SOUND TRANSIT

NORTHGATE LINK EXTENSION

U DISTRICT STATION

TECHNICAL NOISE ANALYSIS AND RECOMMENDED MITIGATION PLAN

SEATTLE, WA

July 25, 2012

Prepared for:

Sound Transit

Prepared by:

JACOBS ASSOCIATES

and

THE GREENBUSCH GROUP, INC.

1900 West Nickerson Street Suite 201
Seattle, Washington 98119

1.0 INTRODUCTION

This Report presents the results of a construction noise study at the U District Station for the Northgate Link Extension section of the Sound Transit Link Light Rail system in Seattle, Washington. The study specifically addresses noise emissions from construction activities associated with the site excavation, excavation of the station box, tunneling from U District Station to University of Washington Station, and construction of the U District transit station.

The requirements of the Seattle Noise Control Code, Seattle Municipal Code (SMC) Chapter 25.08, form the basis of the study. This report includes recommendations to the design team for noise management and mitigation planning, for inclusion in the Contract Documents and for use in preparation of a Noise Variance Application pursuant to SMC 25.08 and Director's Rule 3-2009 (DR). It is our understanding that the Noise Variance Application will request a Major Public Project Construction Variance (MPPCV) for the Project.

Specific mitigation measures associated with the Project, which are outlined in this report, comply with the Federal Transit Administration's Record of Decision (ROD).

2.0 SUMMARY

Construction activities will be divided into four phases, as described in the Table below.

Table 2.1 U District Station Construction Phases

Phase ID	Activity Description	Periods of Site Activity
Phase 1	Site establishment, grading, utility work, contractor facilities and trailers.	Daytime only
Phase 2	Support of excavation; soldier piles & secant piles, temporary bridge construction over station footprint at south end.	Daytime only
Phase 3	Dewatering, box excavation, and muck handling.	Daytime only
Phase 4	Tunnel boring machine reception, maintenance and launch, twin-bored tunnel mining, cross passages excavation and support, tunnel invert and duct banks.	Daytime and nighttime
Phase 5	Floating slab construction, delivery and staging for floating slab construction in the tunnel.	Daytime and nighttime
Phase 6	Station buildup and site restoration.	Daytime only

Source: Jacobs Associates, The Greenbusch Group, Sound Transit

Predicted construction sound levels for each of these Phases will comply with daytime Code limits, including on-site Phase 1 and Phase 2 activities beginning prior to construction of the solid perimeter construction wall.

Predicted nighttime construction sound levels exceed Code limits at some receiving properties during Phases 4 and 5, therefore pursuit of a Variance is recommended.

Given the elevated existing ambient sound levels and the predicted operations associated with the various Phases of construction, we propose structuring the Variance to request average (hourly L_{eq}) nighttime sound level limits of 6 dBA above existing ambient conditions or 6 dBA above Code limits, whichever is greater. Based on ambient

measurement data for the Site, this would correlate to 6 dBA above Code for Commercial properties and 6 dBA above ambient for Residential properties. Due to the challenges related to monitoring compliance with average sound levels, an additional descriptor, the maximum percentile (hourly L_{01}) is also proposed. Hourly L_{01} sound level limits equal to 10 dBA above the average hourly limit (hourly L_{eq}) are recommended for inclusion in the Variance Application.

Predicted nighttime construction sound levels from Phase 4 and Phase 5 activities satisfy these proposed limits. Specific mitigation requirements are recommended in Section 8 below to reduce nighttime construction sound levels from the U District Station site, and are reflected in the predicted nighttime sound levels presented in this document. Additional planning, monitoring, and compliance tracking tools are proposed in Sections 10-12.

3.0 NOMENCLATURE

The auditory response to sound is a complex process that occurs over a wide range of frequencies and intensities. The Decibel level, or "dB," is a form of shorthand that compresses this broad range of intensities into 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 perceived 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 in Table 3.1 below.

Mathematical descriptors have been developed to provide better assessment of sounds that vary over time and the human response to them.

- A-weighted Decibel (dBA)

  The human ear has a unique response to sound pressure. It is less sensitive to those sounds falling outside the speech frequency range. Sound level meters and monitors utilize a filtering system to approximate human perception of sound. Measurements made utilizing this filtering system are referred to as "A weighted" and are called "dBA".

- Sound Pressure Level (SPL)

  Sound pressure level correlates with what is heard by the human ear. SPL is defined as the squared ratio of the sound pressure with reference to 20 micropascal (μPa). Sound pressure is affected by distance, path, barriers, directivity, etc. All sound pressure levels referenced in this document utilize this reference pressure.

- Equivalent Sound Level (L_{eq})

  Equivalent Sound Level is the A-weighted sound pressure level of a constant sound having the same energy content as the actual time-varying level during a specified interval. The L_{eq} is used to characterize complex, fluctuating sound levels with a single number. Typical intervals for L_{eq} are hourly, daily and annually. The Seattle Noise Control Code, SMC 25.08.410, requires intervals for

constant sound sources to be at least 1 minute and non-continuous sound sources to be at least 1 hour. When describing L_{eq} values over multiple time periods, an overall average or range in period L_{eq} values can be reported.

- Maximum Sound Level (L_{max})

  L_{max} is the maximum recorded root mean square (rms) A-weighted sound pressure level for a given time interval or event. L_{max} can be defined for two time weightings, "slow" and "fast." "Slow" uses 1-second time constant, and "fast" uses a 125-millisecond time constant. For transient events of very short duration, L_{max} "fast" will be greater than L_{max} "slow." The Seattle Noise Control Code, SMC 25.08.165, requires the use of L_{max} "fast". When describing L_{max} values over multiple time periods, an overall maximum (highest L_{max} for all periods) or range in period L_{max} values are often reported. Alternatively, the median periodic value also establishes typical L_{max} values at a given location and is often a more representative single-value number that the overall maximum.

- Percent Sound Level (L_n)

  Percent Sound Level is the sound pressure level that is exceeded n percent of the time; for example, L_{08} is the level exceeded 8% of the time. L_{25} is the sound level exceeded 25% of the time. The percent sound level proposed for the Variance, L_{01}, represents the level exceeded 1% of the time, or 36 seconds in an hourly period. This metric is very useful for identifying louder construction noise emissions with minimal influence of ambient conditions.

Table 3.1 A-weighted Levels of Common Sounds, dBA

Sound	Sound Level	Approximate Relative Loudness[1]
Jet Plane @ 100'	130	128
Rock Music with Amplifier	120	64
Thunder, Danger of Permanent Hearing Loss	110	32
Boiler Shop, Power Mower	100	16
Orchestral Crescendo at 25 feet	90	8
Busy Street	80	4
Interior of Department Store	70	2
Ordinary Conversation @ 3'	60	1
Quiet Car at Low Speed	50	1/2
Average Office	40	1/4
City Residence, Interior	30	1/8
Quiet Country Residence, Interior	20	1/16
Rustle of Leaves	10	1/32
Threshold of Hearing	0	1/64

1. As compared to ordinary conversation at 3 feet.

Source: US Department of Housing and Urban Development, Aircraft Noise Impact Planning Guidelines for Local Agencies, November 1972.

4.0 REGULATORY CRITERIA

4.1 Exterior Sound Level Limits

The U District Station site is located in the City of Seattle. The Seattle Noise Control Code, SMC Chapter 25.08, specifies permissible sound levels within the City. SMC 25.08.410 defines limits for exterior sound levels between properties. These Code limits are based on zoning districts. Permissible sound levels transmitted between non-related properties are listed in the Table below.

Table 4.1 Exterior Sound Level Limits, L_{eq}[1] (L_{max}[2])

District of Sound Source	District of Receiving Property		
	Residential	**Commercial**	**Industrial**
Residential	55 (70)	57 (72)	60 (75)
Commercial	57 (72)	60 (75)	65 (80)
Industrial	60 (75)	65 (80)	70 (85)

1. Measurement time is 1-minute for a constant sound source, 1-hour for a varying sound source.
2. "Fast" time weighting.

Source: SMC 25.08.410 Exterior Sound Level Limits

SMC 25.08.100 defines zoning districts, for purposes of the Noise Control Code, as the following zones, as defined in the Seattle Land Use Code, Title 23:

- Residential – all Residential and NC1 zones.
- Commercial – all NC2, NC3, SM, C1, C2, DOC1, DOC2, DRC, DMC, PSM, IDM, DH1, DH2, PMM, and IB zones.
- Industrial – all IG1, IG2, and IC zones.

4.2 General Modifications

Modifications to the exterior sound level limits set forth in Table 4.1 above are subject to SMC 25.08.420, depending on the time of day, classification of receiving properties and the type of sound generated. The modifications to the exterior sound level limits include the following reductions:

- 10 dBA during the nighttime hours of 10:00 p.m. and 7:00 a.m. on weekdays and 10:00 p.m. and 9:00 a.m. on weekends and legal holidays when the receiving property is within a Residential district.
- 5 dBA for sources that carry a pure tone component.
- 5 dBA for impulsive sources not measured with an impulse sound level meter.

These modifications are additive and are independent of one another. Therefore, the exterior nighttime sound level limit in a Residential district for a periodic, tonal source would be 20 dBA less than the exterior sound level limits described in Table 4.1 above.

4.3 Code Modifications for Construction

4.3.1 Non-Impact Construction and Maintenance Equipment

Modifications to the permissible exterior sound level limits set forth in Table 4.1 are allowed for construction activities. Daytime construction is subject to SMC 25.08.425 for non-impact construction activities. For a "public project," such as Sound Transit's Northgate Link Extension project, daytime hours are between 7:00 a.m. and 10:00 p.m. on weekdays and between 9:00 a.m. and 10:00 p.m. on weekends and legal holidays. The modifications allowed in SMC 25.08.425 include the following increases during these time periods:

- 25 dBA for heavy construction equipment.
- 20 dBA for light construction equipment.
- 15 dBA for residential maintenance.

The resulting values for exterior sound level limits are defined at the adjacent property line or 50 feet from the equipment making the sound, whichever is greater, resulting in hourly average (L_{eq}) sound level limits of 85 dBA in Commercial zones and 82 in Residential Zones.

4.3.2 Impact Construction and Maintenance Equipment

SMC 25.08.425 also includes modifications to the permissible exterior sound level limits for impact types of construction equipment. This includes equipment such as pavement breakers, piledrivers, jackhammers, and sandblasting tools. Impact construction equipment is allowed to exceed the exterior sound level limits in any one-hour period between 8:00 a.m. and 5:00 p.m. on weekdays and 9:00 a.m. and 5:00 p.m. on weekends and legal holidays. However, sound levels associated with impact construction equipment are not allowed to exceed the values set forth below in Table 4.2. These values are defined at the adjacent property line or 50 feet from the equipment, whichever is greater.

Table 4.2 Exterior Sound Level Limits: Impact Construction Equipment, L_{eq}

Activity During 1-Hour Period	Sound Level
Continuous	90
30 minutes	93
15 minutes	96
7.5 minutes	99

Source: SMC 25.08.425 Construction and Maintenance Equipment

4.3.3 Limits for Interior Sound Levels

SMC Chapter 25 also applies exterior sound level limits to sound levels measured inside of the buildings adjacent to the construction site. Specifically, construction or maintenance equipment that exceeds the exterior sound level limits specified in Table 4.1 above, when measured from the interior of buildings in a Commercial district, is prohibited between the hours of 8:00 a.m. and 5:00 p.m.. SMC 25.08.425.F states that "interior sound levels shall be measured only after every reasonable effort, including but not limited to closing windows and doors, is taken to reduce the impact of the exterior construction noise."

4.4 Project Site, Nearby Land Use Zoning, and Project Code Limits

The U District Station construction site consists of the western half for the block bounded on the North by NE 45th St., on the East by an alley, on the South by NE 43rd St., and on the West by Brooklyn Ave. NE, and two parcels located west of Brooklyn Ave. NE that are immediately north and south of NE 43rd Street. Sound Transit will likely also use a parcel at the southeast corner of NE 43rd Street and 12th Ave NE for construction trailers, no nighttime activity is expected in this area. The zoning of the main project site is NC3, which is considered a Commercial district in SMC 25.08.100. A map showing the location of the project site area and the immediate surrounding land use zoning is shown in Appendix Figure A-1.

There are a variety of zoning classifications for the properties immediately surrounding the project site area. Properties north, east, southeast, south, and west of the Site are zoned NC3 (Commercial), properties southwest of the Site are zoned MR (Residential).

For a "major public project" as defined in SMC 25.08.168, baseline Code limits, reductions during nighttime hours, and increases allowed for construction equipment, yield the project Code limits outlined in Tables 4.3 and 4.4 below. Code limits for Commercial districts are detailed in Table 4.3 and Code limits for Residential districts are detailed in Table 4.4.

Table 4.3 Permissible Non-Impact Project Sound Levels in **Commercial** Districts, L_{eq} (L_{max})

Time Period	Baseline Code Limit	Nighttime Adjustment	Construction Adjustment	Existing Ambient Sound Level	Project Code Limit
Daytime hours	60 (75)	0	25	61-62 (76-77)[1]	85 (100)[2]
Nighttime hours	60 (75)	0	0	56-58 (71-73)[1]	60 (75)[3]

1. Ranges of period L_{eq} and period median L_{max} at 1303 NE 45th St and 1305 NE 43rd St.
2. As measured at the adjacent property line or 50' from the equipment, whichever is greater (daytime compliance point)
3. As measured at the adjacent property line or adjacent building façade, whichever level is greater (nighttime compliance point).

Source: SMC 25.08, The Greenbusch Group, Inc.

Table 4.4 Permissible Non-Impact Project Sound Levels at **Residential** Districts, L_{eq} (L_{max})

Time Period	Baseline Code Limit	Nighttime Adjustment	Construction Adjustment	Existing Ambient Sound Level	Project Code Limit
Daytime hours	57 (72)	0	25	64 (82)[1]	82 (97)[2]
Nighttime hours	57 (72)	-10	0	58 (78)[1]	47 (62)[3]

1. Overall period L_{eq} and period median L_{max} near 4235 Brooklyn Ave NE.
2. As measured at the adjacent property line or 50' from the equipment, whichever is greater (daytime compliance point).
3. As measured at the adjacent property line or adjacent building façade, whichever level is greater (nighttime compliance point).

Source: SMC 25.08, The Greenbusch Group, Inc.

As provided in SMC 25.08.480, vehicles operating on public roadways are exempt from the levels detailed in the tables above. However, once vehicles turn onto the subject property, the sound they make is included in the Project sound levels that must comply with the permissible sound level limits detailed in Table 4.4 when received in a Residential district. Vehicles operating on public streets are regulated by SMC 25.08.430, and the vehicles associated with this Project are expected to comply with this code section.

5.0 EXISTING AMBIENT SOUND LEVELS

Ambient sound level measurements for the area surrounding the Site were conducted at the following locations:

- Location 1 – 1303 NE 45th St., apartments above the Neptune Theater (June 9 – June 16, 2011)
  - Southern edge of apartment building, approximately 6' above the rooftop.
  - Local noise sources included traffic on NE 45th St. and Brooklyn Ave. NE.
- Location 2 – 1305 NE 43rd St., University Manor Apartments (June 17-24, 2011)
  - Northern edge of building, approximately 5' above the rooftop.
  - Local noise sources included traffic on NE 43rd Street and Brooklyn Ave. NE.
- Location 3 – 4245 Brooklyn Ave. NE, Felch House (October 17-24, 2011)
  - Eastern edge of building, approximately 4' above a second floor balcony.
  - Local noise sources included traffic on NE 43rd Street and Brooklyn Ave. NE.
    - NOTE: This location was selected to represent ambient levels at the Varsity Arms Condominiums (4235 Brooklyn Ave. NE)located immediately south, on Brooklyn Ave. NE.

The following equipment was used during the measurements:

• Rion NL-32 sound level meter	SN 00161680
o Rion NH-21 preamplifier	SN 18454
o Rion UC-53A microphone	SN 309751
o Larson Davis CA250 acoustic calibrator	SN 1193
• Rion NL-32 sound level meter	SN 00161681
o Rion NH-21 preamplifier	SN 18455
o Rion UC-53A microphone	SN 315851
o Larson Davis CAL200 acoustic calibrator	SN 5463

The Rion NL-32 sound level meters conform to a Class 1 rating as delineated in International Electrotechnical Commission (IEC) 61672-1. The Larson Davis acoustic calibrators meet the requirements for an acoustic calibrator defined in International Electrotechnical Commission (IEC) 60942 and American National Standards Institute (ANSI) S1.40. All equipment was laboratory calibrated within 1 year of the measurement date, field calibrated immediately before the measurements, and verified immediately after.

Noise monitoring setups and locations are shown in the Photos below.

Photo 5.1 Location 1, facing Site (S)

Photo 5.2 Location 2, facing Site (N)

Photo 5.3 Location 3, facing SW

Photo 5.4 Typical Equipment Setup

The measured ambient sound levels reported in this study are summarized in Table 5.1 below. The approximate locations of where these measurements were taken, relative to the proposed Site configuration, are shown in Appendix Figure A-1, hourly L_{eq} and L_{max} measurement data are also included in Appendix Tables A-1 through A-3.

Table 5.1 Pre-Construction Ambient Sound Levels, Overall L_{eq} (median of hourly L_{max})

Location	Daytime Sound Levels	Nighttime Sound Levels	Late-Nighttime Sound Levels[1]
Commercial Districts	*Code = 85 (100)*	*Code = 60 (75)*	
Location 1 - apartments above the Neptune Theater	61 (76)	56 (73)	53 (72)
Location 2 - University Manor Apartments	62 (77)	58 (71)	56 (70)
Residential Districts	*Code = 82 (97)*	*Code = 47 (62)*	
Location 3 – Felch House/Varsity Arms Condos[3]	64 (82)	58 (78)	57 (77)

1. Between midnight and 5:00 a.m.

2. 3 dB was subtracted from raw measurement data to account for microphone in proximity to exterior façade of the building, according to standard industry practice.

Source: The Greenbusch Group, Inc.

Comparing Table 5.1 with Tables 4.3 and 4.4, existing average nighttime ambient sound levels are similar to or less than Code Limits for Commercial districts and greater than Code limits for Residential districts.

6.0 CONSTRUCTION NOISE ANALYSIS

6.1 Computer Noise Model

The primary methodology used for the sound level analysis and prediction was a computer noise model. This model was created with the acoustic modeling software Cadna/A. 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. The model accounted for the effects of distance, topography and surface reflections on sound levels predicted for facility operation. Each piece of equipment was modeled as an individual noise source to help identify dominant sources.

6.2 Construction Equipment Sound Levels

The construction noise analysis was based upon site drawings, construction staging plans, and projected construction equipment information provided by Jacobs Associates, the Final Design consultant to Sound Transit. The types of equipment that may be used throughout the course of the Project include, but are not limited to, the equipment listed in Table 6.1 below. Equipment sound levels were based upon levels defined in the Federal Highway Administration (FHWA) Construction Noise Control Specification 721.560. FHWA 721.560 sound levels are maximum sound levels (L_{max}) 50 feet from the sound source. While the Federal Transit Administration (FTA) also publishes sound levels for construction equipment, the FHWA data are more comprehensive, and were selected for use in our analysis. FHWA construction equipment sound levels used in our analysis are shown in Table 6.1 below.

Table 6.1 Major Construction Equipment Sound Levels, L_{max}[1]

Equipment[2]	Sound Level	Acoustical Usage Factor[3], %	Impact Device[4]?
Backhoe	80	40	No
Compressor	80	40	No
Concrete mix truck	85	40	No
Concrete pump truck	82	20	No
Concrete saw	90	20	No
Crane	85	16	No
Delivery and haul truck	84	40	No
Dozer	85	40	No
Drill rig	85	20	No
Excavator	80	40	No
Fork lift[5]	80	40	No
Generator	82	50	No
Loader	80	40	No
Pump	77	50	No
Pump truck[6]	82	20	No
Transformer[7]	42	100	No
Tunnel vent fan	70	85	No

1. At a distance of 50 feet from the equipment, "slow" time weighting. While the City Code uses the "fast" time weighting, the data listed above is applied conservatively in the analysis by assuming that the equipment always generates the maximum sound level listed above, whenever it is active.
2. Generic equipment titles are listed, specific equipment descriptions are provided in Section 6.3
3. Percent of time in each hour equipment typically generates sound.
4. Creates impact sound subject to additional Code limits delineated in SMC 25.08.425.
5. Estimated.
6. Assumed to be similar to "Concrete pump truck."
7. Based on NEMA rating for 5,000 kVA forced air cooled device, will generate much less sound than other sources and is excluded from nighttime sound emission calculations for phases where night work is not scheduled.

Source: FHWA Specification 721.560, The Greenbusch Group

6.3 Construction Phases

Model analyses were developed for all phases of work (Phases 1-6), including two phases with nighttime work (Phases 4 and 5). For each phase, construction activities were identified, and equipment required to perform the work of each activity was activated in the model. Equipment activity locations were predicted where the work is likely required to be performed. While precise equipment locations will be at the discretion of the Contractor, for our analysis, equipment was generally placed at locations where higher sound levels at the receptors adjacent to the Project site would be expected, based on locations identified by Jacobs Associates.

A summary of the construction phases and the activities modeled for each are presented in the Table below.

Table 6.2 Northgate Link Extension U District Station Construction Phases

Phase ID	Activity Description
Phase 1	Site establishment, grading, utility work, contractor facilities and trailers.
Phase 2	Support of excavation; soldier piles & secant piles, temporary bridge construction over station footprint at south end.
Phase 3	Dewatering, box excavation, and muck handling.
Phase 4	Tunnel boring machine reception, maintenance and launch, twin-bored tunnel mining, cross passages excavation and support, tunnel and invert and duct banks.
Phase 5	Floating slab construction staging, delivery and staging for floating slab construction in the tunnel.
Phase 6	Station buildup and site restoration

Source: Jacobs Associates

6.3.1 Phase 1 Construction Equipment

The following activities are expected to occur during Phase 1:

- Site establishment and grading.
- Utility work.
- Construction of Contractor facilities, including temporary buildings and trailers.

The equipment included in our analysis for Phase 1 is outlined in the Table below, noise model equipment locations are shown in Appendix Figure A-3.

Table 6.3 Phase 1 Construction Equipment Assumptions for Noise Model

Equipment	Operating Period
Compressor	Daytime
Concrete pump trucks (2)	Daytime
Concrete mix truck	Daytime
Concrete Saw	Daytime
Cranes (3)	Daytime
Delivery and haul trucks (0.5/hr)[1]	Daytime
Dozers (2)	Daytime
Excavator (3)	Daytime
Loader	Daytime

1. On-site only

Source: Jacobs Associates

6.3.2 Phase 2 Construction Equipment

The following activities are expected to occur during Phase 2:

- Support of excavation.
- Installation of soldier piles and secant piles.
- Temporary bridge construction over station footprint at south end of station box.

The equipment included in our analysis for Phase 2 is outlined in the Table below, noise model equipment locations are shown in Appendix Figure A-4.

Table 6.4 Phase 2 Construction Equipment Assumptions for Noise Model

Equipment	Operating Period
Compressor	Daytime
Concrete mix trucks (2)	Daytime
Concrete pump trucks (2)	Daytime
Cranes (3)	Daytime
Crane	Daytime
Delivery and haul trucks (2/hr)[1]	Daytime
Drill rigs (2)	Daytime
Excavator	Daytime
Generators (2)	Daytime
Loaders (2)	Daytime
Transformer	Daytime/nighttime[2]

1. On-site only
2. Predicted to be within nighttime Code limits.

Source: Jacobs Associates

6.3.3 Phase 3 Construction Equipment

The following activities are expected to occur during Phase 3:

- Dewatering.
- Excavation of the station box.
- Muck handling.

The equipment included in our analysis for Phase 3 is outlined in the Table below, noise model equipment locations are shown in Appendix Figure A-5.

Table 6.5 Phase 3 Construction Equipment Assumptions for Noise Model

Equipment	Operating Period
Cranes (2)	Daytime
Delivery and haul trucks (4/hr)[1]	Daytime
Dozers (2)	Daytime
Drill rigs (3)	Daytime
Excavator	Daytime
Fork lift	Daytime
Generators (2)	Daytime
Loader	Daytime
Transformer	Daytime/nighttime[2]

1. On-site only

2. Predicted to be within nighttime Code limits.

Source: Jacobs Associates

6.3.4 Phase 4 Construction Equipment

The following activities are expected to occur during Phase 4:

- Receive south-bound tunnel boring machine at the north end of the station box.
- Perform maintenance on tunnel boring machine.
- Launch south-bound tunnel boring machine at the south end of the station box.
- Mining of the twin-bored tunnels.
- Excavation and support of cross passages excavation.
- Tunnel invert and duct banks (station box perimeter wells).

The equipment included in our analysis for Phase 4 is outlined in the Table below, noise model equipment locations are shown in Appendix Figure A-6.

Table 6.6 Phase 4 Construction Equipment Assumptions for Noise Model

Equipment	Operating Period
Compressor	Daytime/nighttime
Crane	Daytime/nighttime
Delivery and haul trucks (4/hr)	Daytime/nighttime
Generators (2)	Daytime/nighttime
Loader	Daytime/nighttime
Pumps (4)	Daytime/nighttime
Transformer	Daytime/nighttime
Tunnel fans (2)	Daytime/nighttime

1. On-site only

Source: Jacobs Associates

6.3.5 Phase 5 Construction Equipment

The following activities are expected to occur during Phase 5:

- Delivery and staging for floating slab construction.
- Installation of floating slab in tunnels.

The equipment included in our analysis for Phase 5 is outlined in the Table below, noise model equipment locations are shown in Appendix Figure A-7.

Table 6.7 Phase 5 Construction Equipment Assumptions for Noise Model

Equipment	Operating Period
Compressor	Daytime/nighttime
Crane	Daytime/nighttime
Delivery and haul trucks (4/hr)	Daytime/nighttime
Generators (2)	Daytime/nighttime
Loader	Daytime/nighttime
Pumps (4)	Daytime/nighttime
Transformer	Daytime/nighttime
Tunnel fans (2)	Daytime/nighttime

Source: Jacobs Associates

6.3.5 Phase 6 Construction Equipment

The following activities are expected to occur during Phase 6:

- Station buildup.
- Site restoration.

The equipment included in our analysis for Phase 6 is outlined in the Table below, noise model equipment locations are shown in Appendix Figure A-8.

Table 6.8 Phase 6 Construction Equipment Assumptions for Noise Model

Equipment	Operating Period
Backhoe	Daytime
Cranes (2)	Daytime
Delivery and haul trucks (1/hr)	Daytime
Generators (2)	Daytime
Loader	Daytime
Pumps (4)	Daytime
Pump truck	Daytime
Transformer	Daytime
Tunnel fans (2)	Daytime

Source: Jacobs Associates

7.0 MODELING RESULTS

Actual construction equipment locations and staging of activities will be at the discretion of the contractor. For non-stationary equipment, sound pressure levels at nearby properties will vary depending upon the actual location of the equipment at any given moment in time. For our analysis, equipment was generally placed at locations that tended to maximize predicted sound levels, given the likely site layout and staging.

For each phase of work, results were generated for all activities and at three locations adjacent to the Site boundary where existing ambient sound level monitoring was conducted. Predicted sound levels represent site construction activity only and do not include contributions from existing or future ambient conditions, or off-site haul trucks. All modeling was performed with construction wall doors open for haul truck movement, and haul truck sound levels were included in the predicted values, pursuant to SMC 25.08.480, when the receiving property was within a Residential district.

7.1 Predicted Sound Levels for Construction Phase 1

Nighttime activity is not anticipated for Phase 1. Existing ambient sound levels, predicted average construction sound levels, and Code limits for Phase 1 activities are summarized in the Tables below.

Table 7.1 Average Daytime Phase 1 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Project Level[1]	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	61	75	85
Location 2 - University Manor Apartments	62	81	
Residential Districts			
Location 3 - Varsity Arms Condos	64	74	82

1. Excludes sound reductions from solid perimeter construction wall.

Source: The Greenbusch Group

As shown in the Table above, daytime Phase 1 activities are expected to comply with Code limits, given the modeling conditions presented in Section 6.3.1.

7.2 Predicted Sound Levels for Construction Phase 2

Existing ambient sound levels, predicted average construction sound levels, and Code limits for Phase 2 activities are summarized in the Table below.

Table 7.2 Average Daytime Phase 2 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Project Level[1]	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	61	71	85
Location 2 - University Manor Apartments	62	80	
Residential Districts			
Location 3 - Varsity Arms Condos	64	73	82

1. Excludes sound reductions from solid perimeter construction wall.

Source: The Greenbusch Group

As shown in the Table above, daytime Phase 2 activities are expected to comply with Code limits, given the modeling conditions presented in the Section 6.3.2.

7.3 Predicted Sound Levels for Construction Phase 3

Existing ambient sound levels, predicted average construction sound levels with mitigation, and Code limits for Phase 3 activities are summarized in the Table below, including reductions afforded by the solid construction wall in place during this Phase and on-site mitigation such as upgraded mufflers on louder pieces of equipment, see Section 8.1 for additional mitigation information.

Table 7.3 Average Daytime Phase 3 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Mitigated[1] Project Level	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	61	69	85
Location 2 - University Manor Apartments	62	76	
Residential Districts			
Location 3 - Varsity Arms Condos	64	72	82

1. Includes reductions from solid perimeter construction wall.

Source: The Greenbusch Group

As shown in the Table above, daytime Phase 3 activities are expected to comply with Code limits, given the modeling conditions presented in the Section 6.3.3.

7.4 Predicted Sound Levels for Construction Phase 4

Nighttime activity is anticipated for Phase 4. Existing ambient sound levels with mitigation, predicted average construction sound levels, and Code limits for Phase 4 activities are summarized in the Tables below.

Table 7.4 Average Daytime Phase 4 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Mitigated Project Level	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	61	57	85
Location 2 - University Manor Apartments	62	70	
Residential Districts			
Location 3 - Varsity Arms Condos	64	71	82

Source: The Greenbusch Group

Table 7.5 Average Nighttime Phase 4 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Mitigated Project Level	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	53	49	60
Location 2 - University Manor Apartments	56	63	
Residential Districts			
Location 3 - Varsity Arms Condos	57	62	47

Source: The Greenbusch Group

As shown in Table 7.4 above, daytime Phase 4 activities are expected to comply with Code limits, given the modeling conditions presented in the Section 6.3.4. However, nighttime Code limits are predicted to be exceeded during Phase 4, as shown in Table 7.5.

Due to the proximity of nearby properties and the height of nearby buildings, nighttime Code compliance is not practical. Increased heights for the construction screening walls were considered, but reasonable increases in wall height would not provide significant improvements. Applying an absorptive surface to the barrier was also modeled, but influences to sound level reduction were insignificant, due to the large size of the construction site. Additional perimeter construction wall details are provided in Section 8.1

A variance, as specified in the Seattle Noise Control Code, SMC 25.08.655, would be needed to permit exceeding the nighttime Code limits during this construction Phase.

7.5 Predicted Sound Levels for Construction Phase 5

Existing ambient sound levels, predicted average construction sound levels with mitigation, and Code limits for Phase 5 activities are summarized in the Tables below.

Table 7.6 Average Daytime Phase 5 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Mitigated Project Level	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	61	57	85
Location 2 - University Manor Apartments	62	70	
Residential Districts			
Location 3 - Varsity Arms Condos	64	71	82

Source: The Greenbusch Group

Table 7.7 Average Nighttime Phase 5 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Mitigated Project Level	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	53	49	60
Location 2 - University Manor Apartments	56	63	
Residential Districts			
Location 3 - Varsity Arms Condos	57	62	47

Source: The Greenbusch Group

As shown in Table 7.6 above, daytime Phase 5 activities are expected to comply with Code limits, given the modeling conditions presented in the Section 6.3.5. However, nighttime Code limits are predicted to be exceeded during Phase 5, as shown in Table 7.7.

Due to the proximity of nearby properties and the height of nearby buildings, nighttime Code compliance is not practical. Increased heights for the construction screening walls were considered, but reasonable increases in wall height would not provide significant improvements. Applying an absorptive surface to the barrier was also modeled, but influences to sound level reduction were insignificant, due to the large size of the construction site.

A variance as specified in the Seattle Noise Control Code, SMC 25.08.655, would be needed to permit exceeding nighttime Code limits during this construction Phase.

7.6 Predicted Sound Levels for Construction Phase 6

Existing ambient sound levels, predicted average construction sound levels, and Code limits for Phase 6 activities are summarized in the Table below.

Table 7.8 Average Daytime Phase 6 Sound Levels, Hourly L_{eq}

Receiving Property	Existing Ambient Level	Predicted Mitigated Project Level	Code Limit
Commercial Districts			
Location 1 - apartments above the Neptune Theater	61	60	85
Location 2 - University Manor Apartments	62	71	
Residential Districts			
Location 3 - Varsity Arms Condos	64	68	82

Source: The Greenbusch Group

As shown in the Table above, daytime Phase 6 activities are expected to comply with Code limits, given the modeling conditions presented in the Section 6.3.6.

8.0 RECOMMENDED MITIGATION MEASURES

8.1 Solid Perimeter Construction Walls

Varying heights of construction screening walls were modeled to determine the optimal combination of wall and natural barrier from the excavated pit that will later serve as the station box. Some sound source locations have elevations which are below street level. For these locations, a natural barrier is provided due to screening afforded by the retaining wall for the pit.

The acoustical effectiveness of screening walls is limited by the height of neighboring buildings and the large site area. The screening walls will not benefit the upper story receiver locations that have an elevation with line of sight to the construction equipment over the tops of the screening walls. For example, the University Manor Apartments building is eight stories and approximately 85 feet in height. In order to reduce sound levels at the upper floor of the building, the wall would need to be tall enough to block line-of-sight, which is not feasible. Perimeter wall heights of up to 24 feet were analyzed. The added height did not provide significant reductions in sound level for buildings closest to the site. For example, construction sound level reductions at the upper six stories of the University Manor Apartments are predicted to be between 0 and 1 dBA when compared to a 16 foot wall. As an alternative to taller walls, the wall height was incrementally increased until sound levels at the lower stories were reduced, and alternative on-site mitigation measures were used in the model to reduce sound levels at upper building stories.

We recommend a 16-foot solid perimeter construction wall near noise-sensitive properties built with not less than ¾" marine grade plywood. A "noise-sensitive property" is considered, in this Report, to be a property with residential use, either current or anticipated, in either a Residential or Commercial district. These areas of 16-foot walls would include the entire southern boundary at NW 43rd St. north of the University Manor Apartments and southwestern portion of the site south of the University of Washington Foundation building. Walls 12 feet in height are recommended near non-sensitive properties, with the exception of the University of Washington South Annex building due to the request from the University of Washington for a jersey barrier and chain link fence to provide light and air to the building. While the apartments above the Neptune Theater are considered a sensitive receiver, these apartments are screened by the Neptune Theater building north of the Site for the most part. Therefore a 12-foot wall is recommended at this northern area of the Site.

Adding an acoustically-absorptive surface to the construction-site side of the perimeter walls is predicted to provide negligible reduction in construction sound levels at neighboring properties. Comparative modeling quantified this improvement to be between 0 and 1 dBA, depending on the receiver location. This is due to the large expanse of the Site.

A site plan with proposed perimeter construction wall locations is shown in Appendix Figure A-2.

8.2 Nighttime Haul Truck Controls

To reduce sound generated by the haul trucks, the following contractual requirements are recommended:

- No compression ("jake") brakes shall be used.
- All haul truck beds shall be lined with an appropriate dampening compound to reduce impact sound from debris as it is loaded into the beds, or maintain a minimum 1-foot thick layer of muck or dirt in the bottom of the beds.
- No tonal backup alarms shall be used; broadband backup alarms or strobe lights shall be installed on all muck haul trucks unless workplace safety dictates otherwise.
- Engines shall not idle for longer than 5 minutes while on site and not directly involved in work activities. This would include queuing of haul and delivery trucks.

8.3 Controls for Construction Site Equipment

To reduce sound generated by construction vehicles and activities, the following contract requirements are recommended:

- No tonal alarms shall be used; broadband alarms or strobe lights shall be required on all nighttime site construction vehicles unless workplace safety dictates otherwise. In that event, alternatives must be provided by the Contractor that avoid the use of tonal alarms while providing adequate safety performance.
- No impact sound shall be generated after 5 p.m., including sound from jack hammers, hoe rams, hoe packs and non-impact equipment used in a fashion that generates impact-type sound.
- Radios shall be used for all long-range communication. Raised voices and public address systems are only allowed in the case of an emergency. Such systems shall be tested during daytime hours only.
- The Contractor shall use the quietest equipment available, based on industry standard practice, to meet nighttime sound level limits, as required.
- Upgraded mufflers, engine shrouds, or sound enclosures shall be used on equipment to meet nighttime sound level limits, as required.
- Equipment shall not idle un-used for longer than 5 minutes.
- Monitoring and maintenance of equipment to meet Variance sound level limits.

8.4 Optional Mitigation Measures

Additional mitigation measures could also be implemented by the Contractor on an as-needed basis to satisfy the proposed noise variance limits depending on their final means and methods, including measures identified as optional in the ROD. These measures could include, but are not limited to the following:

- Lined or covered storage bins, conveyors, tailgates, and chutes with sound deadening material.
- Acoustic shields or shrouds for equipment.
- Enclose electrical generators, ventilation fans, pumps, concrete batch plants, and air compressors.
- Minimize the use of generators to power equipment.
- Grade surface irregularities on construction sites.

- Use moveable noise barriers at the source of the construction activity.
- Limit or avoid certain noise-generating activities during nighttime hours.
- Where feasible, equipment operators could drive forward rather than backward to minimize use of back-up alarms.
- Place ventilation fans within shafts and use acoustically absorptive ducting and/or in-line silencers.
- Use electric and hydraulic equipment in lieu of diesel or pneumatic.

9.0 VARIANCE SOUND LEVEL LIMITS

9.1 Methodology and Metrics

The process for determining the variance sound level limits is based on Sound Transit's previous noise variance methodologies for nighttime construction activities at the University of Washington Station (UWS) and Capitol Hill Station (CHS) sites, and on the Washington State Department of Transportation's (WSDOT's) methodology for the SR99 Bored Tunnel Project (SR99).

Sound Transit's methodologies for CHS and UWS developed both average and maximum sound level limits based on existing ambient noise levels during late-nighttime periods (12 a.m. – 5 a.m.), since existing ambient sound levels already exceeded Code limits by as much as 14 dBA[1] in the nearest Residential District. The variance sound level limit for average sound levels (hourly L_{eq}) was set at 6 dBA above existing late-nighttime average ambient (hourly L_{eq}) and the maximum sound level limit (hourly L_{max}) was set as 16 dBA above existing late-nighttime average ambient (hourly L_{eq}).

The SR99 approach established hourly L_{eq} sound level limits based on existing late-nighttime average ambient (hourly L_{eq}) sound levels similar to the approach used at UWS. The existing ambient sound levels along the SR99 site exceeded Code limits by as much as 19 dBA[2]. The hourly average variance sound level limit was calculated in a similar manner to the UWS, by adding 6 dBA to existing ambient levels. However, the SR99 utilized an L_{01} metric equal to 16 dB above the existing late-nighttime average ambient level or 85 dBA, whichever was less, instead of the L_{max} metric used at the UWS.

Sound level compliance monitoring at UWS revealed challenges with monitoring the L_{eq} and L_{max} to assess compliance with variance limits. The L_{eq} was easily influenced by changes in ambient conditions from non-project noise sources. Removing these contributions to the ambient levels measured proved to be problematic. The L_{max} metric was included in the Variance to provide a secondary limit, if monitoring the L_{eq} was not possible with the influences of the non-project sources. However, L_{max} levels were often associated with very short, transient activities, or noise sources not originating from the site. Therefore, the L_{max} did not fully, or fairly, characterize sound level emissions from the construction site. In coordination with DPD, Sound Transit shifted to tracking hourly L_{01} sound levels to assess compliance at UWS. The procedure that was established for using the L_{01} involved evaluating all sound files for events in excess of the L_{01} monitoring threshold to verify whether all 36 seconds of sound above the threshold level (1% of an hourly period) was from the construction site. After moving to the L_{01} metric, compliance assessment was made much more efficient and the occurrences of potential, but unverified, site exceedances were greatly reduced.

This Report implements Sound Transit's experience monitoring compliance of the UWS and CHS by recommending that only the hourly L_{01} limit be used for monitoring to assess compliance with Variance limits, unless a situation arises where monitoring the

[1] . Based on measurements of late-nighttime sound ambient levels (hourly L_{eq}), Technical Noise Variance Decision #3010245, Sound Transit University of Washington Station, 11/05/09

[2] . Based on measurements of late-nighttime sound ambient levels (hourly L_{eq}), Major Public Project Construction Variance Decision # 3011620, SR 99 Bored Tunnel, 08/08/11

hourly L_{01} proves ineffective in light of a specific case of patterned complaint or exceedance, in which case the hourly L_{eq} would also be monitored. In addition, since existing ambient sound levels are generally below Code limits during nighttime hours, it is recommended that Variance limits be calculated based on 6 dBA above existing ambient, or 6 dBA above Code, whichever is greater. Based on ambient measurement data for the Site, this would correlate to 6 dBA above Code for Commercial properties and 6 dBA above ambient for Residential properties. Similar variance sound level limit methodologies and monitoring programs used at UWS and CHS have resulted in an excellent record of compliance.

The following Variance sound level limits are proposed for use in the Noise Variance Application for U District Station:

- Hourly L_{eq} limit for Commercial properties = nighttime Code + 6 dBA
    - These values are primarily used to analyze site construction sound levels, unless monitoring of L_{01} proves to be inadequate for any specific complaint or exceedance patterns that arise during construction, only then would the L_{eq} be monitored.
- Hourly L_{eq} limit for Residential properties = late-nighttime ambient + 6 dBA
    - These values are primarily used to analyze site construction sound levels, unless monitoring of L_{01} proves to be inadequate for any specific complaint or exceedance patterns that arise during construction, only then would the L_{eq} be monitored.
- Hourly L_{01} limit = hourly L_{eq} limit + 10 dBA.
    - These limits are used to monitor compliance with the Variance at the property line or building façade, whichever level is greater. However, this Report proposes initial compliance monitoring to be conducted on short-term (15 minute) intervals and compared to the hourly limits, additional sound level monitoring discussion is presented in Section 11.2.

Given that Cadna/A does not directly predict percentile sound levels like L_{01}, the L_{eq} limits are utilized to assess satisfaction of the proposed variance sound level limits. This is largely due to the unknown use of equipment over an hourly period. To predict hourly L_{eq} sound levels, the model must make an assumption with regard to percent of time a specific piece of equipment is in use, also known as the “usage factor.” The longer the duration a sound source is assumed to be active, the higher the sound emissions from that source. In order to predict percentile levels like L_{01}, however, the model would need to assume what equipment was operating every second of every hour. This level of assumption is not reasonable, rendering accurate L_{01} predictions infeasible. Therefore, this Report utilizes hourly L_{eq} analysis criteria to predict compliance with the L_{eq} and L_{01} limits.

Typical differences between L_{01} and L_{eq} construction sound emissions were calculated from monitoring data collected at CHS, which shares a similar site layout and work scope to this Project. The results of this analysis confirmed a typical difference between L_{01} and L_{eq} to be within the 10 dBA level used in the SR99 methodology.

9.2 Limits for All Phases

Recommended Variance sound level limits and analysis criteria, calculated based on the methodology outlined in Section 9.1, are presented in the Table below.

Table 9.1 Proposed Variance Sound Level Limits for Hourly Nighttime Sound Levels

Location	Nighttime Code L_{eq} (L_{max})	Ambient L_{eq}[1] (L_{01}[2])	L_{eq} + 6 dBA		Proposed Limits[3]	
			Code + 6 dBA	Ambient + 6 dBA	L_{eq}	L_{01}
All Commercial Properties	**60 (75)**	**51-60 (60-66)**	**66**	N/A	**66**	**76**
Apartments above the Neptune Theater		53 (60)				
University Manor Apartments		56 (61)				
All Residential Properties	**47 (62)**	**57 (65)**	N/A	**63**	**63**	**73**
Varsity Arms Condos						

1. Overall L_{eq} between 12:00 a.m. and 5:00 a.m.
2. Median hourly L_{01} between 12:00 a.m. and 5:00 a.m.
3. Due to anticipated monitoring challenges with L_{eq}, it is proposed that only the L_{01} sound level limit be monitored to determine Variance compliance.

Source: The Greenbusch Group, Inc.

Predicted sound levels for nighttime construction activities, including noise reductions afforded by the mitigation outlined in Section 8, are compared with recommended Variance sound level limits in the Table below.

Table 9.2 Predicted Construction Sound Levels and Variance Limit Compliance Analysis

Location	Predicted Nighttime Construction Sound Levels, Hourly L_{eq}	Variance Limit Compliance Analysis Result	
	Phases 4-5	Hourly L_{eq}	Predicted Level below Variance Limit
Apartments above the Neptune Theater	49	**66**	**Yes**
University Manor Apartments	63	**66**	**Yes**
Varsity Arms Condos	62	**63**	**Yes**

Source: The Greenbusch Group, Inc.

10.0 CONTRACTOR'S NOISE CONTROL AND MONITORING PLAN

In order to effectively incorporate and implement all required noise mitigation measures stated in this Report and DPD's Variance Decision, the Contract Documents for the Project will require the Contractor to develop, implement, and maintain a Noise Control and Monitoring Plan ("NCMP"). Sound Transit's contract specification will require the Contractor to submit the NCMP to Sound Transit for review and approval within 45 days of Notice to Proceed. Once approved, it is recommended that Sound Transit submit the NCMP to DPD for review and approval prior to the start of any night work under the Variance. A copy of the NCMP should be maintained in the Contractor's office.

The NCMP should be prepared by an Acoustic Specialist as recognized by membership in National Council of Acoustical Consultants (NCAC), Institute of Noise Control Engineering (INCE), or Acoustical Society of America (ASA), with minimum 5 years of experience in construction noise analysis and control.

As a minimum, we recommend that the NCMP:

- Summarize mitigation requirements in this Report and the Variance Decision.
- Identify additional mitigation measures necessary to mitigate nighttime sound levels to within Variance limits.
- Identify additional mitigation measures necessary to mitigate daytime sound levels to within City Code limits.
- Include lists of construction activities, equipment, layout and staging information, and a rough schedule for nighttime work over the course of the Project.
- Predict daytime sound levels (L_{eq} only) at nearby sensitive receivers, and nighttime sound levels (L_{eq} only) where Variance limits have been established.
- Be consistent with this Report, City Code, and the Variance.

11.0 NOISE VARIANCE COMPLIANCE TRACKING

11.1 Independent Noise Monitor

In order to comply with DR 3-2009, Sound Transit must provide an Independent Noise Monitor (INM) for the Project, to perform the duties stated in Section C, Rule 2 of this Director's Rule. The INM will take direction from the City Noise Abatement Coordinator (NAC) at DPD.

11.2 Sound Level Monitoring

Due to the sensitive nature of some nearby receivers, noise monitoring terminals (NMTs) with the capability to log continuous sound levels and record audio files of louder events are recommended. We recommend that the Contractor be responsible to provide, install, and maintain the NMTs (overseen by the INM), and provide unrestricted physical and unrestricted electronic access (viewing, editing, and controlling) to the INM.

Based on Sound Transit's experience at the Capitol Hill and University of Washington stations, and input provided by DPD staff, we also propose that short-term monitoring be conducted by the INM at the start of the nighttime activities, with not less than 15 minutes of data collected at each monitoring location during each site inspection visit. If the short-term monitoring proves to not provide sufficient data to investigate complaints or potential non-compliance issues, continuous monitoring (whether or not night work is occurring) may be warranted.

It is recommended that the NMTs be equipped with the following:

- One sound level analyzer with the following capabilities and specifications:
  - Type 1 rating as delineated in American National Standards Institute (ANSI) S1.4 and S1.43, or Class 1 rating per IEC 61672.
  - Continuous broadband logging of one-second L_{eq} and L_{max}.
  - Continuous spectral logging of one-second L_{eq} and L_{max}.
  - Periodic reporting of L_{01} (at least 15 and 60 minutes)
  - Capability to record sound files based on a threshold trigger event, adjustable in 1 dB increments, and capable of triggering on the "fast" time-weighted sound pressure level.
  - Sufficient internal memory and power supply for one week of logging, with sound recordings.
  - Calibrated not less than weekly. If charge injection calibration is used, manual calibrations with an acoustic calibrator must occur not less than monthly.
  - Annual calibration at a National Voluntary Laboratory Accreditation Program (NVLAP)-accredited acoustical laboratory.
- One random-incidence microphone housed in an environmental shroud, providing protection from rain and wind conditions. The environmental shroud should be capable of outdoor measurements for at least one year without service or replacement. The sound level analyzer must be able to compensate for the presence of the shroud.

- One lockable and weather-resistant enclosure large enough to hold the battery, sound level meter, and accessories.

Unrestricted physical access and restricted electronic access (viewing only) should be provided to Sound Transit, the NAC, and the Contractor. INM should be responsible for maintaining the collected data on the NMTs, including downloading previous night monitoring data, and reviewing for compliance with Variance limits. It is also recommended that the INM be responsible to log which nights work was occurring, based on construction schedules provided by the Resident Engineer and brief review of sound recordings from nights when work was not scheduled.

While precise installation locations will depend on acquired rights-of-entry or clearance to install devices in public rights-of-way, we propose the following monitoring areas for the NMTs:

- Apartments above the Neptune Theater
- University Manor Apartments
- Varsity Arms Condos

Microphones would ideally be located at, or within, the receiving property. If the solid perimeter construction wall (or other available mounting location such as a utility pole) is not near the property boundary, monitoring data collected at this location will likely not represent Project sound levels received by the property subject to Variance conditions.

11.3 Complaint Response

The INM should remain on-call during all periods of scheduled night work. The Resident Engineer (or delegate) should be required to keep the INM informed of upcoming night work schedules. Noise-related complaints received by Sound Transit's 24-hour construction hotline should be forwarded to the INM during nighttime work hours. Complaints received during the day could be logged and the information sent to the INM. If the INM receives a complaint call during nighttime work hours, they should notify the Resident Engineer (or delegate), perform a site inspection within 30 minutes of receiving the complaint, and conduct short-term noise monitoring (not less than 15 minutes per location) while on-site to determine if a noise variance exceedance is occurring. If

11.4 Noise Variance Non-Compliance Resolution

In the case of prolonged non-compliance issues, the INM should coordinate with the NAC, Sound Transit, and the Contractor, as directed by the NAC. The Contractor may be required to provide additional mitigation measures, such as those listed in Section 8.4 where practical and feasible, to resolve non-compliance issues.

11.5 Compliance Reporting

As required by DR 3-2009, the INM will provide the following reports:

- Weekly reports, provided to DPD and Sound Transit no later than Wednesday following the completion of the reported week, whether or not night work occurred.
    - o Summarize sound level measurements and data collected during the reporting period.

  - Mitigation measures used during the reporting period.
  - Observations of activities not in conformance with Variance conditions during the reporting period, and any corrective actions taken.
  - Complaints received during the reporting period, and any corrective actions taken.
- Annual reports, provided to DPD and Sound Transit no later than one week following the completion of the reported year
  - General summary of performance under the Variance.
  - Summary of weekly reports, including any limit exceedances, complaints received, and corrective action taken.
    - NOTE: The first annual report will be used by DPD during the “one-year check-in review", which is a condition of any MPPCV. This review process will gauge performance of the variance and is defined in DR 3-2009 Section H.
- Final report, provided to DPD and Sound Transit at the end of the Project.
  - General summary of performance under the Variance.
  - Summary of annual reports, including limit exceedances, complaints received, and corrective action taken.

12.0 COMMUNITY OUTREACH

During the entire construction period at the U District Station site, it is our understanding that Sound Transit’s Community Outreach staff will be able to assist citizens by providing up-to-date information on proposed construction activities and responding to and assisting in resolving any noise complaints that may be received. Outreach staff will also work in close coordination to ensure that the public is kept aware of any changes to the work environment that may affect nighttime sound emissions, and that all complaints are dealt with in a timely and effective manner.

Additionally, it is our understanding that Sound Transit will maintain a toll-free 24-hour Construction Hotline to provide a single point of contact for construction inquiries and complaints, including noise complaints. After being logged into a complaint database, noise related calls will be immediately transferred to the INM for evaluation and investigation.

APPENDIX

Figure A-1 Site Plan, Nearby Property Zonings, and Ambient Noise Monitoring Locations

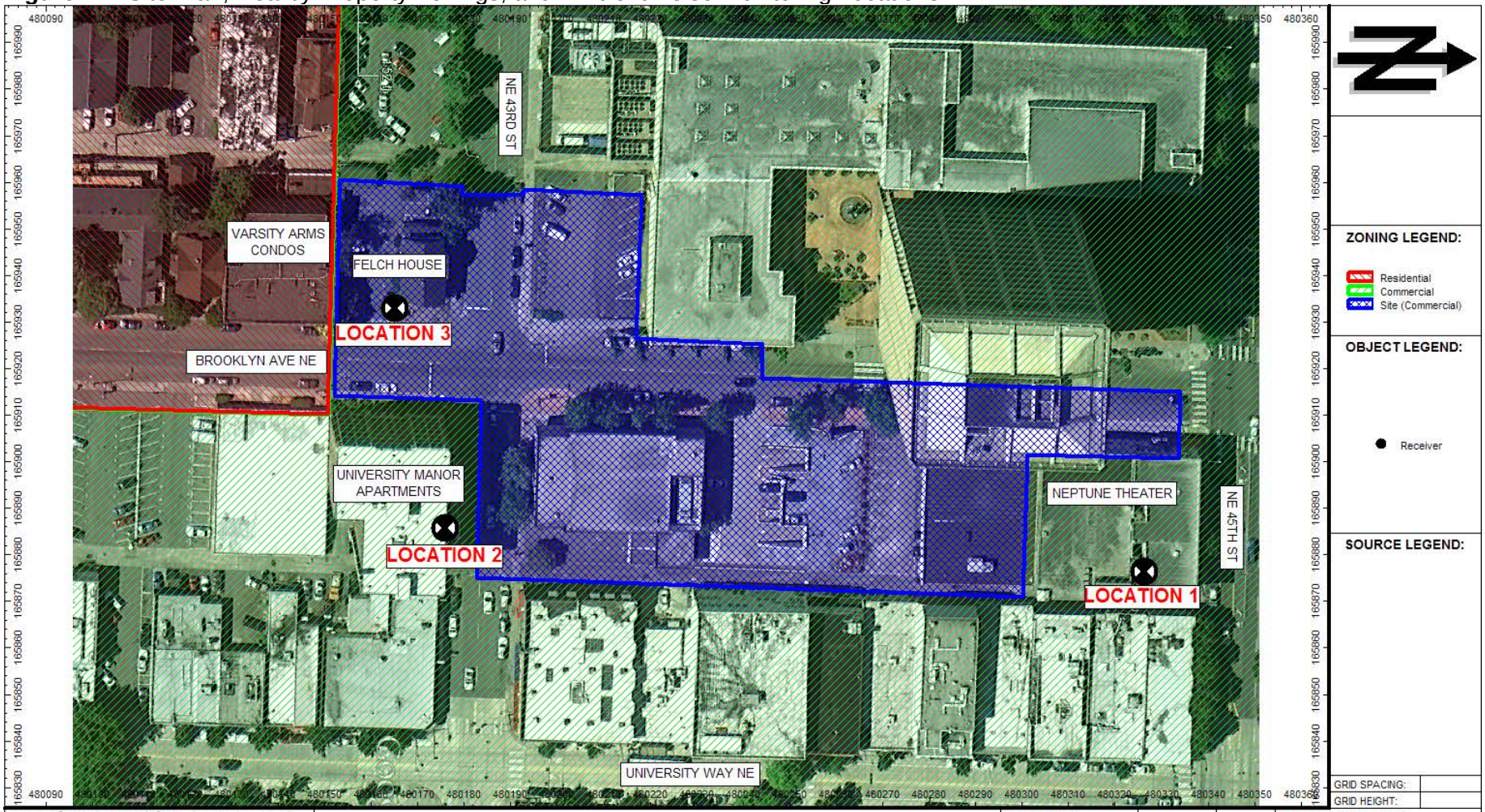


Figure A-2 Proposed Solid Perimeter Construction Wall Locations and Heights

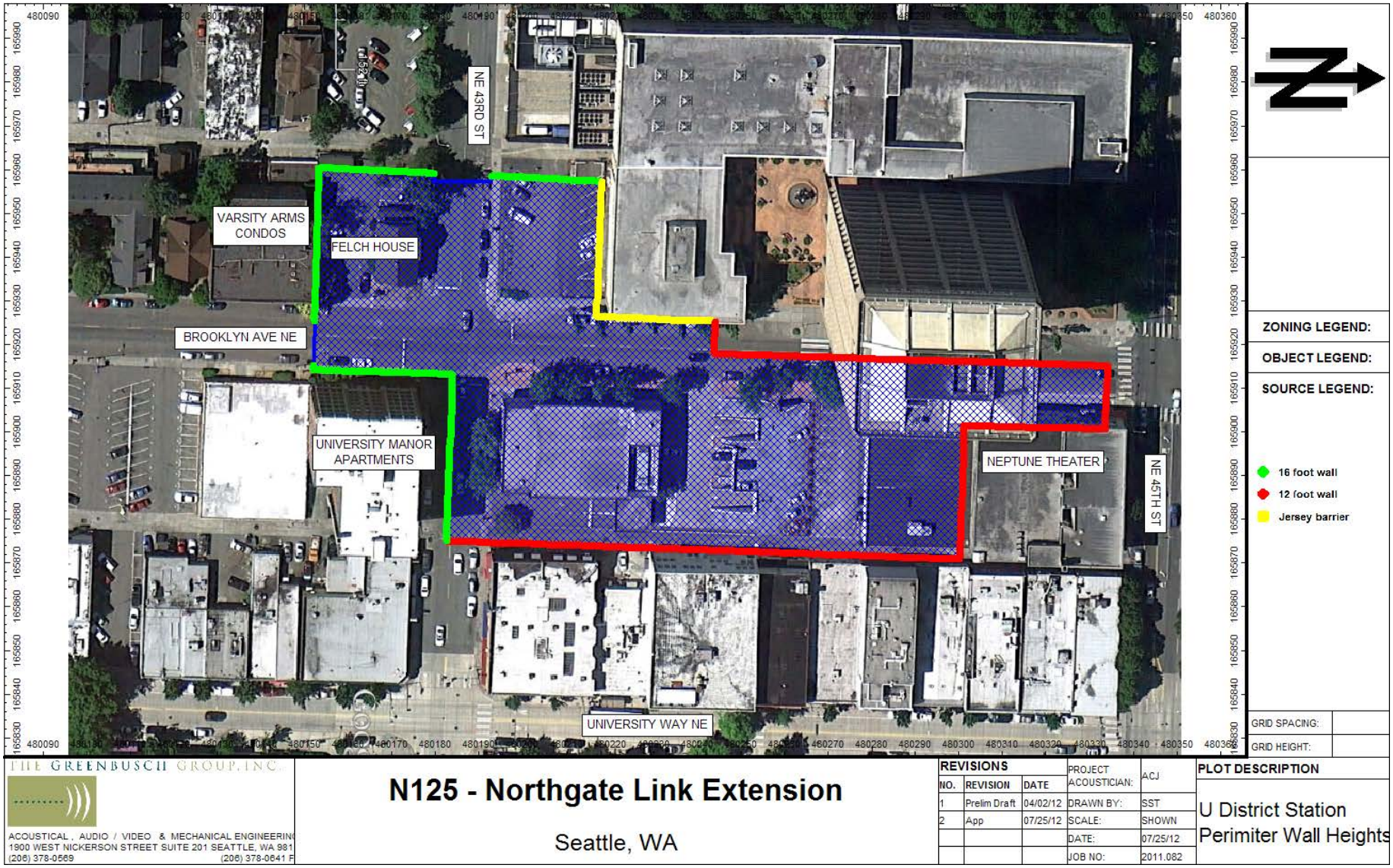
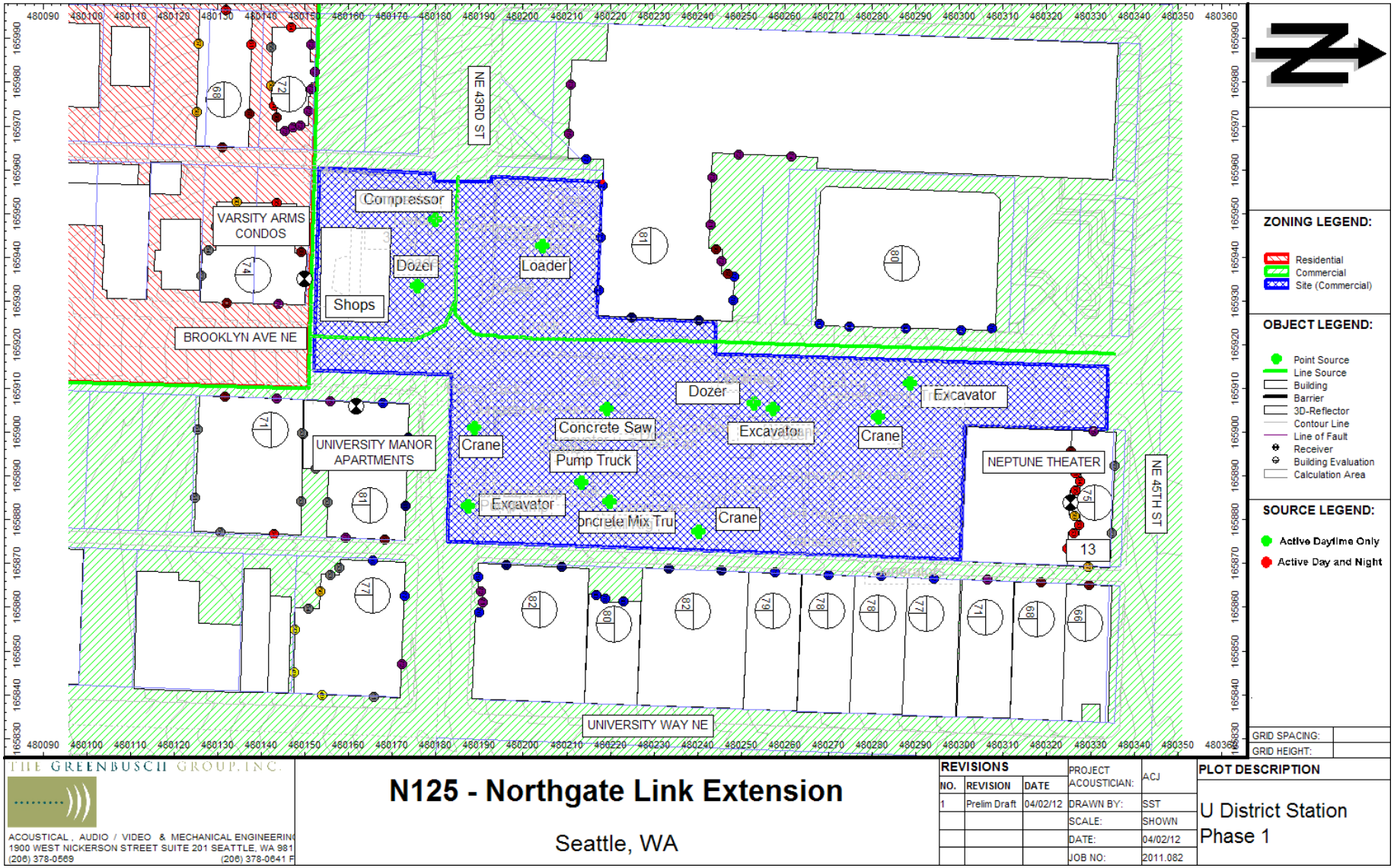


Figure A-3 Phase 1 Modeling Conditions and Predicted Building Sound Levels



THE GREENBUSCH GROUP, INC.
ACOUSTICAL , AUDIO / VIDEO & MECHANICAL ENGINEERIN
1900 WEST NICKERSON STREET SUITE 201 SEATTLE, WA 981
(206) 378-0569 (206) 378-0641 F

N125 - Northgate Link Extension

Seattle, WA

REVISIONS			PROJECT ACOUSTICIAN:	ACJ
NO.	REVISION	DATE		
1	Prelim Draft	04/02/12	DRAWN BY:	SST
			SCALE:	SHOWN
			DATE:	04/02/12
			JOB NO:	2011.082

PLOT DESCRIPTION

U District Station
Phase 1

Figure A-4 Phase 2 Modeling Conditions and Predicted Building Sound Levels

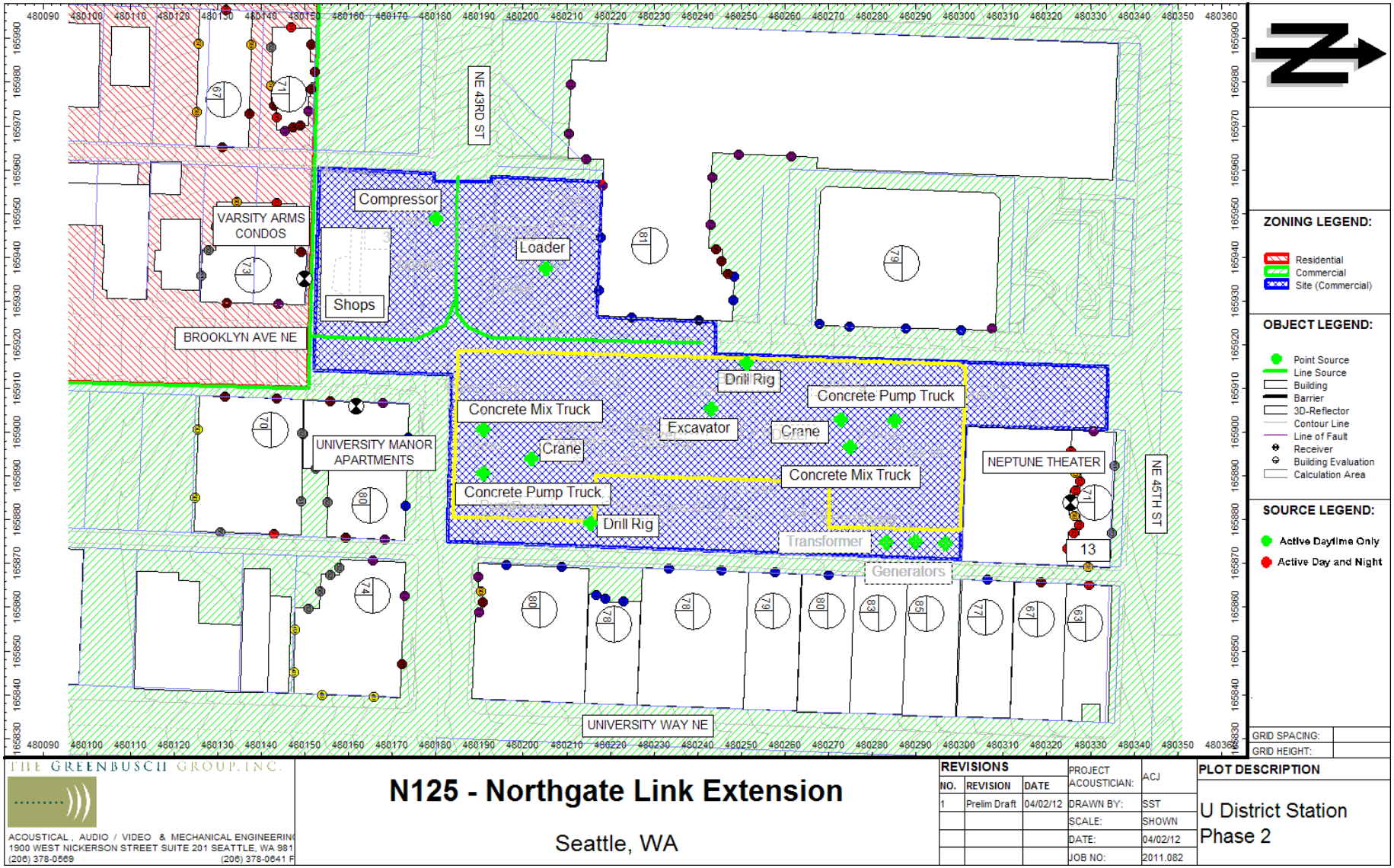


Figure A-5 Phase 3 Modeling Conditions and Predicted Building Sound Levels

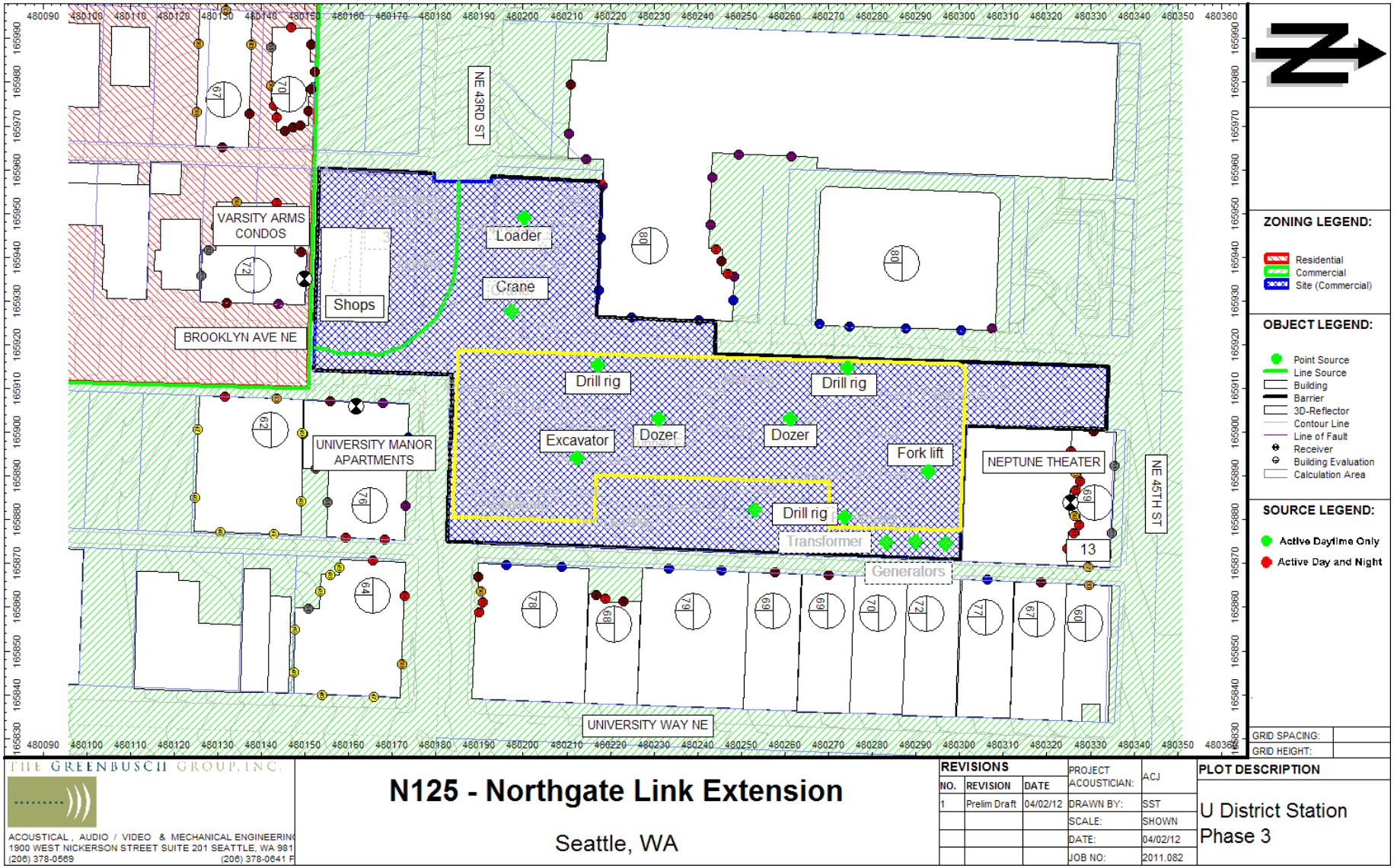


Figure A-6 Phase 4 Modeling Conditions and Predicted Building Sound Levels

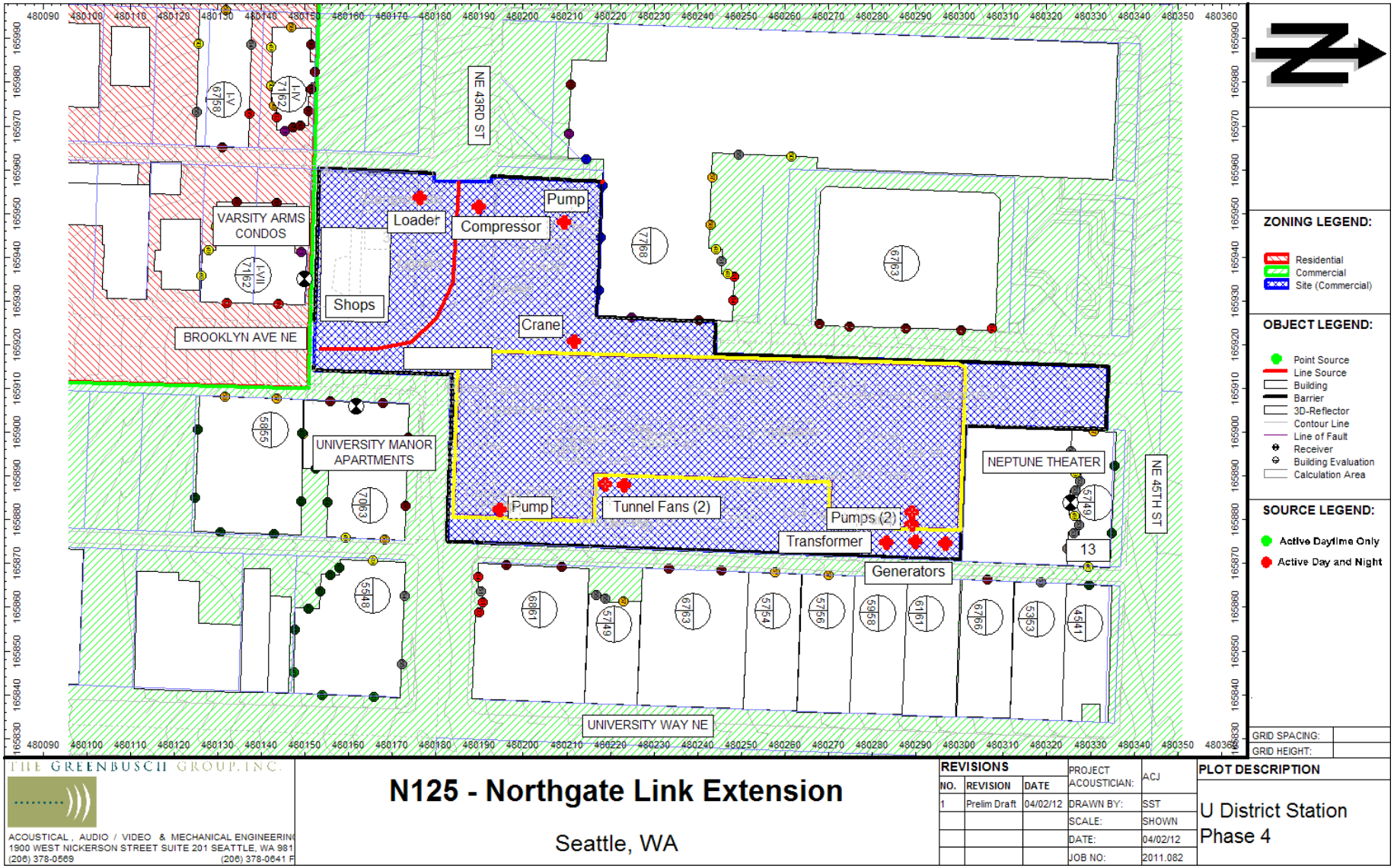
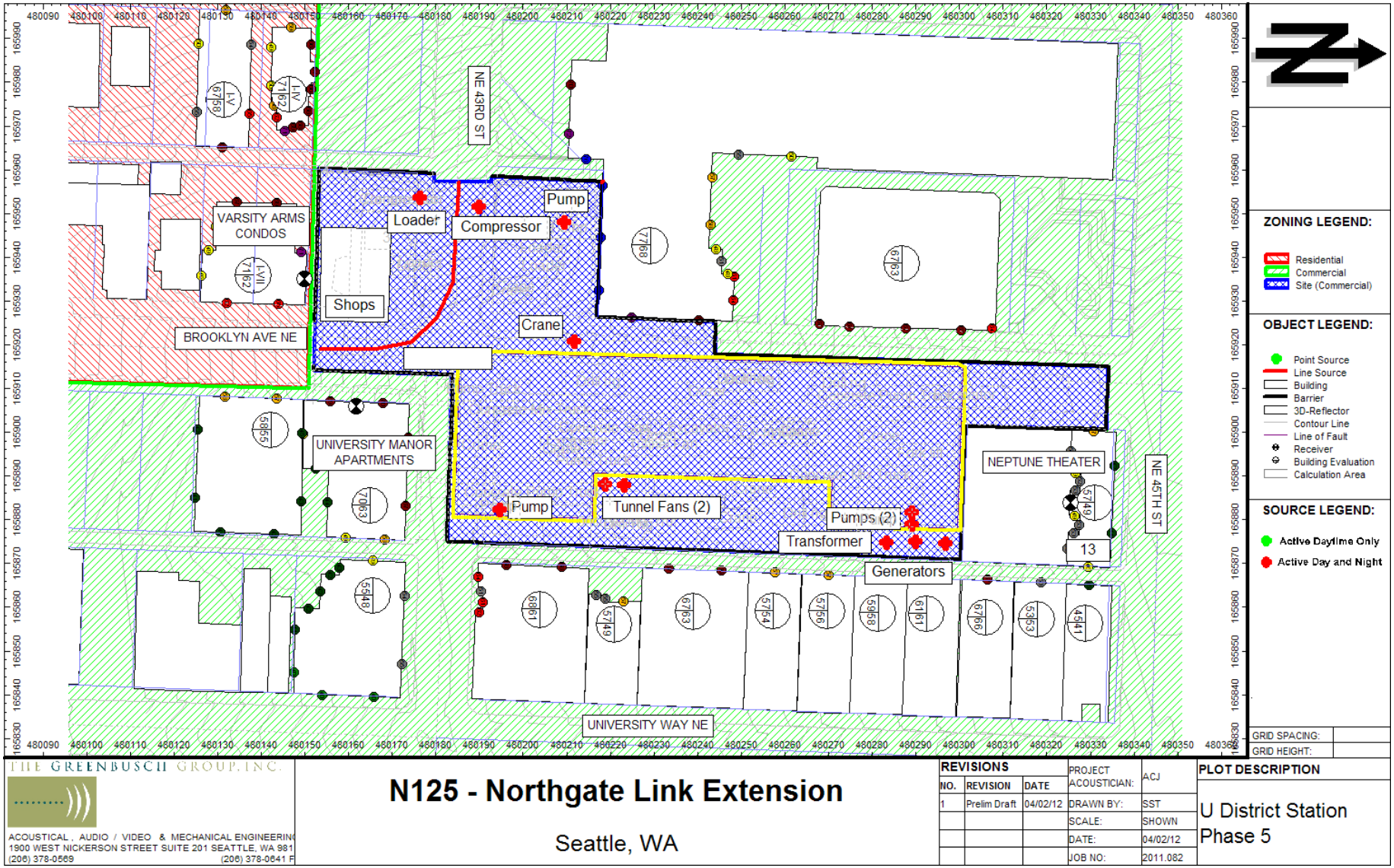


Figure A-7 Phase 5 Modeling Conditions and Predicted Building Sound Levels



THE GREENBUSCH GROUP, INC.
ACOUSTICAL , AUDIO / VIDEO & MECHANICAL ENGINEERIN
1900 WEST NICKERSON STREET SUITE 201 SEATTLE, WA 981
(206) 378-0569 (206) 378-0641 F

N125 - Northgate Link Extension

Seattle, WA

REVISIONS			PROJECT ACOUSTICIAN:	ACJ
NO.	REVISION	DATE		
1	Prelim Draft	04/02/12	DRAWN BY:	SST
			SCALE:	SHOWN
			DATE:	04/02/12
			JOB NO:	2011.082

PLOT DESCRIPTION

U District Station
Phase 5

Figure A-8 Phase 6 Modeling Conditions and Predicted Building Sound Levels

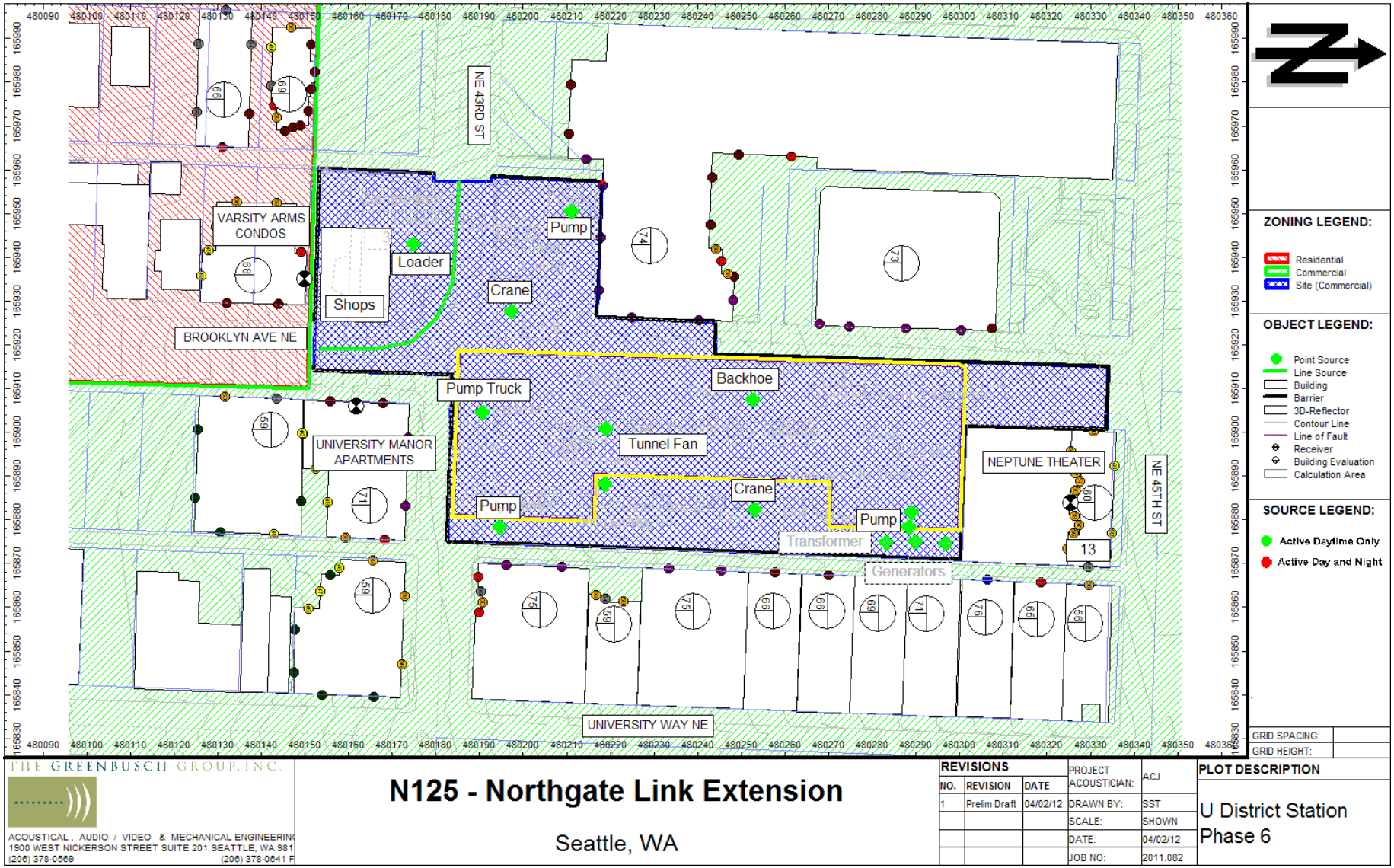


Table A-1 Hourly Ambient Noise Monitoring Data for Location 1 (1303 NE 45th St., apartments above the Neptune Theater)

Start of Hour	06/09	06/10	06/11	06/12	06/13	06/14	06/15	06/16	06/09	06/10	06/11	06/12	06/13	06/14	06/15	06/16
	L_{eq}								L_{max}							
12:00 a.m.		55	56	56	55	55	56	53		72	78	81	71	68	77	69
1:00 a.m.		55	54	54	56	55	53	52		78	81	68	76	79	69	75
2:00 a.m.		52	54	53	52	52	52	50		65	71	71	70	72	74	68
3:00 a.m.		51	51	55	52	52	51	50		60	78	83	73	67	76	69
4:00 a.m.		52	52	50	53	54	52	53		74	68	69	72	74	71	76
5:00 a.m.		61	55	52	57	57	56	57		83	82	74	80	78	73	80
6:00 a.m.		57	54	52	59	59	59	60		77	74	72	79	76	79	78
7:00 a.m.		59	56	54	61	61	60	62		74	75	67	72	78	70	83
8:00 a.m.		60	57	55	61	60	60	60		72	78	70	77	79	74	82
9:00 a.m.		60	58	58	62	60	59	59		73	73	75	74	72	77	70
10:00 a.m.	60	59	60	58	63	61	62		76	73	77	74	83	76	86	
11:00 a.m.	60	59	59	61	61	60	59		78	75	76	83	78	74	84	
12:00 p.m.	59	59	58	58	61	59	58		77	75	75	74	75	72	74	
1:00 p.m.	59	59	76	58	61	60	59		74	79	109	75	79	77	75	
2:00 p.m.	60	59	58	58	62	60	60		81	73	77	73	87	75	80	
3:00 p.m.	58	59	60	58	61	59	59		80	76	85	73	74	72	77	
4:00 p.m.	60	60	59	59	62	60	59		76	77	80	76	76	74	70	
5:00 p.m.	59	59	58	59	60	60	60		85	84	79	77	73	79	88	
6:00 p.m.	58	60	58	60	61	59	59		73	73	76	73	76	73	72	
7:00 p.m.	59	59	59	60	60	59	60		76	72	78	77	76	72	81	
8:00 p.m.	60	60	57	60	60	59	58		72	80	70	74	73	75	73	
9:00 p.m.	59	58	59	60	60	57	57		70	77	82	84	76	71	71	
10:00 p.m.	57	57	57	57	58	56	57		71	79	70	72	72	70	77	
11:00 p.m.	55	57	57	56	60	56	55		67	75	73	70	82	70	69	
Overall daytime[1]	**61**								**76**							
Overall nighttime[1]	**56**								**73**							
Overall late-nighttime[1]	**53**								**72**							

1. Overall L_{eq} calculated as average of hourly levels, Overall L_{max} calculated as median of hourly levels

Source: The Greenbusch Group, Inc.

Table A-2 Hourly Ambient Noise Monitoring Data for Location 2[1] (1305 NE 43rd St., University Manor Apartments)

Start of Hour	06/17	06/18	06/19	06/20	06/21	06/22	06/23	06/24	06/17	06/18	06/19	06/20	06/21	06/22	06/23	06/24
	L_{eq}								L_{max}							
12:00 a.m.		58	56	58	57	57	58	59		73	69	68	79	70	72	79
1:00 a.m.		58	56	54	54	56	56	59		77	67	70	67	69	69	80
2:00 a.m.		61	55	54	54	54	55	56		87	66	70	76	73	72	72
3:00 a.m.		55	55	53	53	54	54	54		65	67	63	67	67	67	68
4:00 a.m.		55	55	56	56	55	56	56		65	67	81	79	75	74	79
5:00 a.m.		55	57	57	57	56	58	61		70	67	72	69	67	71	83
6:00 a.m.		57	58	60	60	59	59	61		67	66	76	83	71	75	72
7:00 a.m.		60	58	61	60	60	61	62		71	68	78	77	73	79	78
8:00 a.m.		61	59	61	62	62	61	63		69	68	72	75	78	74	74
9:00 a.m.	61	63	60	62	62	63	63		76	74	71	79	73	74	80	
10:00 a.m.	62	62	61	63	63	64	63		75	74	73	77	73	75	80	
11:00 a.m.	61	62	62	63	62	64	63		76	81	76	83	84	90	77	
12:00 p.m.	62	62	62	63	62	62	62		76	78	74	74	73	79	77	
1:00 p.m.	61	61	64	63	63	64	63		76	71	93	76	83	82	75	
2:00 p.m.	62	60	61	63	63	64	63		80	72	81	83	79	75	82	
3:00 p.m.	62	59	61	63	63	64	63		81	74	74	76	80	76	78	
4:00 p.m.	62	60	62	62	62	63	62		83	80	77	76	71	73	75	
5:00 p.m.	61	60	62	62	62	63	62		75	72	81	72	80	74	73	
6:00 p.m.	61	59	63	61	61	63	61		79	77	80	73	75	77	78	
7:00 p.m.	60	59	62	61	61	62	62		71	81	80	75	71	77	85	
8:00 p.m.	61	58	62	61	62	61	61		77	76	80	71	76	78	79	
9:00 p.m.	63	58	61	61	62	64	61		83	70	81	74	79	91	79	
10:00 p.m.	59	58	59	59	60	61	60		71	81	72	71	74	73	74	
11:00 p.m.	58	57	59	58	59	59	59		71	68	72	72	73	73	68	
Overall daytime[1]	**62**								**77**							
Overall nighttime[1]	**58**								**71**							
Overall late-nighttime[1]	**56**								**70**							

1. Overall period L_{eq} calculated as average of hourly levels, overall period L_{max} calculated as median of hourly levels

Source: The Greenbusch Group, Inc.

Table A-3 Hourly Ambient Noise Monitoring Data for Location 3 (4245 Brooklyn Ave. NE, Felch House, near Victory Arms Condos)

Start of Hour	L_{eq}								L_{max}							
	10/17	10/18	10/19	10/20	10/21	10/22	10/23	10/24	10/17	10/18	10/19	10/20	10/21	10/22	10/23	10/24
12:00 a.m.		55	55	57	56	59	56	55		80	78	83	74	74	78	76
1:00 a.m.		56	55	55	54	67	56	53		78	83	75	77	100	76	71
2:00 a.m.		52	54	54	54	57	54	54		77	82	74	76	81	74	78
3:00 a.m.		57	53	52	52	57	52	58		85	77	70	74	82	72	86
4:00 a.m.		56	52	60	53	52	50	55		88	76	89	75	70	74	83
5:00 a.m.		57	57	57	59	54	52	57		77	77	81	80	77	72	80
6:00 a.m.		60	61	61	62	56	51	62		82	81	80	84	75	71	82
7:00 a.m.		63	75	62	63	59	55	63		86	110	82	81	80	80	85
8:00 a.m.		64	68	63	64	60	56	65		82	99	81	82	76	76	83
9:00 a.m.		64	65	72	64	61	57			86	90	105	84	80	74	
10:00 a.m.		63	64	64	64	61	58			88	89	85	87	77	74	
11:00 a.m.		62	63	64	64	61	59			86	83	85	83	77	73	
12:00 p.m.		63	64	64	65	61	60			92	89	84	84	76	79	
1:00 p.m.		62	63	63	63	61	60			80	85	80	84	79	83	
2:00 p.m.		62	64	64	64	61	60			86	82	84	85	77	80	
3:00 p.m.		62	64	64	64	61	60			80	81	81	84	76	86	
4:00 p.m.	62	63	63	63	64	61	60		83	88	81	85	86	77	74	
5:00 p.m.	62	63	64	63	64	61	60		81	87	94	82	81	82	81	
6:00 p.m.	61	61	67	61	62	64	59		79	79	98	80	81	98	75	
7:00 p.m.	60	61	61	60	61	60	58		80	81	81	81	80	74	74	
8:00 p.m.	59	60	61	60	62	68	60		84	83	79	81	80	99	73	
9:00 p.m.	58	59	60	60	61	59	59		79	78	83	79	83	77	76	
10:00 p.m.	57	57	59	58	59	58	60		75	80	77	78	82	82	83	
11:00 p.m.	55	56	60	57	60	57	58		70	75	82	77	79	79	88	
Overall daytime[2]	**64**								**82**							
Overall nighttime[2]	**58**								**78**							
Overall late-nighttime[2]	**57**								**77**							

1. Includes 3 dB reductions in measured sound levels to account for proximity (approximately 3 feet) to building façade.
2. Overall period L_{eq} calculated as average of hourly levels, overall period L_{max} calculated as median of hourly levels

Source: The Greenbusch Group, Inc.