this analysis, Class A EDNA applied to Residential zoning and Class B to Public Use zoning.

**Table 2.** Maximum Environmental Noise Levels, SPL dBA re: 20 μPa

| **EDNA of Noise Source** | **EDNA of Receiving Property** | | |
|---|---|---|---|
| | **Class A** | Class B | Class C |
| Class A | 55 | 57 | 60 |
| **Class B** | **57** | 60 | 65 |
| Class C | 60 | 65 | 70 |

*Source: WAC 173-60* [5]

The ordinance also establishes the following modifications to maximum permissible sound levels:

a. Sounds of short duration may exceed the maximum permissible sound levels when comprised of one or any combination of the following in any 1-hour period:
   1) 5 dBA for a total of 15 minutes
   2) 10 dBA for a total of 5 minutes
   3) 15 dBA for a total of 1-1/2 minutes

b. Noise levels are further reduced by 10 dBA between the hours of 10:00 p.m. and 7:00 a.m. where the receiving property is Class A EDNA.

c. Noise from traffic on public roadways, aircraft and safety devices such as back-up warning beepers are exempt from this regulation.

Allowable sound exposure levels for the Houghton Transfer Station would be 57 dBA at all adjacent residential property lines. The nighttime penalty applies only to the residential adjacencies, reducing the permissible levels after 10:00 PM to 47 dBA. However, since Houghton Transfer Station does not operate after 10:00 PM or before 7:00 AM, 57 dBA was used for our evaluation.

## ANALYSIS

### *Roof Replacement*

Background noise levels in this area are dominated by traffic on nearby interstate 405. Noise levels internal to the Station are due to truck and other heavy vehicle movement, and impact sounds caused by the dumping garbage and metal truck gates.

The previous study during the Roof Replacement phase was intended to:

- document the noise characteristics of activity within the existing shelter at the tipping floor
- determine the effectiveness of the existing shelter structure for mitigating sound transfer to adjacent residents
- consider the proposed modifications to the shelter roof, determine the effect of modifications on noise transfer, and make recommendations to reduce transfer of noise, as possible
- determine typical levels of staff noise exposure within the shelter during times of maximum activity
- evaluate noise levels transferred from the tipping floor for compliance with the City of Kirkland Noise code and make recommendations to further mitigate, as required

Enclosed are graphs showing the measurements of the various activities within the shelter. Noise levels from the commercial vehicles are significantly higher than the private vehicles. Table 3 below lists the single A-weighted descriptor associated with the graphed data.

**Table 3.** Measured Noise Levels of Tipping Floor Activity

| ***Vehicle Type*** | ***Activity*** | ***Sound Pressure Level, dBA*** |
|---|---|---|
| Private Vehicle | Dumping at 50 feet, compactor below | 78.3 |
| Private Vehicle | Dumping at 50 feet | 75.5 |
| Private Vehicle | Dumping at 50 feet, tossing metal construction debris | 80.8 |
| Commercial Vehicle | Entering shelter at 10 feet | 79.9 |
| Commercial Vehicle | Active dumping at 30 feet | 84.2 |
| Commercial Vehicle | Backup beeper at 30 feet | 82.7 |
| Commercial Vehicle | Slamming gates | 89.8 |
| Commercial Vehicle | Three commercial trucks simultaneously | 86.5 |
| Commercial Vehicle | Construction debris | 90.3 |

*Source: The Greenbusch Group. Inc.*[3]

The property line sound levels currently associated with the activity inside the tipping floor shelter were within daytime maximum permissible noise exposure limits along the property lines. Code exceedence from activity on the site occurred only along the west boundary and was due primarily to the truck traffic to and from the tipping floor. Recommendations for reducing the sound from on-site truck traffic are addressed under Site Mitigation.

The construction of the previous shelter was a concrete tipping floor and a corrugated metal shelter roof. The roof shape was saw-toothed, directing reflected sound back onto the tipping floor. Both ends of the shelter were open to allow vehicle passage and ventilation. There was line of sight to the residential properties to the east. Limited line of sight exists to the west. The new roof structure has more clearance between the tipping floor and the roof. The configuration of the roof is also no longer saw-toothed in shape. Sidewall panels are also open to encourage ventilation.

Noise levels within the original tipping floor shelter were in the mid 80's to low 90's dBA during times of full activity. The State of Washington Industrial Safety and Health Act (WISHA) places limits on noise exposure to protect the welfare of those working in a noisy environment. The limits are based on the intensity of the noise level and the amount of exposure time. An 8-hour period is limited to a continuous exposure level of 85 dBA. General long-term noise levels within the facility are within compliance of WISHA limits. However, impact sound from the clanging of construction debris and the clanging of metal gates can be quite high. It is our recommendation that staff wear hearing protection while working in the tipping floor area.

All surfaces in the existing facility were constructed from acoustically very reflective materials. The noise levels inside the facility increase, due, in part, to the reflection of sound combining with the direct sound from the operations. The reverberant build-up of sound is significant, adding 5-7 dBA to the noise associated with operations in the reverberant field. This also increases the amount of sound emanating into the neighborhood.

The increased height of the new roof could increase the reverberant build-up to 7-9 dBA. Adding a sound absorbent finish to the new roof structure will have a significant effect in reducing the noise level within the station. Reverberant noise levels would decrease, reducing noise exposure and improving communication among staff. The reduction of noise in the community would less effective. Predicted decreases for community noise are 2-3 dBA, which would be barely audible. However, the dominant source of sound exposure in the community is not from activity at the tipping floor, but from the on-site truck traffic.

The installation of the new roof structure affords an excellent opportunity to add absorption to the shelter. An acoustical deck with a perforated inner skin and batt insulation above would be appropriate in this facility. The deck should be specified with a film facing to withstand moisture levels within the facility. The deck selected should have a minimum NRC 0.60. Alternately, a standard single ply deck could be sprayed with a 1" thick cellulose, minimum NRC 0.65. This material would need an overcoating of silicone to prevent deterioration within the moist environment.

### *Site Mitigation*

Previous noise studies at Houghton Transfer Station by Greenbusch in June of 2000, and by Clayton Group Services, dated February 4, 2005[1], evaluated property line sound exposure levels. The data presented in these studies was used as the basis of evaluation for current proposed mitigation approaches. Several concurrent measurements of site activity were reported in the previous study by Greenbusch documenting sound pressure levels on both sides of the existing fence. This data offered a baseline for comparison of the proposed mitigation approaches.

A logarithmic average was computed from logged measurements made near the existing western fence line as reported in the June 2000 report. The measurement period was between 12:00 PM on May 16, 2000 and 12:00 PM on May 18, 2000. The resulting logarithmic average (Leq) for this time period was 71 dBA. Measurements conducted by Clayton Group resulted in reported hourly levels along the western property line ranging between 65 and 77 dBA. The logarithmic average of the hourly data collected by Clayton is also 71 dBA, consistent with Greenbusch data from several years prior. This level exceeds the 57 dBA Code limit.

The Table below contains the short-term data from the previous study showing the various sources of sound and the associated exposure levels.

**Table 4.** Simultaneous Sound Exposure Levels at West Property Line Fence.

| Site Activity | Microphone Location | dBA |
|---|---|---|
| 1 Garbage truck entering site/1Large truck backup beeper | inside-10 ft from barrier | 67 |
| | outside-30 ft from barrier | 57 |
| 1 Garbage truck exiting toward barrier/ 1 pickup truck entering site | inside-10 ft from barrier | 74 |
| | outside-30 ft from barrier | 61 |
| **1 Garbage truck dumping at station** | inside-10 ft from barrier | 65 |
| | outside-30 ft from barrier | 57 |
| 1 pickup truck on driveway exit parallel to barrier/ **1 Garbage truck dumping** | inside-10 ft from barrier | 61 |
| | outside-30 ft from barrier | 55 |
| 2 pickup truck on driveway exit at barrier/ 2 Garbage trucks entering site | inside-10 ft from barrier | 74 |
| | outside-10 ft from barrier | 64 |
| 1 Garbage truck entering site/ 1 large truck backup beeper/1 pickup truck on driveway exit parallel to barrier | inside-10 ft from barrier | 68 |
| | outside-10 ft from barrier | 58 |
| 3 Garbage trucks exiting toward barrier | inside-10 ft from barrier | 74 |
| | outside-10 ft from barrier | 64 |
| 1 large truck unload on pavement 100 ft from barrier | inside-10 ft from barrier | 70 |
| | outside-10 ft from barrier | 59 |
| 1 Garbage truck backing and exiting toward barrier | inside-10 ft from barrier | 71 |
| | outside-10 ft from barrier | 61 |
| 1 Large truck hitch on pavement 100 ft from barrier | inside-10 ft from barrier | 72 |
| | outside-10 ft from barrier | 61 |
| Haul truck on lower level and 1 large truck hitch on pavement 100 ft from barrier | inside-10 ft from barrier | 72 |
| | outside-10 ft from barrier | 62 |
| 1 haul truck exiting toward barrier and 1 semitruck on pavement 75 ft from barrier | inside-10 ft from barrier | 74 |
| | outside-10 ft from barrier | 63 |
| 1 semitruck backing up on pavement 50 ft from barrier | inside-10 ft from barrier | 76 |
| | outside-10 ft from barrier | 64 |
| 1 haul truck backing up on pavement 50 ft from barrier | inside-10 ft from barrier | 80 |
| | outside-10 ft from barrier | 69 |

*Source: Greenbusch Group* [2]

Both of the studies, by Greenbusch and Clayton, determined existing sound exposure levels were compliant with code levels at the eastern residential property line. Therefore sound exposure levels along this property boundary were not addressed in our analysis.

### *Acoustic Model*

Acoustical modeling of the Houghton project was created with Cadna/A, a software program for prediction and assessment of noise exposure levels. Cadna/A uses the CADNA (Control of Accuracy and Debugging for Numerical Applications) computation engine developed by the Pierre et Marie Curie University of Paris. This model was calibrated with measurements taken from in June 2000 and adjusted to accurately reflect the environment present at the site.

The computed model was extended to include the adjacent property along the western property line to provide estimates for noise exposure levels produced by the Facility. Shielding of noise sources by facility buildings and barriers was computed in the model.

### *Site Modifications*

The existing tipping floor structure scheduled for roof replacement and renovation, will have minimal effect on residential sound exposure levels. The dominant source of sound exposure is generated by on-site truck traffic and trailer connections.

### *Proposed Mitigation*

Several mitigation proposals were considered for effectiveness in reducing sound exposure levels within neighboring residential properties. All mitigation proposals considered include replacing the existing fence with a solid barrier near the western property line. Due to the presence of the wetland buffer zone, it is not possible for the existing fence to be replaced by a taller barrier for the entire length of the property boundary. The following mitigation proposals have been considered in our analysis:

1. Replacement wall 6 feet in height for the entire length.
2. Replacement wall 6 feet in height within buffer impact zone, 12 feet in height outside buffer impact zone.
3. Replacement wall 6 feet in height within buffer impact zone, 12 feet in height outside buffer impact zone. Additional wall 10 feet in height located east of the replacement wall to provide additional screening throughout the replacement wall's lower height region.

To determine code compliance, site-generated sound exposure levels were predicted for two locations. The first location was defined as the highest predicted sound pressure level at the adjacent residential property line west of the facility. This analysis point was oriented at an elevation of 5 feet above grade. The second analysis point predicted sound exposure levels at the nearest residence's eastern façade located approximately 80 feet west of the existing fence line. Topography west of the site places grade elevation at the nearest residence approximately 9 feet higher than at the western property line directly east of the residence. Due to the elevated height of the residence, sound

exposure is greater at the structure than the property line in some locations. Both the existing western fence and property lines vary in elevation north and south of this point.

In order to reduce the amount of reflected sound, a wall with absorptive properties has been proposed by the City of Kirkland. A comparison between reflective and absorptive walls was also included in the analysis. However, an absorptive surface has little to no effect on the acoustical screening performance of the wall. Therefore, all evaluations of the mitigation proposals include walls with reflective surfaces.

## RESULTS

### *Proposal #1: Replacement wall 6 feet in height*

Replacing the existing fence with a 6-foot solid wall is not predicted to provide sufficient mitigation to ensure code compliance. Average sound levels (Leq) are predicted to reach 59 dBA at the western property line and 60 dBA at the nearest residence. Both of these values exceed the daytime code limit of 57 dBA. If there were no wetland buffer impact concerns, this wall height could be increased to 10 feet and comply at the western residential property line. However, a height of 12 feet is required to comply at both the property line and the nearest western residence. See Figure 1 for predicted sound level contours of the western boundary for this mitigation proposal.

### *Proposal #2: Replacement wall 6 feet in height within buffer impact zone, 12 feet in height outside buffer impact zone.*

This option will provide sufficient mitigation to ensure code compliance. Average sound levels (Leq) are predicted to reach 57 dBA at the western property line and 57 dBA at the nearest residence. Both of these predicted levels comply with the daytime code limit of 57 dBA. See Figure 2 for predicted sound level contours of the western boundary for this mitigation proposal.

### *Proposal #3: Replacement wall 6 feet in height within buffer impact zone, 12 feet in height outside buffer impact zone. Additional wall 10 feet in height located east of replacement wall to provide additional screening throughout the replacement wall's lower height region.*

Adding a wall east of the replacement wall described in Option #2 is predicted to provide additional reduction to off-site sound exposure from transient events in the trailer yard. This additional wall is not to aid in meeting code limits and will not reduce the overall average sound level generated by the site below that of Option #2, but will assist in reducing the louder events of short duration that emanate from the trailer yard. This wall should be located immediately west of the trailer yard, extend north to the paved private haul access road and 30 feet south of the

replacement wall height transition at the southern boundary of the wetland buffer impact zone. This additional wall will only offer more acoustical screening for transient trailer yard activities such as truck/trailer connections and back-up beepers that do not have much influence on the average sound level (Leq). Average sound levels (Leq) are predicted to reach 57 dBA at the western residential property line and 57 dBA at the nearest western residence, which are the same levels predicted for Proposal #2. Both of these levels comply with the daytime code limit of 57 dBA. See Figure 3 for predicted sound level contours of the western boundary for this mitigation proposal.

**Table 5.** Mitigation Analysis Results, SPL dBA re: 20 μPa

| Mitigation | Western Property Line | Nearest Western Residence | Code Limit |
|---|---|---|---|
| Proposal #1 | 59 | 60 | 57 |
| Proposal #2 | 57 | 57 | 57 |
| Proposal #3 | 57 | 57 | 57 |

*Source: The Greenbusch Group*

### *Absorptive Treatments*

Walls with reflective surfaces are predicted to have an additive effect on site sound levels. The magnitude of this effect depends on the distance between a receiver and the wall as well as the distance between a sound source and the wall. Given the site geometry and distance to the eastern property line, absorptive treatment of the wall at the western fence line is expected to yield negligible reductions to on-site sound levels and the resulting eastern property line sound exposure levels.

## REFERENCES

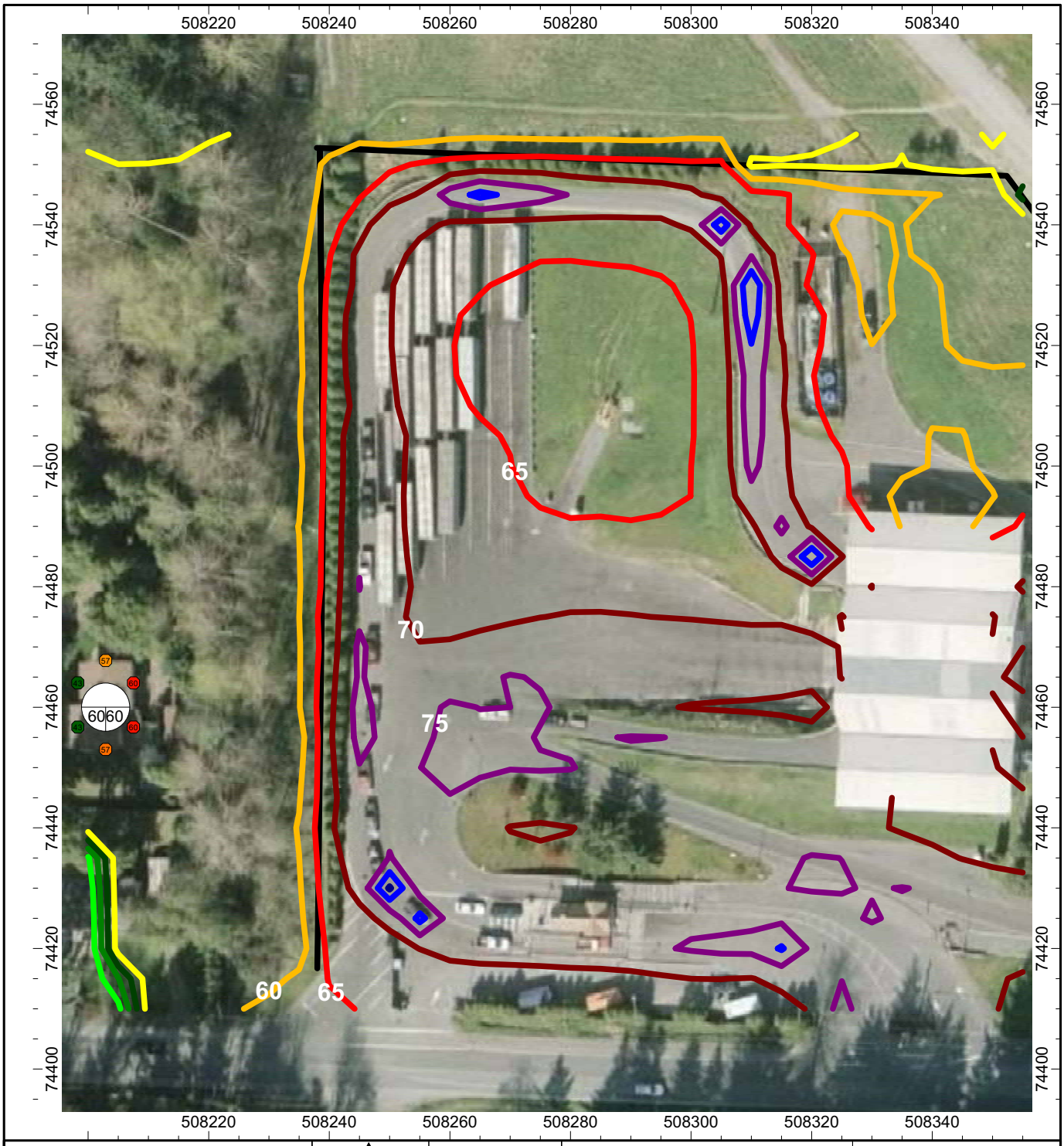
1. Clayton Group Services, “Transfer Station Noise Surveys A Comparison to Applicable Noise Ordinance Levels Criteria 13,” February 4, 2005.

2. Kirkland Zoning Code, Section 115.95 Noise Regulations.

3. The Greenbusch Group, Inc., “Houghton Transfer Station Roof Replacement Project”, October 2001.

4. The Greenbusch Group, Inc., “Houghton Transfer Station Safety Improvements-Noise Study”, June 2000.

5. Washington Administrative Code, Chapter 173-60, Maximum Environmental Noise Levels. December 2000




sound exposure level in dB(A)
receiver point height: 1.52 m above ground
grid distance: 5 m

Scale 1 : 794

# Figure 1

- > -99.0 dB(A)
- > 35.0 dB(A)
- > 40.0 dB(A)
- > 45.0 dB(A)
- > 50.0 dB(A)
- > 55.0 dB(A)
- > 60.0 dB(A)
- > 65.0 dB(A)
- > 70.0 dB(A)
- > 75.0 dB(A)
- > 80.0 dB(A)
- > 85.0 dB(A)

| | Date | Name |
|---|---|---|
| Drafted | 05/14/07 | ACJ |
| Checke | | |

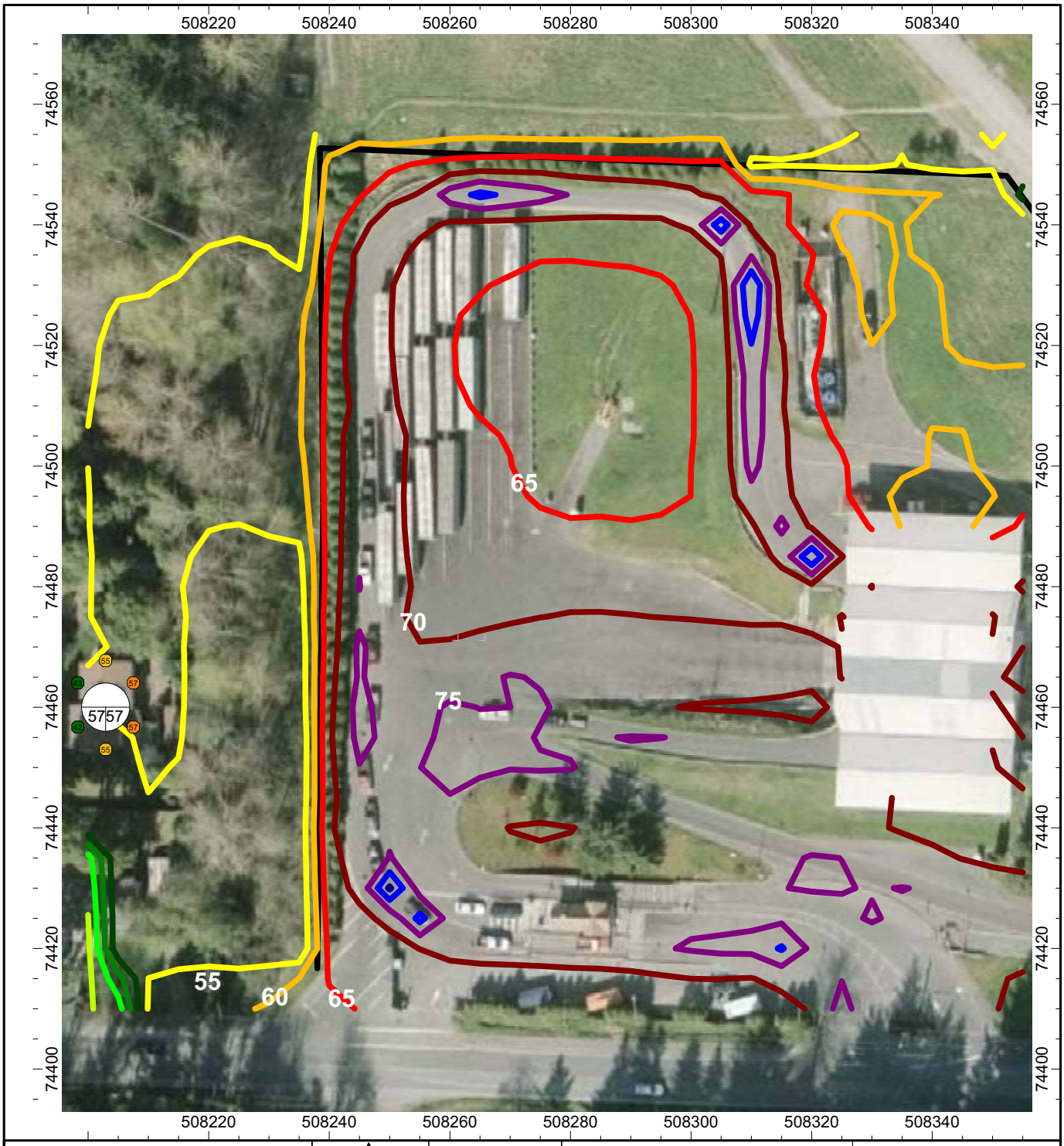
**Proposal #1**
**Replacement wall 6 feet in height**

THE GREENBUSCH GROUP, INC.

Houghton Transfer Station
Kirkland, WA

sheet No.

tot.sh.




sound exposure level in dB(A)
receiver point height: 1.52 m above ground
grid distance: 5 m

Scale 1 : 1000

# Figure 2

- > -99.0 dB(A)
- > 35.0 dB(A)
- > 40.0 dB(A)
- > 45.0 dB(A)
- > 50.0 dB(A)
- > 55.0 dB(A)
- > 60.0 dB(A)
- > 65.0 dB(A)
- > 70.0 dB(A)
- > 75.0 dB(A)
- > 80.0 dB(A)
- > 85.0 dB(A)

| | Date | Name |
|---|---|---|
| Drafted | 05/14/07 | ACJ |
| Checke | | |

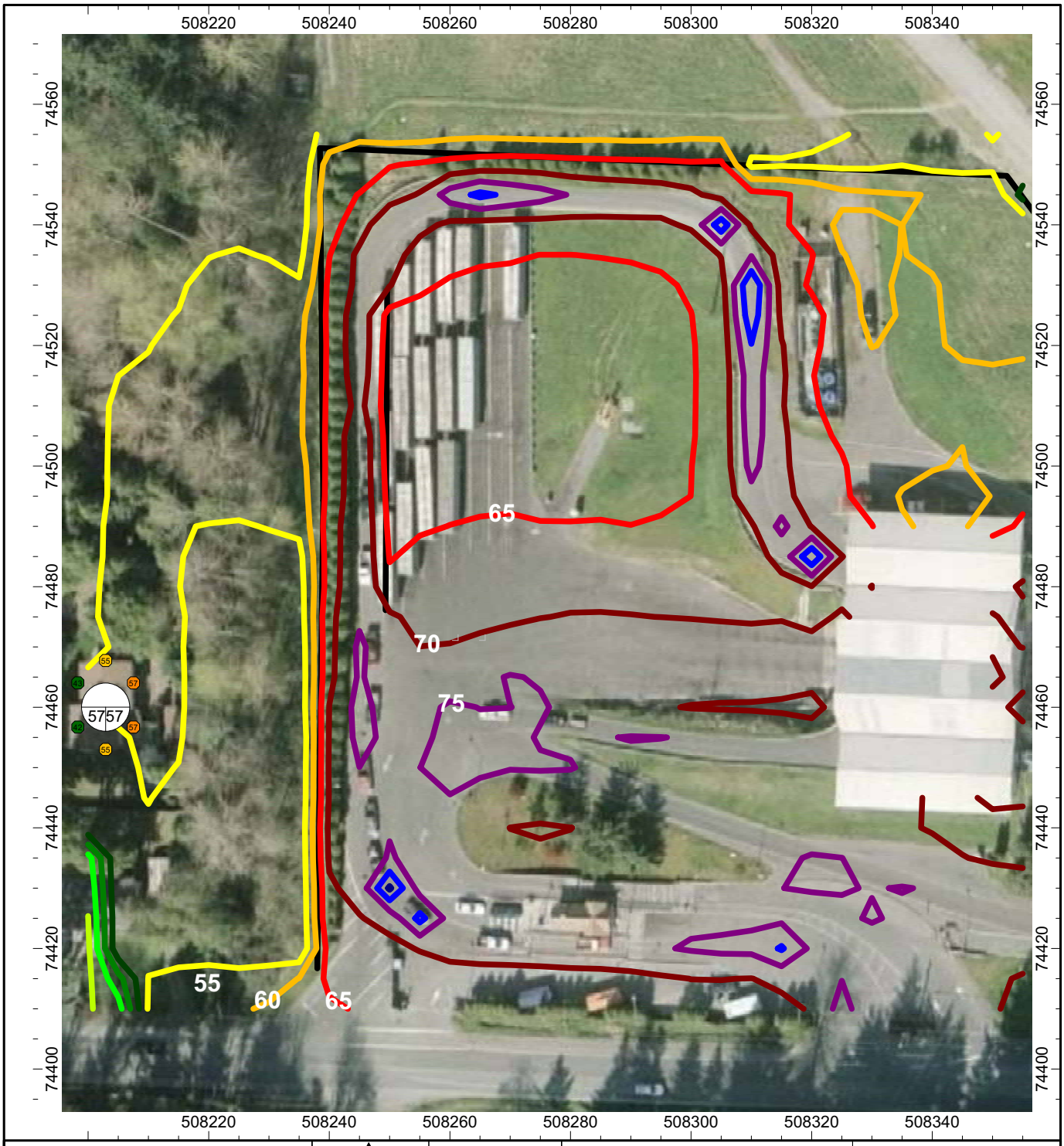
**Proposal #2**
**Replacement wall 12 feet in height**
**6 feet in height within buffer impact zone**

THE GREENBUSCH GROUP, INC.

Houghton Transfer Station
Kirkland, WA

sheet No.

tot.sh.




sound exposure level in dB(A)
receiver point height: 1.52 m above ground
grid distance: 5 m

Scale 1 : 794

# Figure 3

- > -99.0 dB(A)
- > 35.0 dB(A)
- > 40.0 dB(A)
- > 45.0 dB(A)
- > 50.0 dB(A)
- > 55.0 dB(A)
- > 60.0 dB(A)
- > 65.0 dB(A)
- > 70.0 dB(A)
- > 75.0 dB(A)
- > 80.0 dB(A)
- > 85.0 dB(A)

| | Date | Name |
|---|---|---|
| Drafted | 05/14/07 | ACJ |
| Checke | | |

**Proposal #3**
**Replacement wall 12 feet in height**
**6 feet in height within buffer impact zone**
**Additional 10 foot wall near trailer yard**

THE GREENBUSCH GROUP, INC.

Houghton Transfer Station
Kirkland, WA

sheet No.

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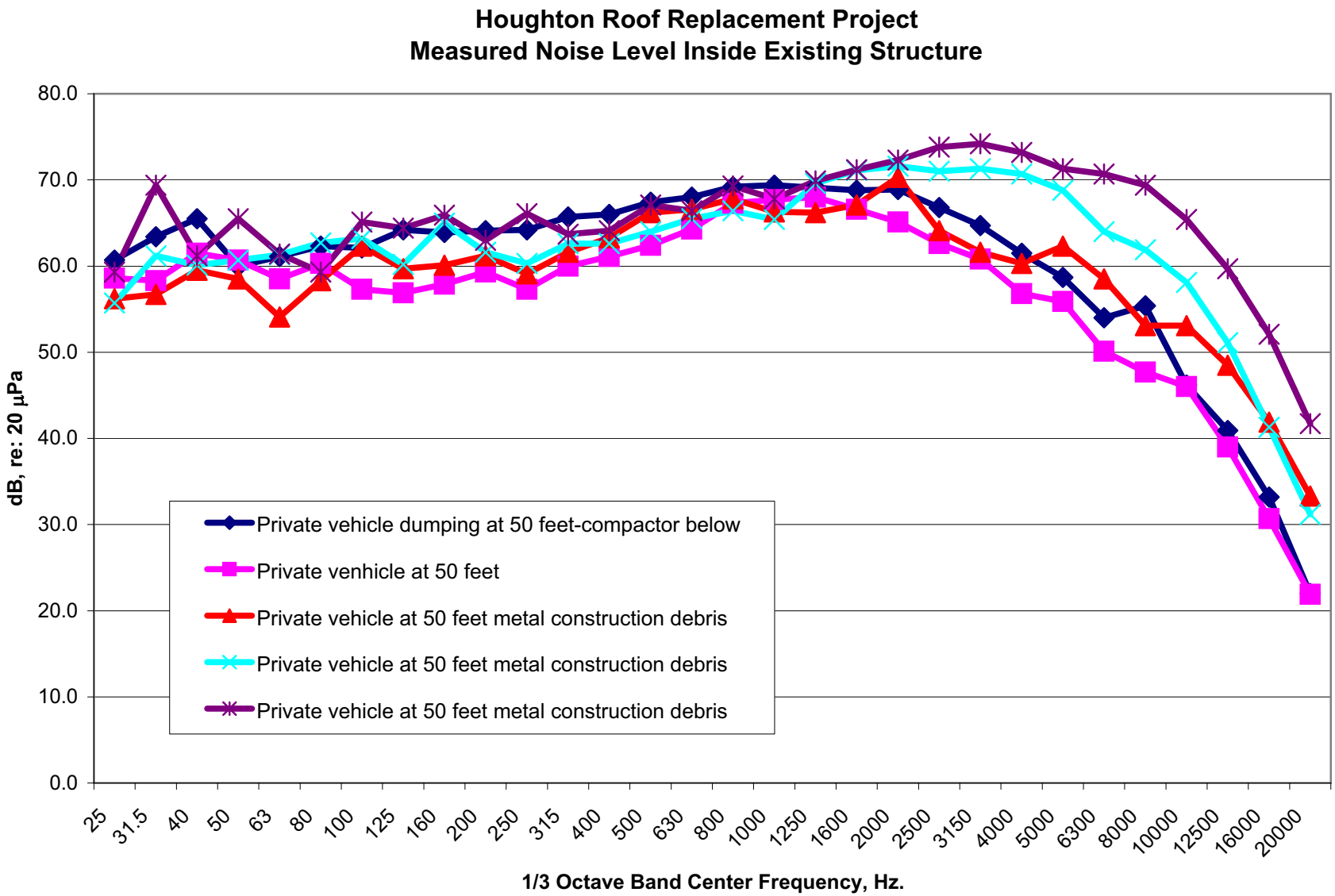
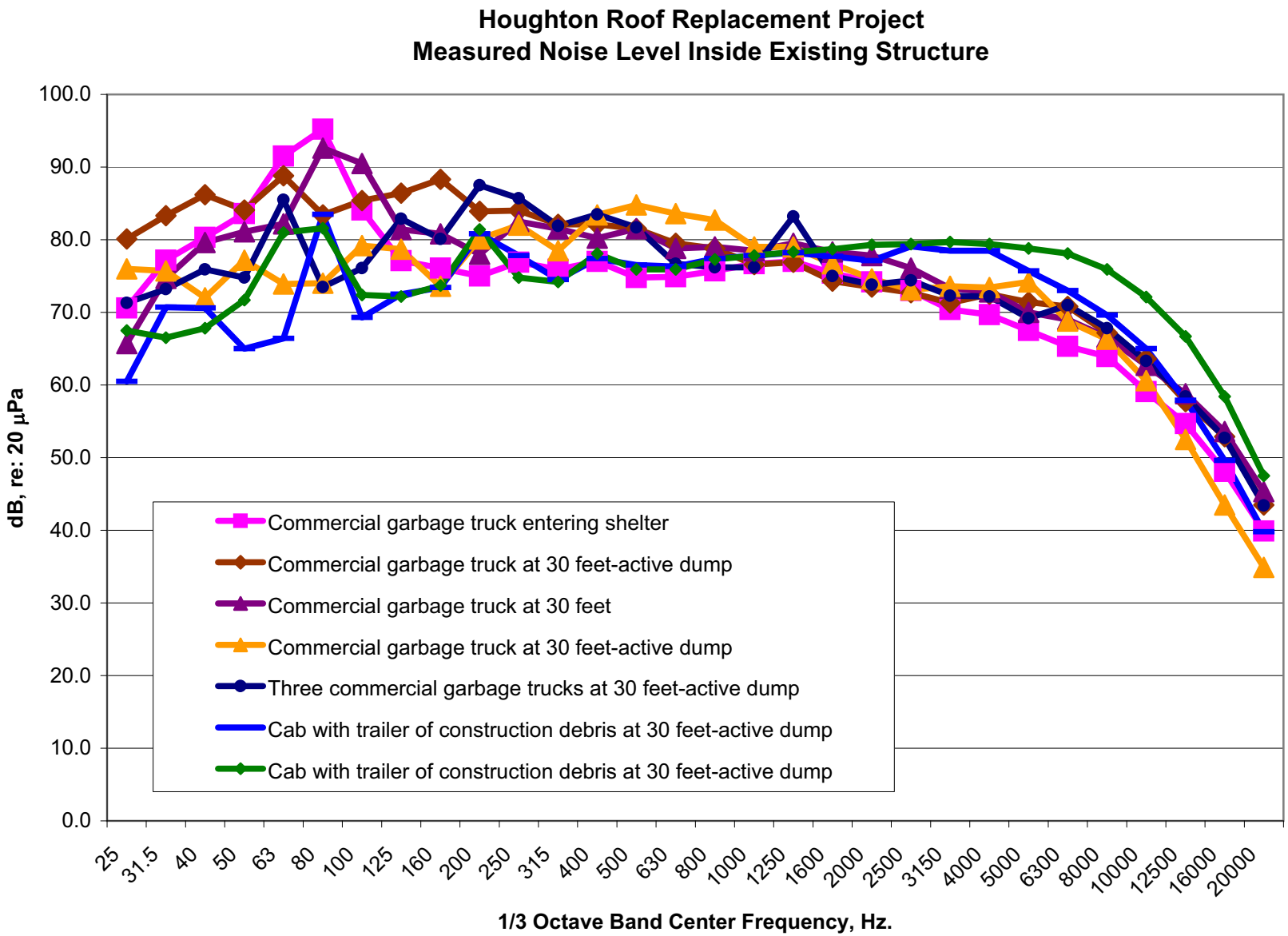

Houghton Roof Replacement Project
Measured Noise Level Inside Existing Structure
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
dB, re: 20 µPa
Private vehicle dumping at 50 feet-compactor below
Private venhicle at 50 feet
Private vehicle at 50 feet metal construction debris
Private vehicle at 50 feet metal construction debris
Private vehicle at 50 feet metal construction debris
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
1/3 Octave Band Center Frequency, Hz.


Houghton Roof Replacement Project
Measured Noise Level Inside Existing Structure
dB, re: 20 µPa
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Commercial garbage truck entering shelter
Commercial garbage truck at 30 feet-active dump
Commercial garbage truck at 30 feet
Commercial garbage truck at 30 feet-active dump
Three commercial garbage trucks at 30 feet-active dump
Cab with trailer of construction debris at 30 feet-active dump
Cab with trailer of construction debris at 30 feet-active dump
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
1/3 Octave Band Center Frequency, Hz.