Chapter 18. Noise and Vibration

18.1 Overview

This chapter discusses the regulatory framework relevant to noise and vibration in the vicinity of ARC. It also discusses the existing noise environment at ARC as well as relevant policies and measures that address potential noise effects of operations and future development at ARC. Information presented in this chapter was obtained from the November 2009 NASA ARC ERD (NASA 2009), NADP EIS (Design, Community & Environment 2002), and applicable regulations.

18.2 Regulatory Background

18.2.1 Federal Regulations

18.2.1.1 *Occupation Safety and Health Administration*

OSHA has developed noise exposure standards for United States workers. These noise exposure standards allow for noise levels of 90 dB[16] for 8 hours per day and decreasing exposure duration for higher noise levels up to a maximum of 115 dB for 15 minutes or less without hearing protection. These standards apply to virtually all industries within the United States (Department of Labor Occupational Noise Exposure Standard. 29 CFR. Part 1910, Subpart G).

18.2.1.2 *National Aeronautics and Space Administration*

The NASA Health Standard on Hearing Conservation (NPR 1800.1C) establishes minimum requirements for the NASA Agency-wide Hearing Conservation Program. This standard is applicable to all NASA employees and NASA-controlled, government-owned facilities. Exposure limits outlined by the NASA Hearing Conservation Program vary with the sound pressure level of the noise, as detailed in Table 18-1. It is NASA policy to control noise generated by NASA operations and to prevent occupational noise-related hearing loss. In accordance with this policy, maximum exposure limits have been established to provide an environment free from hazardous noise.

Table 18-1. Exposure Limits for Noise According to NASA's Hearing Conservation Program

Duration (Hours)	dBA
16	82
8	85
4	88
2	91

[16] dB: A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure, which is 20 micropascals (20 micronewtons per square meter).

Duration (Hours)	dBA
1	94
0.5	97
0.25	100
0.125	103
Source: NPR 1800.1C, Table 1	

The Hearing Conservation Program establishes a noise hazard area as any work area with a noise level of 85 dBA[17] or greater. Thus, NASA's program is 3 dB more stringent than OSHA's. Earmuffs or earplugs are to be provided to attenuate employee noise exposure to a level above 85 dBA. A combination of both earmuffs and earplugs are to be required where noise levels equal or exceed 97 dBA.

18.2.1.3 *U.S. Department of Housing and Urban Development*

The U.S. Department of Housing and Urban Development (HUD) relies on noise exposure criteria to evaluate the acceptability of sites for housing assistance. Typically, outdoor L_{dn}[18] or CNEL[19] below 65 dB is considered acceptable to HUD for residential land uses. HUD does not detail noise criteria for land uses other than residential. For comparison, Table 18-2 lists HUD's noise exposure criteria and those of other federal, state, and local agencies, as discussed in the remainder of this section.

18.2.1.4 *Federal Aviation Administration*

According to the FAA, L_{dn} or CNEL below 65 dB is considered acceptable for residential land use, and L_{dn} values below 70 dB are normally acceptable for commercial land use. Commercial land use is conditionally acceptable between 70 dB and 80 dB, while industrial land use in areas below L_{dn} values of 85 dB is normally acceptable. Open space use is to occur in areas below 75 dB.

18.2.1.5 *U.S. Army*

The U.S. Army's noise thresholds are based on guidelines established by the Federal Interagency Committee on Urban Noise with the goal of protecting public health and welfare with regard to noise. The Interagency guidelines describe the 65 L_{dn} contour as the threshold of significant impact for residential land uses and a variety of noise-sensitive

[17] dBA: An A-weighted system of noise measurement, in which the decibel values of sounds at very high or very low frequencies are reduced to correct for the frequency response of the human ear, compared with unweighted decibels (dB), in which no correction is made for audio frequency.

[18] L_{dn}: The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 p.m. and 7:00 a.m.

[19] CNEL: The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 p.m. to 10:00 p.m. and after addition of 10 decibels to CNEL levels measured in the night between 10:00 p.m. and 7:00 a.m.

institutions such as hospitals, nursing homes, schools, auditoriums, and outdoor music shells. For noise exposure between L_{dn} 65-70 dB, the guidelines call for building codes to require at least 25 dB outdoor-to-indoor noise level reduction (NLR); between L_{dn} 70-75 dB, the guidelines call for at least 30 dB NLR.

18.2.1.6 *National Environmental Policy Act*

NEPA requires federal agencies to include in their decision-making process appropriate and careful consideration of all environmental effects of a proposed action and of possible alternative actions. Measures to avoid or minimize the adverse effects of proposed actions and to restore and enhance environmental quality as much as possible must be developed and discussed where feasible.

18.2.2 State Regulations

18.2.2.1 *California Office of Planning and Research*

In 1990, the California Governor's Office of Planning and Research published guidelines to aid California municipalities in preparing their general plans. This document uses the CNEL and L_{dn} noise descriptors interchangeably to relate land use compatibility for community noise environments.

The most commonly used noise exposure measure for environmental noise is L_{dn}. This is a night-penalized average used for most noise and land use compatibility criteria. The day-night average sound level is obtained after the addition of 10 dB to noise levels measured in the night between 10:00 p.m. and 7:00 a.m. In California, an alternative measure is the CNEL, which is similar to L_{dn} except a 5 dB penalty is added during the evening hours of 7:00 p.m. to 10:00 p.m. Because L_{dn} and CNEL nearly always render results within 1 dB, they can generally be compared in land use compatibility analyses.

The California State Planning Guidelines (Figure 18-1) show L_{dn} or CNEL values below 60 dB to be acceptable for residential land use, and values below 70 dB as acceptable for commercial land use. Industrial land use in areas below L_{dn} values of 75 dB is also acceptable. Open space use is acceptable in areas below 70 dB, depending upon the specific nature of the space; for example, playgrounds are acceptable up to 70 dB and golf courses are acceptable up to 75 dB.

18.2.2.2 *California Division of Aeronautics*

The California Division of Aeronautics (CDA) relies on the noise criteria contained in Article 3, Chapter 4, Part 1, Division 9, Public Utilities Code (Regulation of Airports), which governs the operation of aircraft and aircraft engines at the State's airports. The CDA sets L_{dn} 65 dB as its official noise limit for residential land use; however, this this only applies to aircraft noise at state facilities and not at ARC. NASA attempts, whenever possible, to meet local guidelines and standards and considers them as advisory in nature.

Table 18-2. Land Use Compatibility Noise Exposure Criteria

		Residential		Commercial		Industrial		Open Space	
Sources	**Measure**	**Norm. Acceptable**	**Cond. Acceptable**	**Norm. Acceptable**	**Cond. Acceptable**	**Norm. Acceptable**	**Cond. Acceptable**	**Norm. Acceptable**	**Cond. Acceptable**
Department of Housing and Urban Development	L_{dn}	<65	65–75	–	–	–	–	–	–
Federal Aviation Administration	L_{dn}/ CNEL	<65	–	<70	70–80	<85	–	<75	–
U.S. Army	L_{dn}/ CNEL	<65	65–75	<70	70–80	<85	–	<75	–
California Planning Guidelines	L_{dn}/ CNEL[1]	<60	55–70	<70	67.5–77.5	<75	70–80	<70–75	67.5–80
California Division of Aeronautics	CNEL[2]	<65	65–70	–	–	–	–	–	–
City of Mountain View	L_{dn}/ CNEL	<55	55–65	<60	60–70	<65	65–75	<55	55–65
City of Sunnyvale	L_{dn}/ CNEL	<60	60–70	<65	65–77.5	<70	70–80	<70	
Santa Clara County	L_{dn}	<55	55–65	<65	65–75	<70	70–75	<55	55–80

[1] Uncorrected CNEL.
[2] Annual average.
– = No criteria for this land use.
Source: NASA 2009.

Figure 18-1. Land Use Compatibility for Community Noise Environments

(Source: NASA 2009)

18.2.2.3 *Local Regulations*

18.2.2.3.1 Santa Clara County

Santa Clara County follows the lowest noise acceptability limits found in California for residential land use, at a L_{dn} of 55 dB.

18.2.2.3.2 City of Mountain View

The City of Mountain View has one of the strictest residential noise standards of any municipality in California for residential land use. A L_{dn} below 55 dB is specified for new construction, although many residences throughout the city are already exposed to more severe noise environments. The commercial and industrial land use criteria are 60 dB.

In addition to the noise exposure criteria in the Mountain View Noise Element, a noise ordinance is also referenced in the Noise Element and applied by the city. It specifies a 55 dB maximum noise level from stationary emitters in the City of Mountain View when measured at residential property lines during the daytime and 50 dB during the nighttime (10:00 p.m. to 7:00 a.m.).

18.2.2.3.3 City of Sunnyvale

The Sunnyvale criteria follow the state guidelines rather closely, the only exception being open space use, which is to occur in areas below a L_{dn} of 70 dB. The authors of the Sunnyvale Noise Supplement indicated that L_{dn} should be interpreted as the yearly average throughout their document.

18.3 **Regional Setting**

This ERD encompasses the entire ARC, a federal facility located on approximately 800 hectares (2,000 acres) of land between U.S. Highway 101 and the southwestern edge of the San Francisco Bay in the northern portion of Santa Clara County, California. The City of Mountain View borders it to the south and west, and the City of Sunnyvale to the south and east. ARC is about 56 kilometers (35 miles) south of San Francisco and 16 kilometers (10 miles) north of San Jose, in the heart of Silicon Valley. Figure 1-1 shows the regional context of the site and Figure 1-2 shows the local context. For planning purposes, ARC is divided into four subareas: the NASA Research Park, Eastside Airfield, Bay View, and the Ames campus (Figure 1-3).

The closest residential land use is the DOD housing at Wescoat Village, located south of the NRP area. The other land uses directly adjacent to the site are office, industrial, and open space. In addition, within approximately 610 meters (2,000 feet) is Santiago Villa, an existing mobile home facility. The next nearest residential land uses are on the south side of U.S. Highway 101. The most sensitive land uses are the residential uses. Office use is the next most sensitive land use, and the least sensitive land uses are commercial/industrial uses.

18.4 **Existing Site Conditions**

This section describes the existing noise environment at ARC. Noises generated by ARC and Moffett Field have historically been a source of complaints from surrounding areas. Noise produced by many of the wind tunnels and aircraft operations generate complaints from residents off site. Figures showing noise contours described in this section all occur at the end of this section.

18.4.1 Wind Tunnels

Among NASA's wind tunnels, the primary noise generators include:

- 40- by 80-Foot Wind Tunnel. The 40- by 80-Foot Wind Tunnel is a closed-circuit wind tunnel. A typical test day can consist of one or two shifts, day or night. Each test shift averages approximately 4 hours, with the wind tunnel running. Current noise exposure levels from this facility are presented in Figure 18-2.
- 80- by 120-Foot Wind Tunnel. The 80- by 120-Foot Wind Tunnel is a non-return wind tunnel that shares the same drive system as the 40- by 80-Foot Wind Tunnel. Because both facilities use the same drive system, only one can be operated at a time. Figure 18-3 shows the current noise exposure levels for the 80- by 120-Foot Wind Tunnel.
- Unitary Plan Wind Tunnels. The Unitary Plan Wind Tunnel complex consists of three wind tunnels, the 11-foot, the 9- by 7-foot, and the 8- by 7-foot. Only one of these tunnels can be used at a time. At present, only the 11-foot tunnel is regularly used. The 9- by 7-foot Supersonic Wind Tunnel and the 8- by 7-foot Supersonic Wind Tunnel are currently not in operation. Noise levels were measured during operation of the 11-foot Transonic Wind Tunnel in October 2000. Measured noise levels ranged from 80 to 85 dBA along Wagner Lane at distances of 15 to 20 meters (50 to 75 feet) west of the facility. Noise levels along Mark Avenue between Wagner Lane and Boyd Road typically range from 75 to 79 dBA. Noise levels were measured inside the lobby of Building N-234 on Boyd Road directly east of the wind tunnel. The measured noise level was 48 dBA and the operating tunnel was barely audible. Noise levels along DeFrance Avenue were measured at several locations north of the facility and typically ranged from 65 to 70 dBA. Figure 18-4 shows the current noise exposure levels for the complex.
- 12-Foot Pressure Wind Tunnel. The 12-foot Pressure Wind Tunnel also generates noise. Noise levels measured for NASA worker exposure evaluations provide some data for the tunnel. The measured noise levels are 90 dBA at 61 meters (200 feet) from the tunnel at Bushnell Street and 80 to 90 dBA at the cooling towers located north, south, east, and west of the facility. Figure 18-5 shows the noise exposure contours for the 12-foot Pressure Wind Tunnel. (This wind tunnel is not currently in operation.)

18.4.2 Arc Jets

The arc jet facility is used to perform high temperature materials tests. Noise levels were measured during operation of the arc jets in June 2001. Measured noise levels reached 80 dBA at a distance of 50 meters (146 feet) north of the facility, 78 dBA at a distance of 75 meters (246 feet) to the east of the cooling towers, and 75 dBA along Boyd Road south of the facility. Figure 18-6 shows the noise exposure levels for the arc jets facility.

18.4.3 Airfield Operations, Traffic, and Other Existing Noise Sources

In addition to the wind tunnels, the OARF, and arc jets, there are several other noise sources at and beyond the ARC that affect the four planning areas and the surrounding community, most notably airfield operations and traffic noise from local highways.

ARC is home to a variety of government-related aircraft. Noise from MFA was evaluated for the period from 1999 to 2010. Noise exposure contours were determined in terms of CNEL. Figure 18-7 shows noise contours from NASA baseline aircraft operations.

Ambient traffic noise measurements were made during the preparation of the NADP EIS at four locations within ARC. Figure 18-8 shows the locations of the noise measurements. Noise levels were measured adjacent to U.S. Highway 101 at an exposed location along South Perimeter Road (S1), in a location protected by a sound wall at Wescoat Court (S2), and at a distance from the highway near Building N-547C on Girardi Road (S3) to determine how noise levels decrease over distance. The final measurement was conducted at the intersection of Cody Road and Severyns Avenue (S4). The data gathered during these measurements is summarized in Table 18-3. The existing L_{dn} noise exposure contours resulting from traffic are shown in Figure 18-9.

18.4.4 Composite Noise Exposure Contours

Composite noise exposure contours of existing noise conditions at ARC are presented in Figure 18-10. These contours were developed using the following information:

- Moffett Field airstrip CNEL Noise Exposure, 1999
- Noise measurement along U.S. Highway 101
- Noise measurement of the Unitary Plan Wind Tunnel
- NASA Ames Aerodynamic Testing Project EIS
- Noise measurement of the arc jets

Thus, Figure 18-11 represents a composite of noise contours from all of these noise sources.

Table 18-3. Ambient Traffic Noise Levels

Location	Leq[1]	L(10)[2]	L(50)[3]	L(90)[4]	Dominant Noise Source
S1: Recreation Fields south of Dailey Road; microphone 5 feet above grade	74	76	73	72	U.S. Highway 101 traffic
S2: Wescoat Court; 50 feet from the property line; microphone 5 feet above grade	68	69	67	66	U.S. Highway 101 traffic
S3: Building N-547C; microphone 5 feet above grade	56	57	55	54	U.S. Highway 101 traffic

Location	Leq[1]	L(10)[2]	L(50)[3]	L(90)[4]	Dominant Noise Source
S4: Cody Road at Severyns Road; microphone 5 feet above grade	53	57	50	49	U.S. Highway 101 traffic

Notes:
[1] Leq: The average A-weighted noise level during the measurement period.
[2] L(10): The A-weighted noise levels that are exceeded 10% of the time during the measurement period.
[3] L(50): The A-weighted noise levels that are exceeded 50% of the time during the measurement period.
[4] L(90): The A-weighted noise levels that are exceeded 90% of the time during the measurement period.
Source: NASA 2009.

18.4.5 Outdoor Aerodynamic Research Facility

The OARF is located in the Bay View area and is used to obtain a wide range of hover and acoustic data on full-scale or small-scale aircraft and other aerospace components. High noise-generating projects, such as powered model tests, run an average of 2 hours per day when the facility is in operation. Other tests have been administered at the facility for up to 7 hours per day.

The experimental physics branch of ARC tested hybrid rocket fuel motors at the OARF. NASA staff measured rocket fuel test noise levels in September 2001. The orientation for the rocket test rig and measured noise levels are shown on Figure 18-11. The measured noise levels reflect the effects of orienting the facility to mitigate potential noise impacts. The noise levels are generated for very short time intervals, approximately 10 to 20 seconds.

18.5 Environmental Requirements

NASA has identified the following environmental policies and measures that address potential noise effects of operations and future development at ARC.

18.5.1 NASA Procedural Directive 8500.1, NASA Environmental Management

Per NPD 8500.1, it is NASA policy to: maintain compliance with all applicable federal, state, and local environmental requirements; to incorporate environmental risk reduction and sustainable practices to the extent practicable throughout NASA's programs, projects, and activities; and to consider environmental factors throughout the life cycle of programs, projects, and activities (as defined in NPD 7120.4, *NASA Engineering and Program/Project Management Policy*, and related documents), including planning, development, execution, and disposition activities. Examples of environmental factors include consideration of environmental impacts as required by the NEPA and NHPA; the proposed use of hazardous materials; the potential for waste generation; the need to acquire necessary permits, waivers, and authorizations; and the use of environmentally-preferable materials and processes wherever practicable.

18.5.2 Ames Procedural Requirements 8500.1, Ames Environmental Procedural Requirements

APR 8500.1 sets forth general procedural requirements to ensure compliance with applicable federal, state, and local environmental laws; regulations and EOs; and NASA policies and procedures. Organizational directors, division chiefs, branch chiefs, section heads, supervisors, managers, and CORs are responsible for planning, designing, constructing, managing, operating, and maintaining facilities in conformance with applicable regulatory directives, and should obtain environmental review from the Environmental Management Division early in project planning consistent with NASA's NEPA implementing procedures (NPR 8580.1 and EO 12114), NASA policies and procedures for programs and projects (NPR 7120), and NASA regulations related to environmental quality (14 CFR 1216). Program and project managers should coordinate with the Environmental Management Division in a timely manner to ensure that any new or modified programs, projects, and activities comply with regulatory requirements.

18.5.3 Ames Procedural Requirements 8715.1, Ames Health and Safety Procedural Requirements

APR 8715.1 establishes the procedural requirements for complying with the NASA Agency-wide Hearing Conservation Program. It includes a description of organizational and individual responsibilities at ARC for complying with program requirements, as well as NASA's allowable noise exposure limits, which are generally applied as an eight-hour exposure limit of 85 dBA. For exposures of shorter or longer durations, the exposure limit may be adjusted accordingly. Hearing Conservation Program elements are required to be implemented at the Action Level; that is, whenever employee noise exposures equal or exceed an eight-hour time-weighted average of 82 dBA for 30 days per year, or 85 dBA for one day. Hearing Conservation Program elements include exposure monitoring, audiometric testing, medical monitoring, and training.

18.5.4 Ames Environmental Work Instructions

Ames's EWIs, which replace the previous Ames Environmental Handbook (APR 8800.3), set forth requirements to ensure that programs, projects, and activities at ARC comply with applicable federal, state, and local laws; regulations and EOs; and NASA policies and procedures. Each EWI lists relevant regulatory authorities and documents, assigns individual and organizational responsibilities within ARC, and identifies specific requirements applicable to the work being performed.

The following EWIs are relevant to potential noise effects of operations and future development at ARC.

- EWI 12, Public Involvement
- EWI 14, NEPA and Environmental Justice
- EWI 18, Environmental Requirements for Construction Projects (Under review)

18.5.5 NASA Ames Development Plan Final Programmatic Environmental Impact Statement

The NADP EIS identifies the following mitigation measures to address potential noise impacts from build out of NADP Mitigated Alternative 5.

18.5.5.1.1 Mitigation Measure NOISE-1a

For development on NRP Parcels 2, 4, 9,10, 11, 12, 12a, and 16, and the Ames Campus, noise mitigation measures, including site planning to protect noise sensitive outdoor activity areas and building sound insulation treatments to protect noise sensitive indoor spaces, would be included in project design and development. Buildings would be designed to provide an appropriate Noise Level Reduction (NLR) depending upon the designated uses of the sensitive spaces.

18.5.5.1.2 Mitigation Measure NOISE-1b

Residential development proposed on Parcels 6, 12, and 12a would be designed so as to achieve an indoor Ldn of 45 dB or less. The housing would be provided with forced-air mechanical ventilation or air-conditioning as necessary to achieve a habitable interior environment with the windows closed.

18.5.5.1.3 Mitigation Measure NOISE-2a

For development on parcels in the Bay View area near the OARF, noise mitigation measures including site planning to protect noise sensitive outdoor activity areas and building sound insulation treatments to protect noise sensitive indoor spaces would be included in project design and development. Buildings would be designed to provide an appropriate Noise Level Reduction (NLR) depending upon the designated uses of the sensitive spaces.

18.5.5.1.4 Mitigation Measure NOISE-2b

Once development occurs in the Bay View area, NASA would operate the OARF so that noise generated by it would not exceed the following levels when measured on any residential property:

	L_{max}[1]	L_{eq}
Daytime (7 am - 10 pm)	70	50
Nighttime(10 pm - 7 am)	65	45
Notes: [1] L_{max}: The maximum and minimum A-weighted noise level during the measurement period. Source: Design, Community & Environment 2002.		

18.5.6 **NADP Construction Noise Best Management Practice**

As discussed in NADP EIS Chapter 4.10, *Noise*, implementation of the NADP will require demolition and construction activities, which will cause temporary increases in noise levels at ARC. These disturbances may be minimized through the appointment of a noise coordinator to deal with construction-related noise effects.

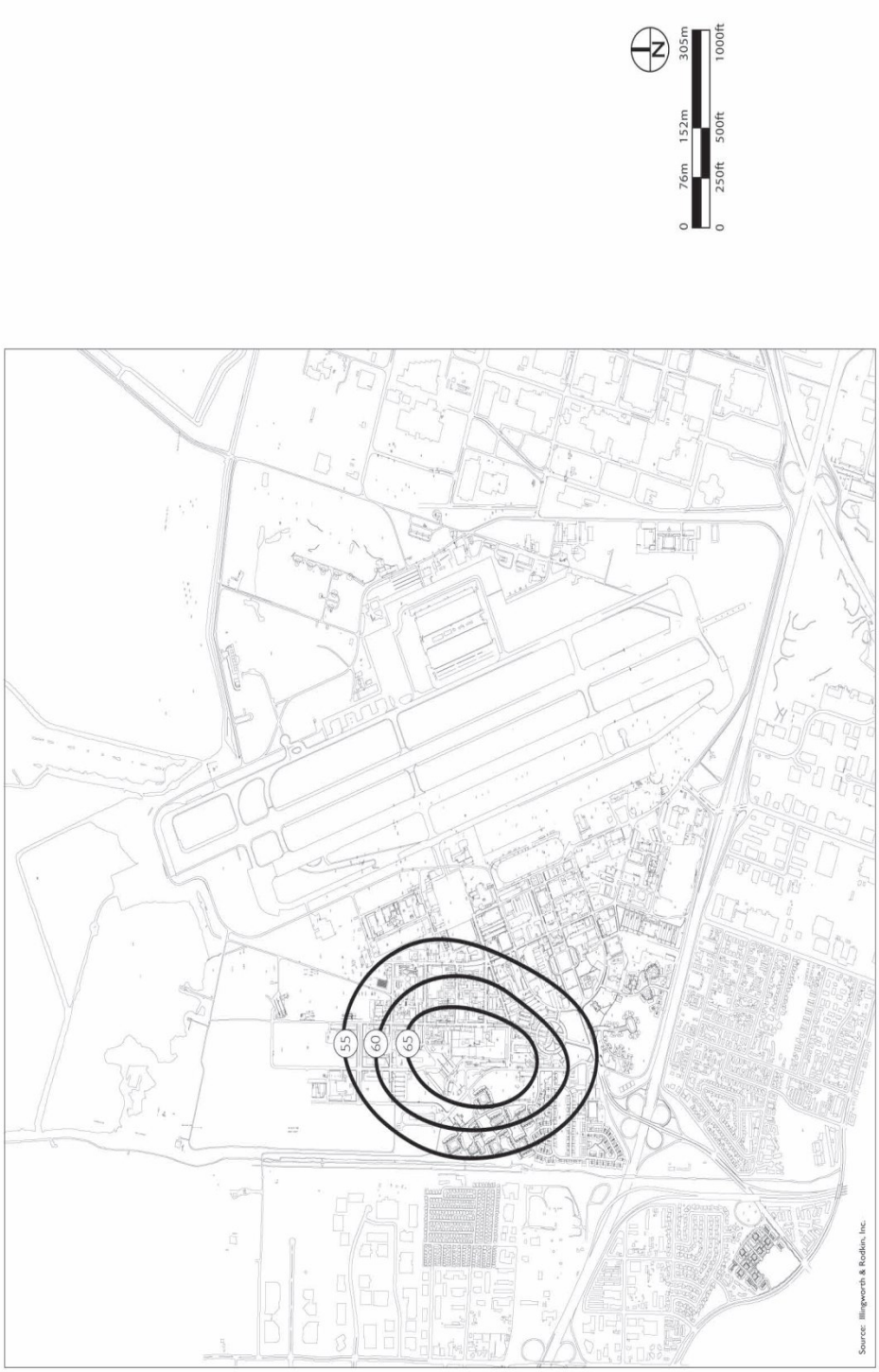

Figure 18-2. Existing 40-By-80-Foot Wind Tunnel Operations: Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

Figure 18-3. Existing 80-By-120-Foot Wind Tunnel Operations: Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

Figure 18-4. Unitary Plan Wind Tunnel: Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

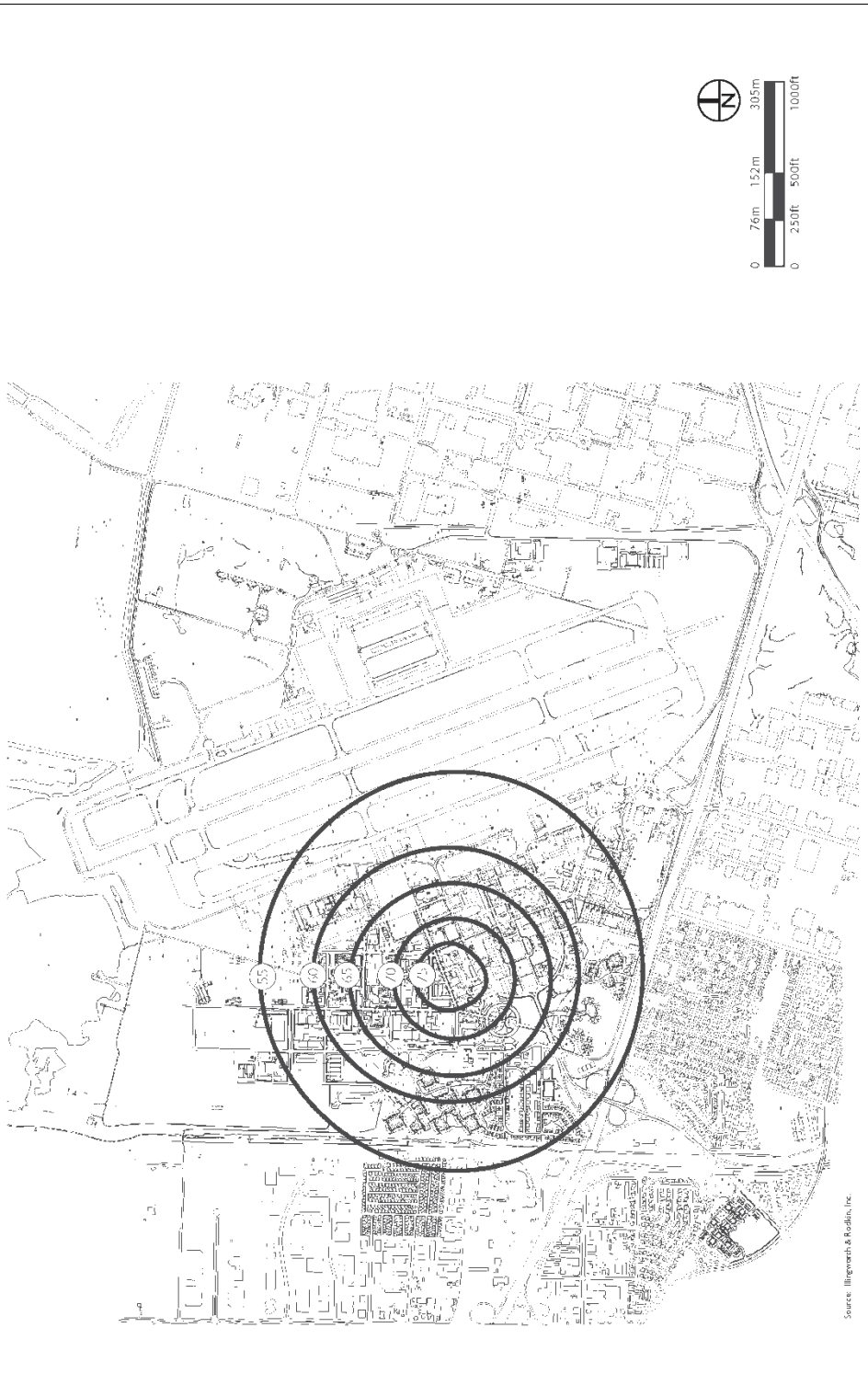

Figure 18-5. 12 Foot Pressure Wind Tunnel: Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

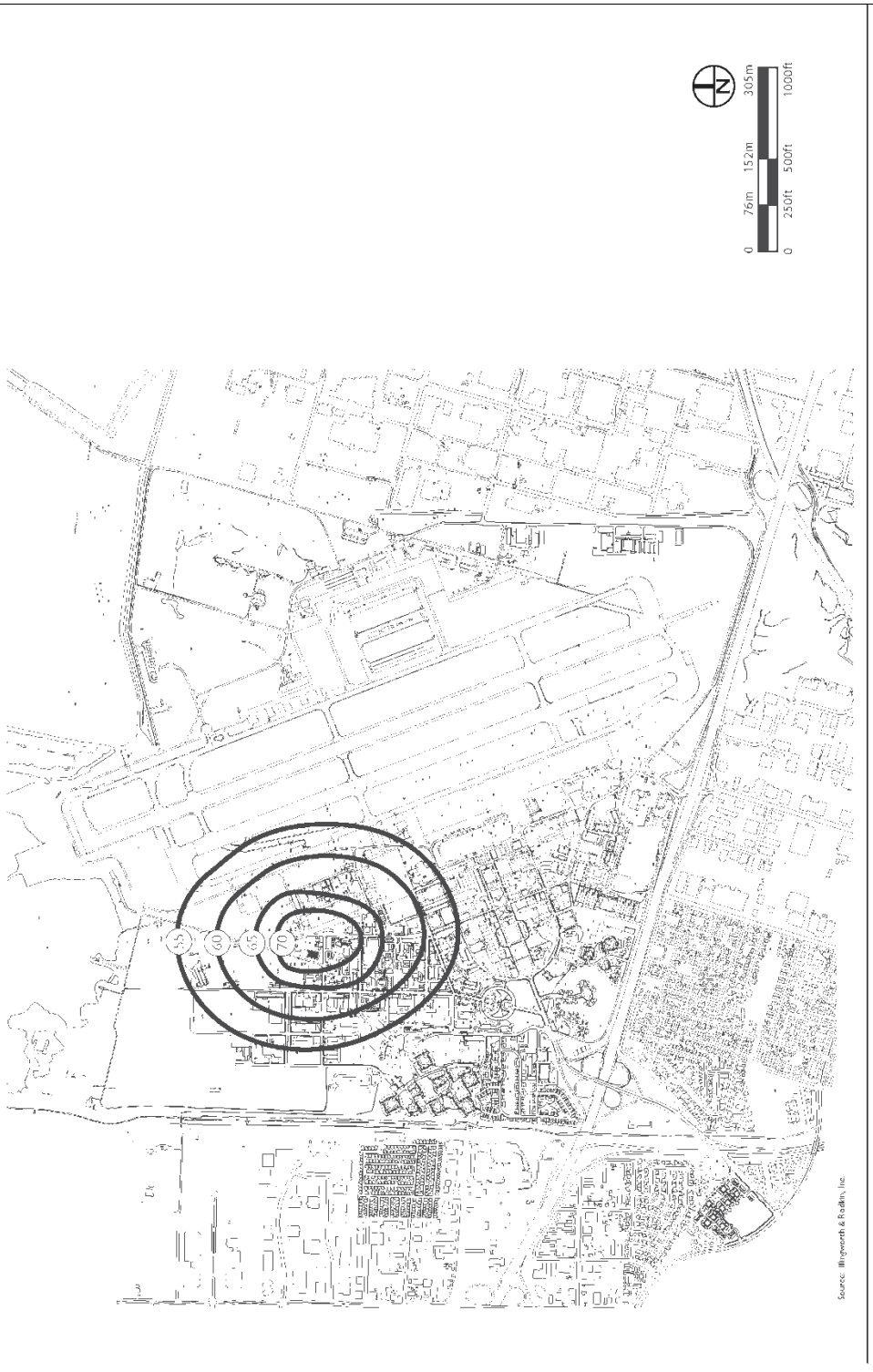

Figure 18-6. Arc Jets: Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

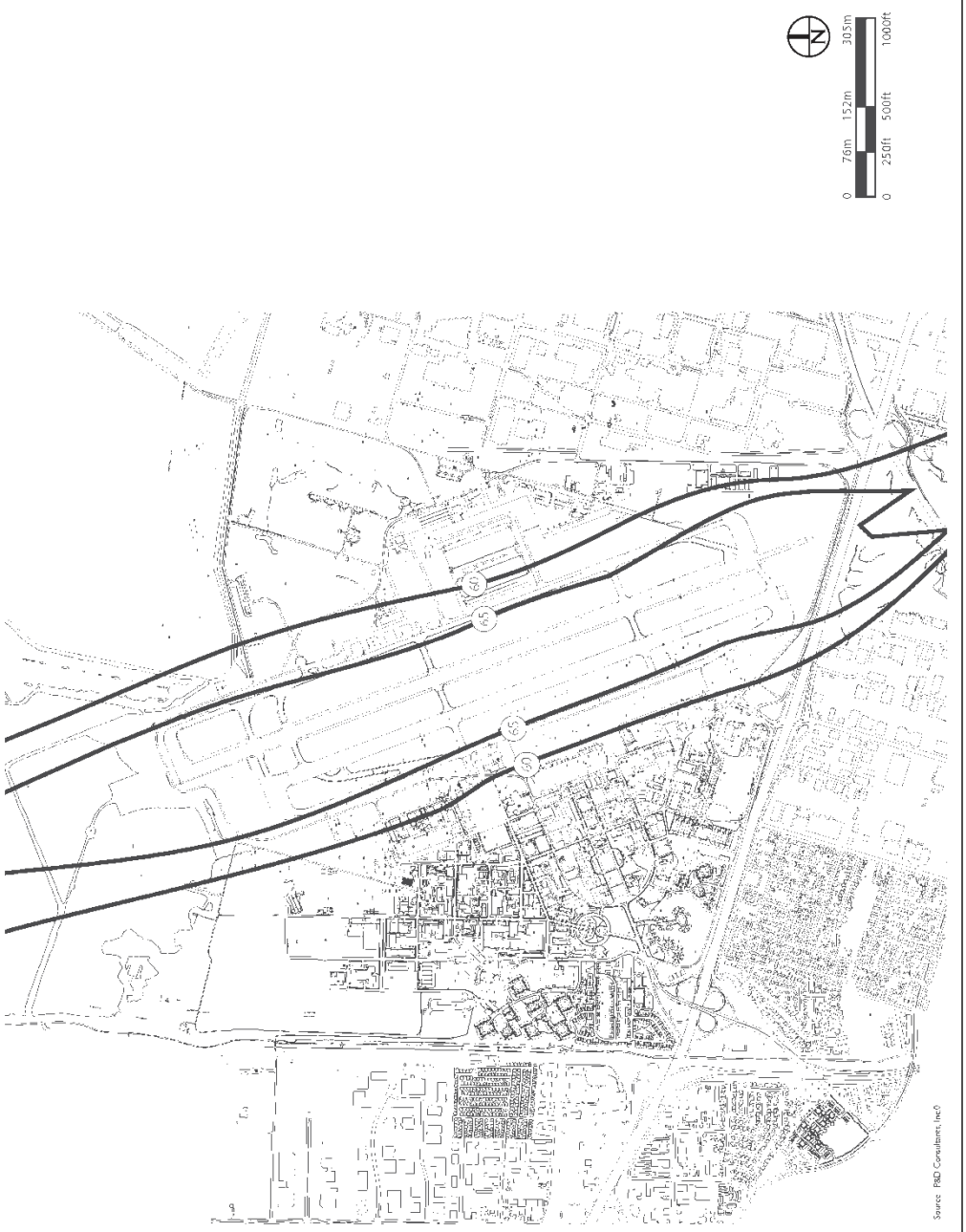

Figure 18-7. Airfield CNEL Noise Exposure (dB) (Applicable to both 1999 and 2010)

(Source: NASA 2009)

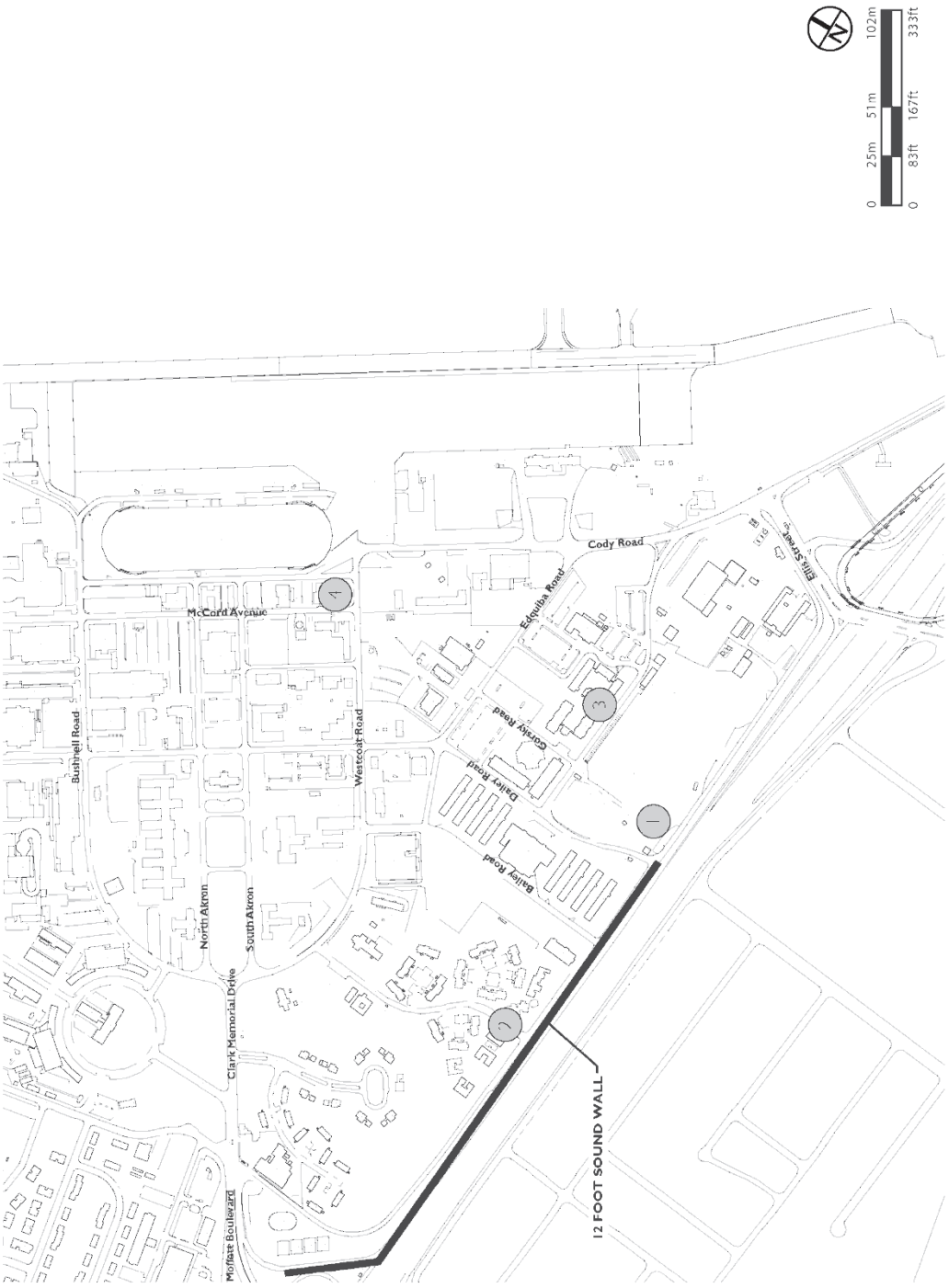

Figure 18-8. Location of Ambient Traffic Noise Measurements

(Source: NASA 2009)

Figure 18-9. Ambient Highway 101 Traffic: Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

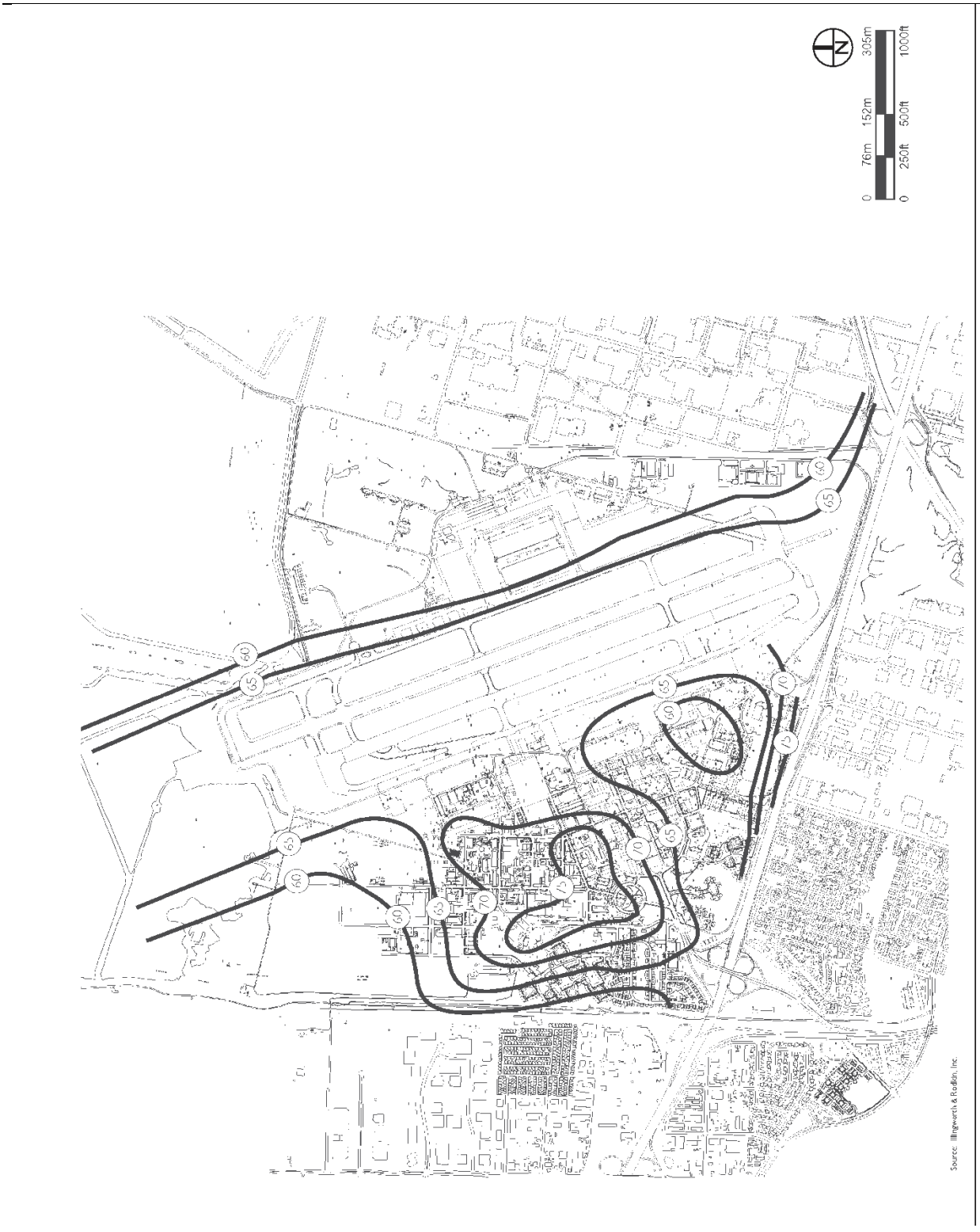

Figure 18-10. Composite Annual L_{dn} Noise Exposure Contours (dB)

(Source: NASA 2009)

Figure 18-11. Hybrid Rocket Fuel Test Facility Noise Levels

(Source: NASA 2009)