AIRCRAFT NOISE CONTROL AND LAND USE COMPATIBILITY STUDY

ANCLUC

TORRANCE MUNICIPAL AIRPORT

TOA

prc Speas

TORRANCE MUNICIPAL AIRPORT

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY STUDY

FINAL REPORT

TORRANCE, CALIFORNIA

NOVEMBER 1981

PRC SPEAS ASSOCIATES

The preparation of this document was financed in part through a planning grant from the Federal Aviation Administration as provided under Section 13 of the Airport and Airway Development Act of 1970. The contents of this report reflect the views of the professional staff of PRC Speas participating in this project. PRC Speas utilized, in some cases, airport operations data and land use and zoning information supplied by the City of Torrance. The scope of the project and procedural policies were determined jointly by PRC Speas and the City of Torrance who share the responsibility for the facts and accuracy of the data presented in this report. The contents do not necessarily reflect the official views or policy of the FAA. Acceptance of this report by the FAA does not in any way constitute a commitment on the part of the United States to participate in any development depicted therein nor does it indicate that the proposed development is environmentally acceptable in accordance with Public Laws 91-190, and/or 90-495.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

LIST OF EXHIBITS

LIST OF EXHIBITS

LIST OF TABLES

SUMMARY

SUMMARY

The Airport Noise Control and Land Use Compatibility (ANCLUC) planning project for Torrance Municipal Airport (TOA) has focused on the unique problems associated with a municipal airport handling a large number of annual general aviation aircraft operations. These operations represent an average of over five hundred overflights each day affecting the City of Torrance as well as other nearby communities. The fact that these operations are conducted almost exclusively by small propeller or turbo prop aircraft presents some unprecedented challenges in defining the aircraft noise environment and formulating a program to achieve compatibility between the community residents and operations at the airport. While state and federal guidelines for airport land use compatibility do not show any incompatible residential property around TOA, there is clearly a noise related problem in some neighborhoods around the airport.

One important characteristic of the ANCLUC planning program has been the use of aircraft noise energy averages such as the Community Noise Equivalent Level (CNEL) scale in developing land use compatibility guidelines. The differences in noise characteristics and numbers of operations between small piston engine aircraft and large jet aircraft result in a need to supplement the CNEL scale with some more descriptive aspects of the aircraft noise exposure conditions. As a result, the aircraft noise control objectives and land use compatibility plan will be unique to conditions at Torrance Municipal Airport.

The ANCLUC plan at TOA should combine a schedule for aircraft noise reduction and a procedure for reviewing land use changes in the City for purposes of evaluating compatibility with airport operations.

I. Recommended Aircraft Noise Reduction Program

A. Establish a noise reduction objective of one dBA per year in the aircraft single event noise limits over a five-year period. The SENEL limit would be reduced to 83 dBA (day) and 77 dBA (night) with a peak instantaneous limit of 77 dBA (day) and 71

dBA (night). If this rate of reduction is judged to prohibitive, a compromise value of one dBA each two or three years should be evaluated.

A survey should be undertaken over at least three busy days of operations to obtain a statistical distribution of noise levels at selected monitor stations. This would be done for the purpose of determining how many currently operating aircraft would be affected by a reduction in the single event noise limits.

B. Develop a formal procedure for training pilots in noise reduction techniques. Baseline single event noise levels and improvement under standardized operating conditions would be documented for all operators exceeding the noise limit. This program could possibly result in the major area of noise reduction in the community west of TOA.

C. Consider the feasibility of assessing fees based on exceedance of single event noise limits. Identification of consistent violations of the single event noise level could be followed by the training/orientation program carried out by the City Staff at the airport. If it is determined that the aircraft cannot achieve the prescribed single event noise levels under safe operating conditions, an excess noise fee could be levied for continuing use of the airport. An alternative would be preferential access to the training pattern or semi-restricted departure hours for quiet aircraft flown by pilots completing the noise abatement training program.

D. Relocate selected remote monitor stations as procedure for controlling prescribed noise abatement departure tracks. An additional site to the west of the airport and another in Walteria would be useful.

E. Implement standard reporting procedures for community organizations for purpose of identifying highest priority noise abatement actions. Community groups should work with the CACAN organization in developing both a technical and a policy evaluation for each airport noise problem.

F. Develop change in the helicopter departure route passing over Redondo Beach to avoid the higher elevations.

II. <u>Recommended Land Use Compatibility Program</u>

A. Establish an Airport Planning District conforming to boundaries defined in this ANCLUC report. This Airport Planning District will require notification of noise reduction procedures for all building permits. Recommended conditions for this district include the following:

   1. Attachment of disclosure of aircraft noise exposure conditions as part of permit application review.
   2. Requirement for specific aircraft noise compatibility plan for all land use changes within the District.

B. Develop plan for specific acoustical insulation procedures to be made available to applicants for building permits. These procedures would be incorporated in plans for new construction as a result of the specific aircraft noise compatibility plan developed for each project. Recommended noise reduction modifications to existing structures would be keyed to the specific location of the structure.

C. Implement mandatory noise insulation procedures within the maximum impact areas identified within the Airport Planning District. This Maximum Impact Area lies to the west of the airport and is defined in Exhibit 5-5, Section 5 of this report.

   1. Require specific noise insulation specifications, approved by a qualified engineer, as a condition for building permits in the maximum impact areas.

1.0 INTRODUCTION

1.0 Introduction

This report is the final report in the Torrance Municipal Airport Noise Control and Land Use Compatibility (ANCLUC) study. The project was initiated in February 1979 under the sponsorship of the City of Torrance, California. The project was conceived as a special focused ANCLUC study, utilizing the guidelines contained within the ANCLUC planning process designed by the Federal Aviation Administration.

Prior to this study at Torrance, the ANCLUC programs have been carried out at air carrier airports throughout the United States. This is the initial application of the ANCLUC planning concept at a general aviation airport with no significant jet aircraft traffic. Rather than follow a straightforward application of the planning process, the decision was made to focus the study on those characteristics of a general aviation airport which were most directly related to land use incompatibilities in the surrounding community.

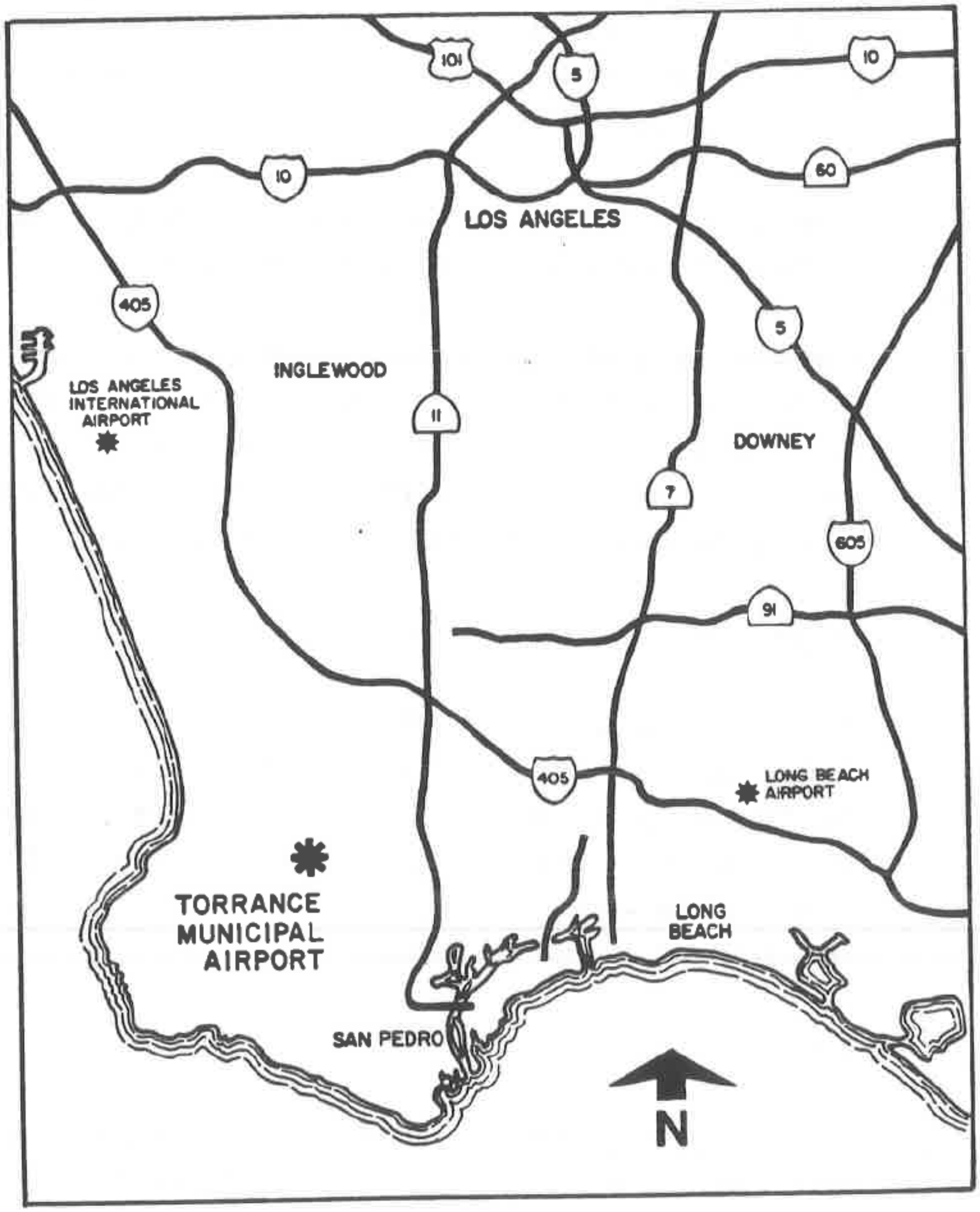
1.1 Project Location

Torrance Municipal Airport (TOA) is located in the City of Torrance in the southwest sector of the Los Angeles metropolitan area. The location of the airport within this region is shown in Exhibit 1-1. The airport is used primarily by general aviation aircraft with occasional military itinerant flight operations. The airport is operated by the City of Torrance.

1.2 ANCLUC PROJECT OBJECTIVES

The long history of over 1000 flight operations per day at Torrance Municipal Airport (TOA) has produced conflicts with surrounding residential land uses that were sufficient to cause the City to initiate a comprehensive aircraft noise abatement program. Continuing development in Torrance together with the possibility of increased flight operations raised the requirement for careful land use

EXHIBIT 1-1 LOCATION WITHIN REGION



compatibility planning in the airport environs in order to avoid more serious conflicts in the future. In order to meet this challenge, the City created an Office of Noise Abatement for TOA and installed a permanent monitoring system to measure the noise from aircraft as well as other sources in the community. The current focused ANCLUC project was an additional element in the City's long range noise abatement planning at the airport.

The first step in the ANCLUC study process is a comprehensive review of existing conditions in the airport community. This includes measurements and analyses of aircraft noise exposures as well as land use compatibility evaluations carried out in cooperation with the City of Torrance. Projections for future noise impact conditions are based on forecasts of changes in the airport use patterns and the effectiveness of the ongoing noise abatement program.

The most important goal for ANCLUC project is the implementation of all feasible actions to reduce the aircraft noise impact on the population around the airport. The elements of the program necessary to accomplish these objectives are:

- Minimizing noise emissions at the source and adjusting aircraft and airport operations patterns to minimize the exposed population.
- Analyzing airport vicinity land uses to determine the existing incompatibilities, identifying future incompatible areas based on local plans and statutes, and resolving the conflicts both existing and potential to the greatest degree possible through a coordinated and comprehensive program of land use controls.
- Involving and coordinating all relevant governmental agencies and jurisdictions in a comprehensive program to reduce noise and eliminate land use conflicts.
- Informing the public systematically on the goals, conduct and results of planning activities and in the decision-making process, and responding to the needs and concerns of the affected population as evidenced in the established review procedure.
- Preserving, protecting, and enhancing both the airport and the local community in terms of economic benefits, levels of public service, cooperative understanding and sensitive environmental practices.

1.3 Study Organization

Organization of the ANCLUC planning process and the review procedure are shown in the chart in Exhibit 1-2. The principal consultant for the ANCLUC project was PRC Speas Associates, Los Angeles. The City of Torrance participated in the project by providing Staff Personnel for technical tasks and support services.

1.4 ANCLUC Study Assumptions

In the execution of the ANCLUC study, several assumptions on both policy and methodology are necessary for future planning. These are as follows:

- All aircraft operating at Torrance Municipal Airport are assumed to fall under the jurisdiction of the single event aircraft noise limits currently in effect.
- The study utilizes the Community Noise Equivilent (CNEL) measurement system. This system is required because its basic noise measurement unit, dBA, facilitates noise monitoring and enforcement procedures. It produces annual average energy summations which represent useful guidance in establishing compatible land uses, but do not precisely define areas of noise exposure. The noise contours generated are thus a planning tool for defining varying degrees of noise exposure.
- Criteria for land use compatibility are explicitly defined through input from the local community, but they are based on general standards expressed in the FAA Land Use Guidance Charts, and on the CNEL standards as they have been developed by the State of California.

PROJECT ORGANIZATION

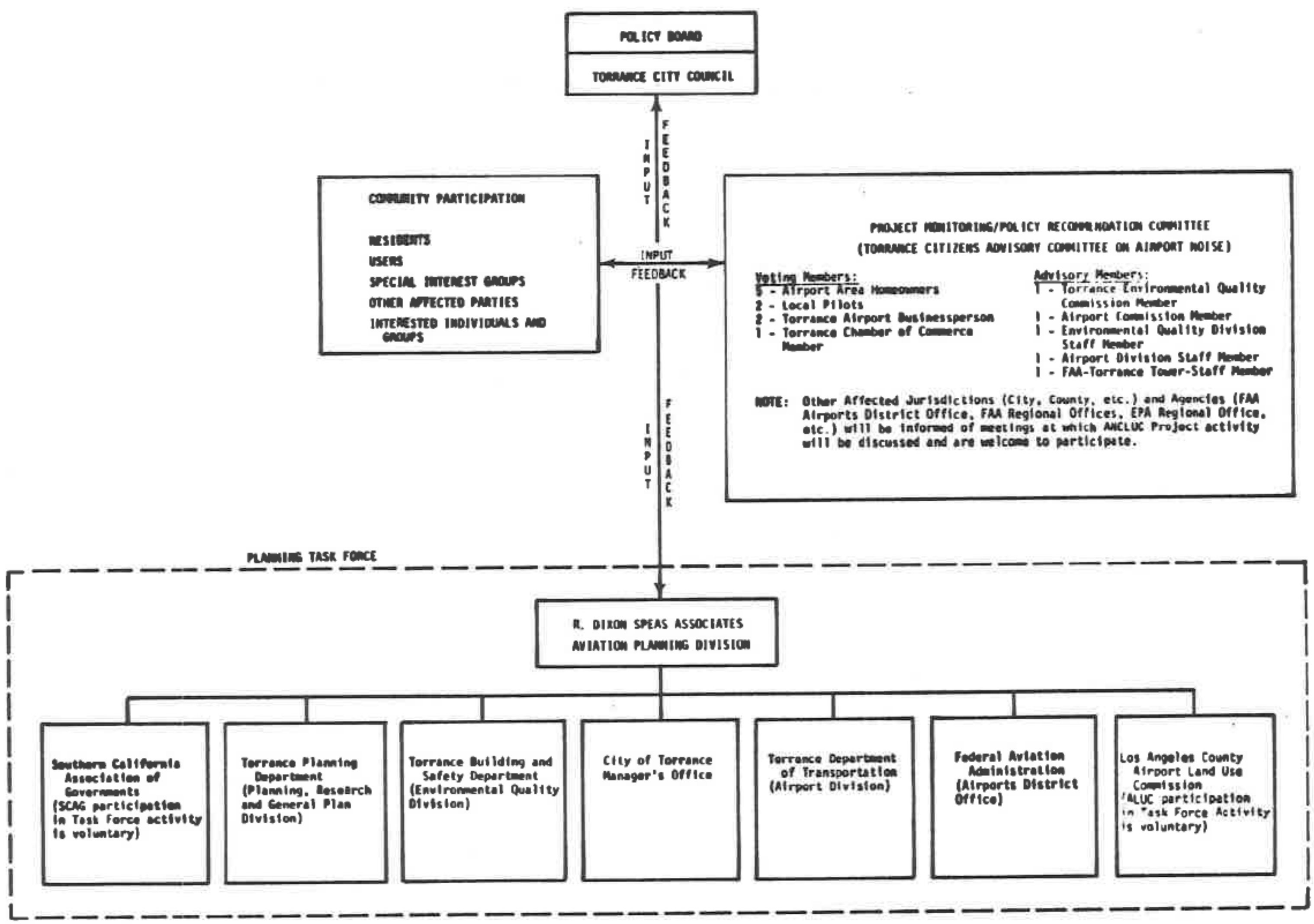


EXHIBIT 1-2 PROJECT ORGANIZATION - TORRANCE MUNICIPAL AIRPORT (ANCLUC) STUDY

2.0 FLIGHT OPERATIONS

2.0 FLIGHT OPERATIONS

Flight operations at Torrance include a combination of single-engine and multi-engine aircraft. For the most part, single-engine general aviation aircraft comprise the majority of the Torrance traffic. The hours of operations of the FAA air traffic control tower at Torrance are from 0800 to 2000 Hrs. At 2300 Hours a departure curfew is imposed on a daily basis and remains in effect until 0630 Hours. Additionally, touch and goes, stop and goes, and low approaches are permitted only during the periods 0800 to 2000 Hours Monday through Friday, and 1000 to 1700 Hours Saturday, Sunday and holidays (for based aircraft only after April 1980). Jet operations at TOA are discouraged by City Council resolution, however, the airport is open to jet aircraft just as it is for all general aviation aircraft. Actual operations by jet aircraft at TOA have been infrequent in the past. The lack of availability of jet fuel at the airport is another deterrent to jet operations.

2.1 Activity Statistics

The level of activity used as a basis for the initial June 1978-May 1979 average noise exposure computations was 422,586 operations. The twelve month period coinciding with the first twelve full months of continuous noise monitoring at TOA showed a drop in activity to a level of 386,239 operations. This represents a decline of 8.6% for the July 1979-June 1980 period.

The frequency of aircraft movements at Torrance varies considerably based on the season of the year and time of day. For purposes of estimating an annual CNEL noise level, the total number of aircraft takeoffs and landings over a 12 month period are divided by the total number of days in the year to arrive at an average daily operations figure. The average daily number of operations are partitioned by time period of the day and type of aircraft and then allocated to flight tracks. The assumed distribution of operations for the July 1979-June 1980 period is shown in Table 2-I.

The distribution of activity at TOA was assumed to be the same as that determined for the June 1978-May 1979 period. Operations at Torrance occur, for the most part, during day hours. Using tower records, the percentage of the total daily activity occuring between 0700 and 1900 Hours was calculated to be 91.5 percent. Operations during the evening hours (1900-2200 Hours) are estimated to be eight percent, and nighttime operations (2200-0700 Hours) are assumed to be one-half percent.

A large percentage of the daytime flights are touch and go operations. Again, using tower logs for the 12 month period June 1978-May 1979, touch and go operations were calculated to represent 52.3 percent of the total daytime operations. This was increased slightly to 53 percent for the latest analysis period. Recent observations by the City Staff at the airport showed touch and go activity at 58 percent for a brief observation period. This could reflect a period of good weather and extended daylight hours. During the evening the percentage of touch and go operations was judged to decrease substantially to an average of 7.5 percent of the total evening operations. Touch and go maneuvers during the nighttime period are prohibited.

Wind conditions at Torrance favor a northwest flow of traffic a majority of the time. During the daytime period, it is estimated Runway 29 is utilized 75 percent of the time. During the evening and nighttime period, Runway 29 utilization was estimated to increase to 80 and 95 percent, respectively. This is primarily due to calmer wind conditions during this period and the fact that Runway 29 is the designated calm wind runway.

TABLE 2-I FLIGHT OPERATIONS ASSUMPTIONS FOR JULY 1979-JUNE 1980

1. Annual Operations (July 1979-June 1980)

Total Annual Operations	386,239

2. Day/Evening/Night Distributions

Day	(7am-7pm)	91.5 %
Evening	(7pm-10pm)	8 %
Night	(10pm-7am)	0.5 %

3. Percent Touch and Go

	Touch & Go	Itinerant
Day	52.3 %	47.8 %
Evening	7.5 %	92.5 %
Night	0 %	100.0 %

4. Runway Utilization

	Runway 11	Runway 29
Day	25 %	75 %
Evening	20 %	80 %
Night	5 %	95 %

5. Aircraft Mix

	Composite Single Engine	Composite Multi-Engine	Heli-copter	TOTAL
Day-Itinerant	88 %	10 %	2 %	100 %
-Touch & Go	94 %	2 %	4 %	100 %
Evening-Itinerant	88 %	11 %	1 %	100 %
-Touch & Go	93 %	0 %	7 %	100 %
Night-Itinerant	67%	31 %	2 %	100 %

The FAA Tower reported an estimate of 10 percent use of Runways 11 L/R during the summer of 1981. This could again be reflecting seasonal variations in runway utilization. This historical data from the past five years and records from the 1979-1980 observation period show an average runway utilization corresponding to Table 2-1.

The operations by single engine aircraft have been grouped in Table 2-I under the designation Composite Single Engine. This is the division used, together with the Composite Multi-Engine category, to compute the average noise exposure. The process for utilizing these date is described in Section 3.

2.2 Aircraft Flight Patterns

The aircraft flight paths around TOA have remained essentially constant since the baseline analyses were carried out. The assumptions established at that time are reproduced in Appendix A to facilitate reference to data used in this report.

The only assumption changed for the most recent noise exposure analysis was the landing approach profile for Runway 29L. This particular flight path was studied extensively as part of the VASI evaluation project. [1/] The results of this study showed a segmented approach profile, i.e., varying angles of descent as opposed to the average continuous angle of 4.7^{o} assumed in the baseline study. The average altitudes at each of the measurement locations were used to describe this landing altitude profile in the current CNEL computations.

Helicopter activity at TOA was shown in the original operations assumptions (Table 2-I) to be at a level of approximately five itinerant flights and ten touch and go loops per day. This

---

1/ An evaluation of the effects of a VASI system for landing operations on Runway 29L was conducted through a joint effort by the FAA, the City of Torrance and PRC Speas. This work included documentation of the land altitude profiles out to approximately three miles from the airport.

low level of operations did not influence the CNEL values significantly. Helicopter overflights have produced periodic complaints in the airport environs for a number of years. There was no evidence of concerted community action against helicopter operations available at the outset of the ANCLUC project. Since 1979, however, residents of the Walteria District in Torrance and in the higher elevations in Redondo Beach complained to the City concerning helicopter activity at TOA. This led to an investigation of the subject which is described in Section 7.6 of this report.

2.3 Current Activity Levels

Unexpected changes in the level of monthly operations at TOA during the latter part of 1980 and early 1981 has raised an issue that was not apparent during the initial ANCLUC study period. Since there are implications from this activity decline relating to noise abatement regulations at TOA, the progress of this trend should be followed closely during the coming months.

Examination of six months of operation at TOA (May 1980 through October 1980) shows a marked drop in the activity levels. Total operations for these six months in 1980 are an average of 19 percent below the averages for the same months during the preceding five years. There is a general decline in general aviation activity throughout the United States, attributable in part to prevailing economic conditions. Another contributing factor may be the recently imposed ban on training operations by non-based aircraft. The monthly totals for operations at TOA through October 1980 are shown in Table 2-II.

The information in Section 2.2 concerning flight operations at TOA between July 1979 and June 1980 formed the input data base

TABLE 2-II

ANNUAL OPERATIONS TORRANCE MUNICIPAL AIRPORT   REPORT 252

YEAR	1966	1967	1968	1969	1970	1971	1972	1973	1974
JAN	23074	23401	29515	23720	26972	27521	25579	30051	24719
FEB	23619	29705	28171	30820	33145	27607	25196	28092	34344
MAR	22353	33672	39179	39580	36111	30992	26772	38180	35311
APR	31254	32277	40226	38942	37491	31395	36487	38277	38587
MAY	30812	30819	39799	34897	41168	35235	36673	39109	39549
JUN	28289	32555	35956	36381	35823	34187	32030	37012	38829
JUL	36194	36689	39341	37161	39540	34237	37742	39413	40071
AUG	24500	38605	43336	35613	38883	34149	40915	30740	39142
SEP	33098	30469	37484	28741	31895	31459	33124	35665	29787
OCT	29561	27535	29847	35257	33039	28471	32685	35317	36182
NOV	27818	28292	34836	34107	27514	22687	30869	32947	33954
DEC	26054	27735	30437	25260	30784	24289	31964	33843	30616
TOTAL	336646	371754	428129	400479	412365	362229	390036	427655	421091

YEAR	1975	1976	1977	1978	1979	1980	1981	1982	AVERAGE
JAN	31740	38837	32783	26060	28512	25492	27552		27846
FEB	27080	29039	29900	26038	28872	26329	27203		28448
MAR	31315	38782	35093	32042	35513	32980	29660		33596
APR	35798	39971	37938	36939	39667	33087	31586		36245
MAY	33444	41904	37796	40076	36889	28445	28384		35937
JUN	31824	41043	34717	39478	34801	32891	29544		34710
JUL	38889	38530	44609	42613	35780	33871	33026		37982
AUG	38431	40056	38402	40184	38907	31981	29824		36479
SEP	37360	30117	35109	35815	34531	27524	27782		32498
OCT	35696	33024	32076	28850	31875	22869	28276		31285
NOV	35660	31314	34431	33735	33130	26446	26208		30872
DEC	33611	36529	20087	32458	32792	24245			29380
TOTAL	410848	439146	412941	414288	411269	346159			395278

used in the FAA Integrated Noise Model (INM) used to describe aircraft noise exposure levels. The results produced by the prediction model are, of course, no more accurate than the assumptions relating to the operating characteristics and noise emission characteristics of the aircraft. The next section will describe the procedure used with the prediction model and compare the CNEL predictions with twelve-month averages obtained from the permanent monitoring system.

3.0 AIRCRAFT NOISE EXPOSURE AT TORRANCE AIRPORT

3.0 AIRCRAFT NOISE EXPOSURE AT TORRANCE AIRPORT

3.1 AIRCRAFT NOISE METRICS

At the end of June 1980, a one-year period of continuous noise monitoring in the Torrance Municipal Airport (TOA) environment was completed. Data from these measurements, collected at different locations in the community, were expressed in several different noise scales or metrics for both aircraft and non-aircraft noise. These data provide a history of the actual noise exposure conditions at the 11 monitoring locations. These records constitute important descriptions of the daily and seasonal variations in aircraft noise exposure around the airport. The information is necessarily restricted, however, due to the relatively small number of monitor locations with respect to the large land area around TOA. In an attempt to supplement the direct measurements and fill in estimates of aircraft noise levels where there are no monitors, an aircraft noise prediction model is used. The principles of this procedure were described in the July 1979 report on aircraft noise exposure characteristics in Torrance.[1/]

The concept of a time averaged aircraft noise energy level was included in the State Airport Noise Regulation[2/] and designated the Community Noise Equivalent Level (CNEL). This State regulation was prepared on the basis of direct measurements which average the aircraft noise environment and, to this end, explicit technical specifications for these measurements were included in the regulation. The nature of sound level measurements obtained using the specified procedure is such that all sounds occurring at the microphone station (aircraft and non-aircraft) are included in the summing and averaging process unless some of the

1/ Torrance Municipal Airport, Aircraft Noise Control and Land Use Compatibility (ANCLUC) Plan, First Quarterly Aircraft Noise Evaluation, July 6, 1979.

2/ California Administrative Code, Title 21, Chapter 2.5, Subchapter 6, Section 5000 et. seq.

unique characteristics of aircraft noise are used to isolate that particular class of noise event. This latter technique is used in virtually all permanent aircraft noise monitoring systems to record aircraft CNEL and non-aircraft CNEL values separately. The characteristics of the aircraft sounds used to isolate these events are quite variable so that a particular measurement system may or may not record all aircraft noise events, depending on the refinement of the identification process.

The permanent measurement systems such as the one operated at TOA may then record separate CNEL values for aircraft and non-aircraft noise events as well as combined noise energy averages at locations in the community. Some small portable measurement systems do not have this capability for identifying aircraft noise events and are, therefore, restricted to displaying combined community CNEL values. There is an apparent inherent assumption in the State Airport Noise Regulations that the aircraft noise environment existing around airports will be defined primarily through direct measurements in accordance with the technical specifications included in the regulation. There is, however, no specification for defining the identifying characteristics to be used to isolate aircraft noise events. Consequently, no provision is made in the regulation to segregate aircraft CNEL values from measurements of combined community CNEL.

This problem is compounded somewhat by the fact that all airport noise impact areas defined for purposes of evaluating compliance with the State Airport Noise Law are developed through the use of aircraft noise prediction models and not through direct measurements as envisioned in the legislation. The CNEL values computed through this method include only the aircraft noise component of the overall CNEL measured at a particular location.

These various considerations involved in defining a CNEL environment around an airport raise the issue of separate identification of values obtained using the different procedures. Any land use compatibility planning based on the CNEL environment should use all available CNEL data but should recognize the separate contributions of aircraft and other noise sources to the overall noise environment.

The noise monitor system at TOA is programmed to identify aircraft noise events and produces a corresponding noise metric designated CNEL which represents only the aircraft noise components. This is the measurement from the system most closely related to the aircraft CNEL values computed using the noise prediction model, in this case the FAA Integrated Noise Model (INM). All references to CNEL values in this report, unless otherwise designated, will refer to computations and measurements comprising only noise produced by aircraft. The computation procedure used in the aircraft noise prediction model is described in Appendix B.

3.2 AIRCRAFT CNEL VALUES AT TOA

The 1978-79 annual CNEL computations from the prediction model utilized a small amount of data from the newly installed monitor system to select appropriate noise characteristics for the general aviation aircraft types operating at TOA. This process of selecting representative aircraft types and specifying their noise emission characteristics introduces the most variable assumption in the prediction mode. The method of segregating aircraft types into only two categories, subject to continual refinement of the noise emission level assumption was adopted for the baseline (1978-79) CNEL computation. This involved segregating the aircraft into only two types, single engine and twin engine, and specifying an average noise level versus distance function for each category. While the deviation from this average noise level may be quite large at the outset, the information accruing from the monitor system may be used to provide a means for successively refining the estimates and creating new categories when new data are available.

The importance of the modeling assumptions involving this noise emission characteristic are illustrated by measurements of aircraft noise levels at TOA obtained by the Noise Abatement Office at the airport. These noise levels, tabulated by specific aircraft type, were measured at fixed monitor locations and, in some instances, showed variations greater than 20 dBA for the same aircraft types following identical nominal ground tracks. This represents the differences in noise emissions attributable to factors such as engine rpm, propeller pitch, performance degradation at high temperature, affects of meterology on sound propagation and deviations from the nominal three dimensional flight path. This variability, together with the fact that there are no data for the precise mix of aircraft types at the airport, provides sufficient reason to treat this assumption with extreme caution in developing CNEL values for operations at Torrance Airport.

Continuing work on the ANCLUC project and related studies carried out with the TOA Noise Abatement Office have provided information leading to refinement of some of the original assumptions used in the noise prediction model. Landing approach altitude profiles have been adjusted to reflect more accurately the actual conditions at TOA. These refinements were introduced into the TOA data base one at a time and new CNEL baseline contours using 1978-79 annual operations data were computed. The distributions of aircraft, by category, on the flight tracks specified in the 1979 report data base were retained in preparing a revised version of the baseline noise contours.

Each of the revised flight track and altitude profile assumptions were tested with the 1978 operations data and new CNEL maps were computed for each modification. These computations showed no significant deviations from the CNEL contour map shown in the July 1979 baseline report. This led to a decision to use CNEL contours based on the refined flight path data as an update to the baseline CNEL contour in the 1979 report. The purpose of this baseline CNEL map was to compare the 1978-79 noise exposure areas with those reflecting subsequent changes in numbers of operations and changes in other assumptions for the 1979-80 period. The CNEL map for these revised 1978-79 baseline conditions is shown in Exhibit 3-1. The CNEL contours shown in Exhibit 3-1 are based on 422,586 annual operations during the 1978-79 period.

The CNEL contours for the July 1979-June 1980 period reflect an 8.6 percent decrease in total annual operations relative to the baseline period. These contours, shown in Exhibit 3-2, are reduced less than 0.5 CNEL from the baseline condition and the changes are difficult to locate on a small scale map. The reduction in the CNEL 55 contour to the west is of the order of 500 feet with smaller changes produced in other locations.

The accuracy of these contours may be checked against the twelve-month average CNEL values for aircraft noise from the permanent

EXHIBIT 3-1

TORRANCE MUNICIPAL AIRPORT ANCLUC STUDY

CNEL CONTOURS 1978-79 FLIGHT OPERATIONS

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC)

prc SPEAS ASSOCIATES

EXHIBIT 3-2

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

CNEL CONTOURS
1979 - 80
FLIGHT OPERATIONS

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

prc SPEAS ASSOCIATES

monitoring system. The average CNEL for this period at each monitor location is shown in Exhibit 3-2. The following table, 3-I, shows the differences between the measured and predicted aircraft CNEL values for those stations located near or inside the CNEL 55 contour boundaries. The individual monitor stations are shown in Exhibit 3-4.

The largest discrepancies between the measured CNEL data from the monitor system and the values predicted using the INM are at RMS 9 and RMS 11. The CNEL values at RMS 9 are overstated by 3 CNEL. These CNEL values are determined primarily by straight-out departures on Runways 29L and 29R. The good agreement between measured and predicted CNEL values at RMS 1 and RMS 10, affected mostly by takeoff noise, suggests that the allocation of operations to the straight-out departure tracks may be too high resulting in the overestimate at RMS 9. This possibility might be evaluated in subsequent appications of the INM to operations at TOA.

The 4 CNEL overstatement at RMS 11 by the prediction model may result from an excessive engine landing power assumption in the INM. The aircraft altitudes at this close-in location on the landing track were verified through measurements and are assumed to be accurate. Thus, the assumed noise vs. distance characteristics for the aircraft during final landing approach conditions may be overstated and require additional refinement. A reduction of 4 dBA in the landing power noise curve in the INM data base should be tested in subsequent applications of the model at TOA.

The difficulties encountered in achieving a close agreement between CNEL values from long term monitoring and those from prediction models illustrate a little recognized fact relating to airport noise descriptions. The California Airport Noise

TABLE 3-I

COMPARISON OF MEASURED AND PREDICTED CNEL VALUES

Remote Monitor Station	Measured 12-Month Average CNEL	INM Predicted CNEL	Difference
1	59	59	0
5	58	56	-2
6	53	54	+1
9	53	56	+3
10	62	63	+1
11	57	61	+4

Note: The remaining permanent monitor stations are not included due to their distant location outside the largest CNEL contour boundary.

Regulations require a definition of CNEL contours around airports for purposes of evaluating compatible land uses. There is no recognition of the important distinction between CNEL values produced exclusively by aircraft (CNELA) and the composite CNEL values which include all noise sources, including aircraft. In actual practice, all CNEL contours around airports are generated by some form of prediction model. These prediction model contours may be refined using measurement data from those airports operating noise monitoring systems, but it is obvious that 10-20 isolated monitor locations are insufficient to define the contour boundaries with an acceptable degree of accuracy.

The absence of any standardized procedure in the Regulations for developing flight operations and noise emission assumptions for airport operations creates a large amount of uncertainty in interpreting airport noise exposure contours. The method used in this analysis has attempted to isolate and document the component parts used in developing aircraft CNEL values so that the analysis may be replicated and refined as new data are made available.

A summary of the various noise metrics collected from the TOA monitor system from July 1979 through June 1980 is shown in Table 3-II. It is apparent from these data that only monitors RMS 1 and RMS 5 in the community show aircraft noise (CNELA) as a significant component of the overall community noise (CNELC). For most of the community, aircraft noise would not seem to be a significant factor when judged solely on the basis of the measured or predicted CNEL values.

TABLE 3-II

AVERAGE FOR 366 DAYS FROM SUNDAY 07-01-79

SITE	1	2	3	4	5	6	7	8	9	10	11	12
CNELA	59	50	48	44	58	53	53	51	53	62	57	0
CNELC	61	60	59	61	61	60	68	64	59	64	60	0
LDNA	59	50	48	43	57	53	53	96	53	61	56	0
LDNC	61	59	58	60	61	59	68	64	58	64	59	0
LEQC	61	58	56	57	60	57	63	60	58	65	59	0
L1	72	67	64	66	68	66	67	64	67	75	68	35
L10	61	59	56	59	59	57	57	56	57	63	57	35
L50	50	51	50	51	52	51	50	50	50	50	50	35
L90	45	45	45	45	46	46	45	45	45	47	46	36
L99	43	43	44	43	43	44	43	43	44	44	44	35

3.3 SINGLE EVENT AIRCRAFT NOISE EXPOSURE LEVELS

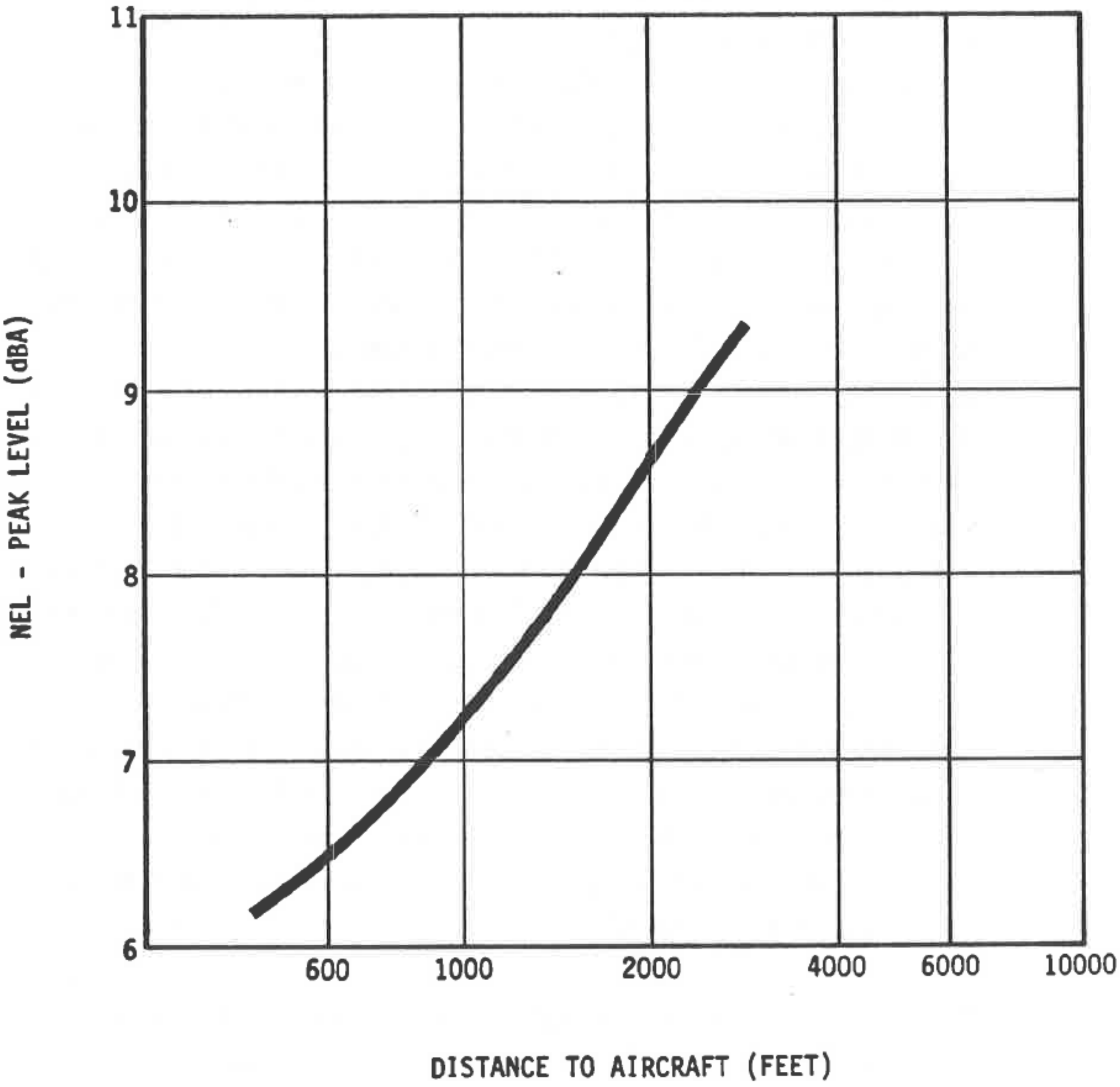
The CNEL contours depict the average daily aircraft noise energy exposure around TOA. This is based on flight operations averaged over the entire year including all different runway use patterns and weather conditions. As a result, the average aircraft noise exposure level affecting a particular residential location is different than the maximum or minimum levels which exists when other than average weather and/or air traffic conditions exist. As an example, an unusually low ceiling or an approaching fog bank may result in aircraft flying closer to a given area, and creating more noise exposure than is typically the case. Similarly, air traffic conditions may dictate continuous use of a particular runway and cause more aircraft noise events over a specific area than the area's inhabitants normally experience.

Recognizing that it is often these extreme conditions which cause annoyance and give rise to complaints of excessive noise, it is useful to supplement the CNEL exaluation with a more direct and specific measure of the characteristics of aircraft noise that affect human activities. This is accomplished, to a degree, by defining the noise produced by single operations of the different aircraft/engine types operating at TOA. These values are designated as single event noise levels. The existing airport noise ordinance enforced at TOA uses single event noise levels to regulate noise exposure in the community. The prevailing limits are in the form of a time-integrated Single Event Noise Exposure Level (SENEL) and a maximum instantaneous sound level. The current SENEL limit is 88 dBA (Day) and 82 dBA (Night), while the peak instantaneous limit is 82 dBA (Day) and 76 dBA (Night).

The use of single event aircraft noise levels described in this section is intended exclusively as a land use planning tool. The intent is to obtain explicit physical descriptions of the aircraft noise events and use these data, together with the frequency of occurrence of the events, to determine specific effects on human activities in the community. This will provide a measurable and comprehensive description of the impact of aircraft noise available for use when selecting appropriate land use compatibility strategies.

The analysis of single event aircraft noise impact is carried out on the basis of specific land parcels, i.e., on a site-by-site basis. This procedure may be followed for any location around the airport. The method used here to assess the effects of the individual aircraft noise events involves tabulating the noise vs. distance characteristics for operations of each aircraft type together with the assumed altitudes of the aircraft over each of the population centers in the airport environs. These time-integrated Noise Exposure Levels (NEL/SENEL) are taken from the INM data base and recorded, by aircraft type, for the appropriate distance and engine power. The NEL values are then converted to peak dBA levels for purposes of comparing the levels with speech interference criteria. The conversion from NEL to peak dBA is based on aircraft noise recordings obtained for different aircraft types during test conducted at TOA. The relationship is plotted in Exhibit 3-3. The conceptual basis for the NEL and peak dBA-comparison is described in Appendix B. This relationship is applied for aircraft velocities in the range of 75-125 knots. Special consideration is required for cases at TOA where the velocities fall outside this approximate range.

EXHIBIT 3-3 DIFFERENCE BETWEEN SENEL AND PEAK dBA LEVEL AT TOA



The nominal aircraft altitudes along each of the flight tracks is shown in Exhibit 3-4. These altitudes, together with the horizontal ground distance from the flight track to the site being evaluated, may be used in the manner described in this Section to compute the direct distance, or slant distance, from the site to the aircraft. It should be noted that these are average or nominal altitudes which vary according to weather and aircraft operating conditions. This slant distance is used with Exhibits 3-5 and 3-6 to determine the SENEL value. The SENEL-to-Peak dBA conversion is made from Exhibit 3-3 and this Peak dBA is then used to evaluate the specific effects on human activities at the site. Specific aircraft types included in the noise prediction model are identified in Exhibit 3-5. To utilize such data, one would calculate the average daily number of aircraft noise events occuring at the points along given flight paths which are closest to the site in question. Recalling that these are daily averages over an entire year, the total number of aircraft noise events affecting particular locations over the year is obtained as the product of the daily average and the number of days during the one year period. Adding the products obtained by this method (logarithmetically) gives the cumulative aircraft noise exposure at the site. It is important, also, to note that the number of takeoffs or landings affecting a point on any particular day may well be the sum of all operations distributed over the various flight paths for that type of operation. This concentration of noise events does not occur each day, but can produce the single most intrusive aircraft noise situation in the community.

The specific procedure for estimating the maximum dBA level at any ground location affected by aircraft noise is:

1. Determine the nominal aircraft altitude on the closest flight tracks from Exhibit 3-4.

EXHIBIT 3-4
NOMINAL AIRCRAFT ALTITUDES

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

SPEAS ASSOCIATES

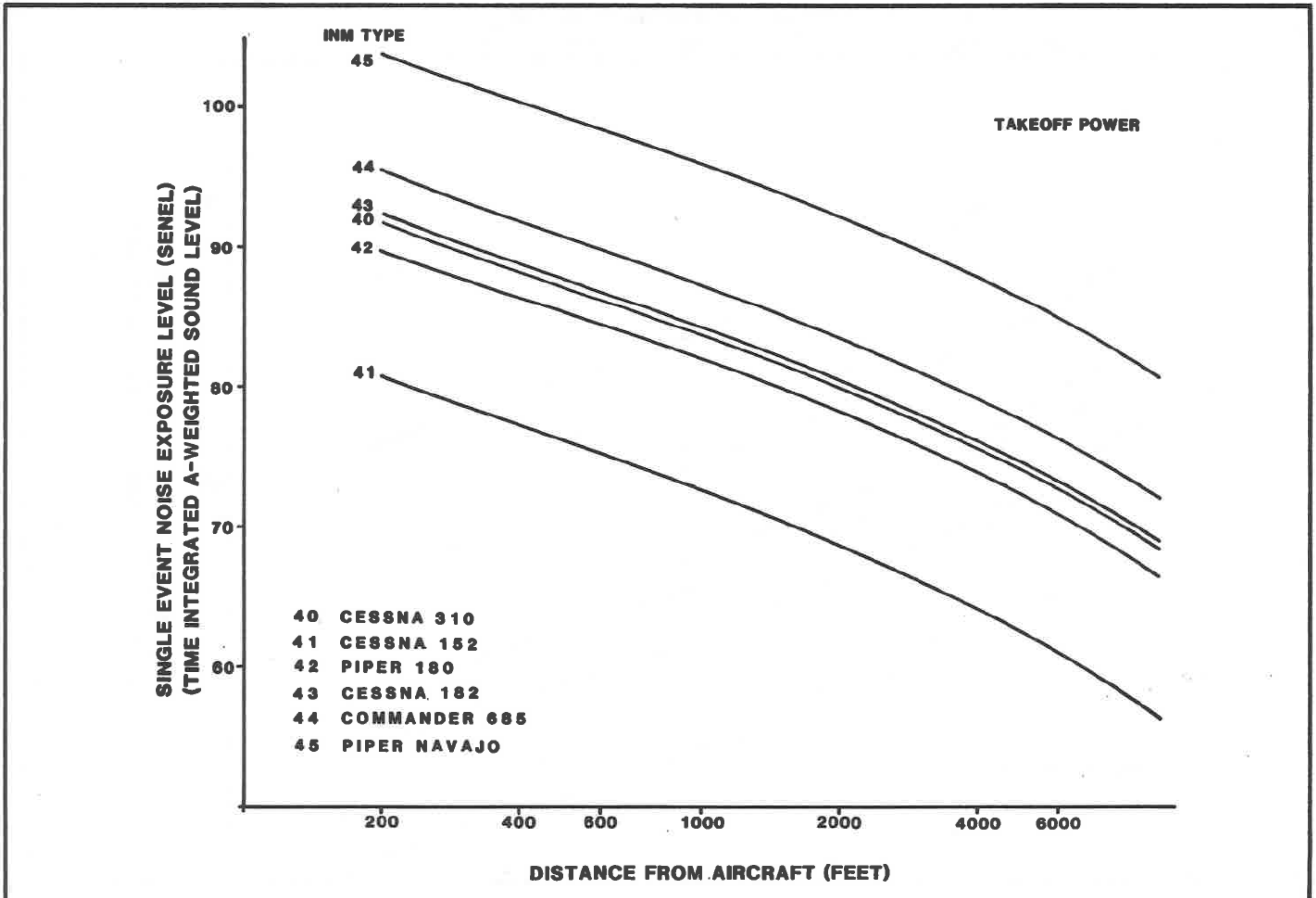


EXHIBIT 3–5 SENEL VS DISTANCE FOR INM GENERAL AVIATION TYPE AIRCRAFT

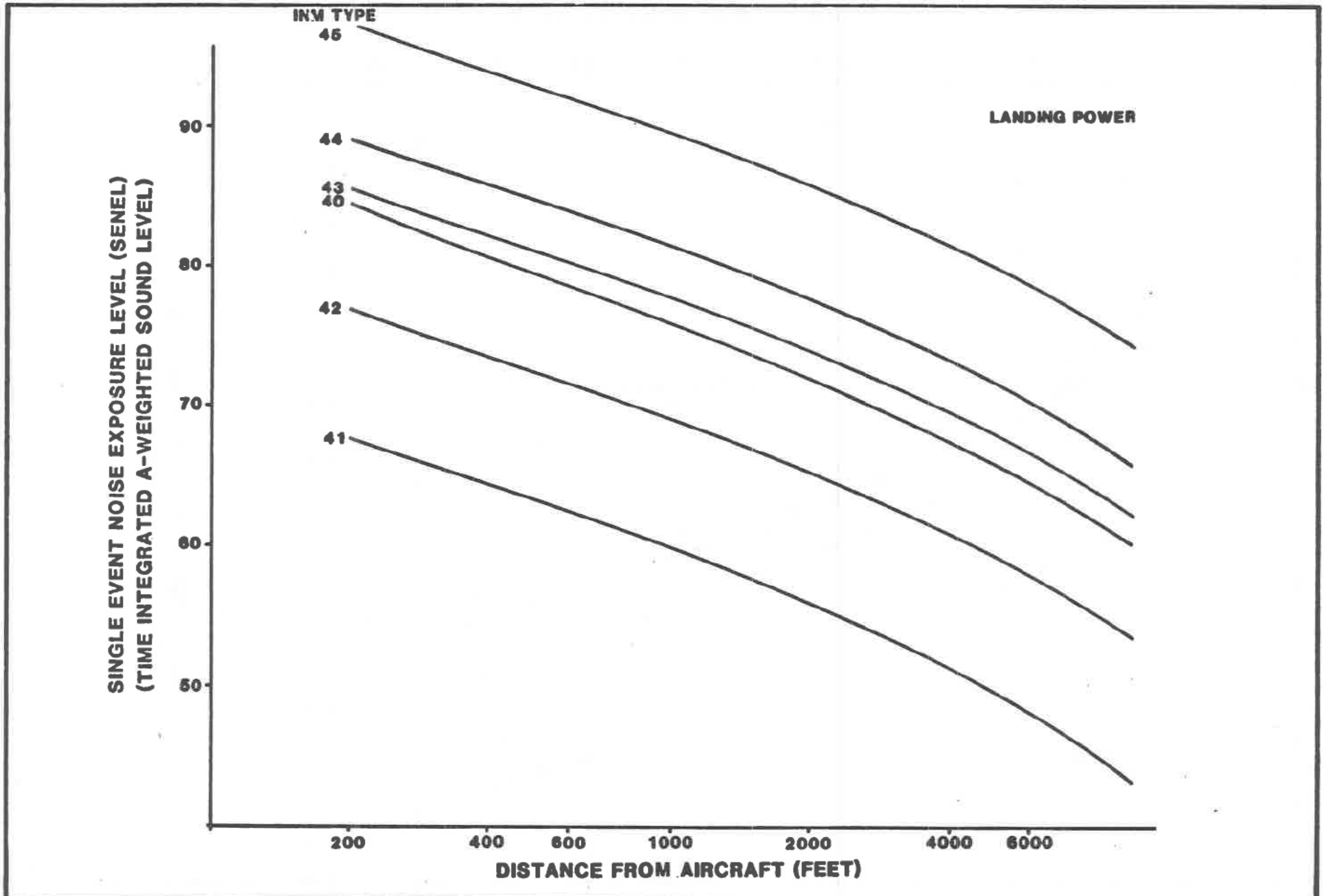


EXHIBIT 3-6 SENEL VS DISTANCE FOR INM GENERAL AVIATION TYPE AIRCRAFT

2. Measure the perpendicular distance from each flight track of interest to the ground location being evaluated.
3. Compute the slant distance from the aircraft to the ground location being evaluated.

   $$\text{Slant Distance} = \sqrt{(\text{aircraft altitude}^2) + (\text{distance off flight track}^2)}$$

4. Determine the SENEL value for the particular aircraft types operating on each flight track from Exhibits 3-5 and 3-6. Exhibit 3-5 should be used for departure flight tracks and Exhibit 3-6 should be used for arrival flight tracks.
5. Use Exhibit 3-3 to determine the estimated difference between the SENEL value and the Peak dBA value. The Peak dBA is always lower than the SENEL.

The different aircraft on each flight track from Exhibits 3-5 and 3-6 should be used in determining the distribution of maximum dBA values at a ground site.

This method for estimating the maximum dBA levels at a ground location may be illustrated using a location around TOA. The intersection of Anza and Calle Mayor, west of the airport, is approximately 10,500 feet from the start of the takeoff roll on Runway 29R and virtually directly beneath the straight-out departure path for that runway. Aircraft departing to the west from Runway 29L will also affect this ground location. For Runway 29L, the designated location is 9,500 feet from the start of the takeoff roll and 500 feet off the flight track. Using operations on Runway 29L to illustrate the procedure, the following computations are carried out.

1. Aircraft altitude --- This value may be taken from the INM data tables or obtained through computations. Assuming an average 1000 feet ground takeoff roll for light single engine aircraft or 1500 feet for heavier twins, a constant rate climb angle of 5^o (single engine) or 5.5^o (twin) is assumed. The altitude for a single engine aircraft is obtained by taking the distance of the site from the point where the aircraft begins the climb (9500 - 1000). The product of this distance (8500 feet) and the tangent of the climb angle ($\tan 5^o = .087$) gives the altitude, 740 feet.
2. The horizontal ground distance from the site to the flight track is 500 feet.
3. The slant distance from the aircraft to the site is

   $$Ds = \sqrt{(740^2) + (500^2)} = 893 \text{ feet}$$

4. From Exhibit 3-5, the SENEL for the single engine aircraft, departing with maximum takeoff power, is 74 dBA.
5. Exhibit 3-3 shows that the difference between the SENEL and Peak dBA value is 7.2 dBA. Thus, the peak or maximum dBA level at this location from single engine aircraft should be approximately 67 dBA.

This procedure is repeated for each aircraft type operating on each flight track affecting the site. Computations for the twin engine aircraft on Runway 29L and both single and twin engine aircraft on Runway 29R would show the range of maximum aircraft noise levels affecting the site. Reference to the operations data in Appendix A shows the frequency of overflights on each of the flight tracks. This procedure will allow the analyst to compute the aircraft noise levels at any location for the maximum or worst case conditions or for an average derived from all aircraft operating at TOA.

Both the SENEL and Peak dBA values obtained from this procedure may be used in assessing community response at a specific site. The SENEL may be used to compute a CNEL value for the site.

$$CNEL = SENEL + 10 \log N_D + 3N_E + 10N_N - 49.4$$

Where: N_D = No. of Day Hour Operations (0700 - 2200 Hours)
N_E = No. of Evening Hour Operations (1900 - 2200 Hours)
N_N = No. of Night Hour Operations (2200 - 0700 Hours)

The CNEL is computed for each separate aircraft type on each of the tracks affecting the site. These values are then summed using the expression:

$$CNEL_T = CNEL_1 + 10 \log \left(1 + 10^{-\left[\frac{CNEL_1 - CNEL_2}{10}\right]}\right)$$

Where: $CNEL_T$ = Sum of two CNEL values. The CNEL values are summed two at a time, beginning with the two lowest values then adding the sum of that part to the next lowest value.
$CNEL_1$ = Higher of the two values
$CNEL_2$ = Lower of the two values

The site specific CNEL may be used with the FAA land use guidelines to obtain an overall estimate of the compatibility of a particular land use with airport operations.

4.0 COMMUNITY RESPONSE TO AIRCRAFT NOISE

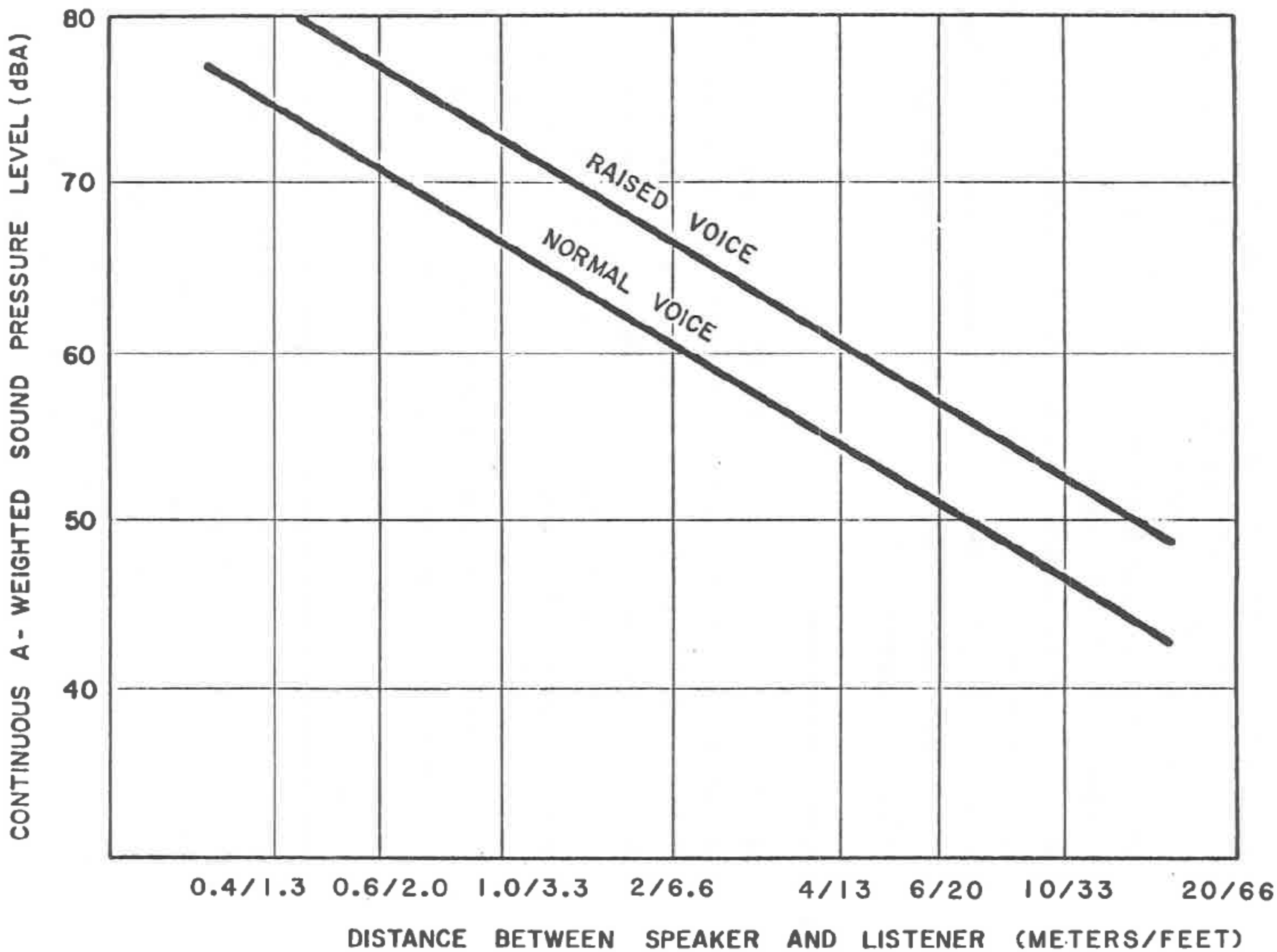
4.0 COMMUNITY RESPONSE TO AIRCRAFT NOISE.

Some aspects of human response to aircraft noise are highly subjective. Surveys and laboratory tests indicate significant variance from individual to individual in sensitivity and annoyance due to aircraft noise. Annoyance is the most variable of the human responses to aircraft noise and the most difficult to quantify. It is possible to develop accurate measures of some of the direct effects on human activities such as the interference with speech communications, including face to face speakers, radio and television listening and telephone conversations.

4.1 Speech Interference

Speech interference is a relatively straightforward phenomenon wherein speech intelligibility is interrupted when the intrusive noise exceeds the level of the speaker's voice. The relationship between the level of intrusive noise and the maximum distance between speaker (or television, or radio) and listener necessary for effective communication is shown in Exhibit 4-1 for both normal and raised speaking voice. Additional factors associated with speech interference include duration of the interference, and sound isolation provided by structures.

The duration of each period of speech interruption is determined under most conditions by the amount of increase of the peak level of aircraft noise above a specified criterion level. For most conditions under consideration, the aircraft noise rises to the peak level then falls off at a rate of about 1 to 2 dBA per second. This rate of increase and decrease of the noise is a function of the distance of the observer from the aircraft and the speed of the aircraft for most fixed wing aircraft operations. Using this relationship,



SOURCE: WEBSTER, J.C., "EFFECTS OF NOISE ON SPEECH INTELLIGIBILITY," NOISE AS A PUBLIC HEALTH HAZARD, 1969.

EXHIBIT 4-1. Levels of Continuous Noise Interfering with Speech in Normal and Raised Voices.

the speech interference may be estimated from the peak level of the aircraft noise. An indoor peak aircraft noise level of 70 dBA would exceed a speech interference level criterion of 60 dBA by 10 dBA, requiring a total of about 10 to 20 seconds to rise above then fall back to the 60 dBA level. As a result, speech in a normal voice over a distance of six feet would be interrupted for this period of time. The precise rate of increase/decrease for the aircraft noise may be determined by recordings of noise from the flyover events at specific locations. For prolonged noise events, such as from aircraft circling overhead, the duration of the interruption will exceed that experienced by a stationary observer with the aircraft moving in a straight line.

There is the additional consideration of the reduction in the intrusive noise level produced by the structure, such as a school or home. This varies with the construction characteristics of each different structure. The typical outdoor-indoor noise reduction expected from a house with no special noise control design in the TOA environs, is on the order of 10-15 dBA (windows open) up to about 20 dBA indoors if the windows of the structure are left closed. Reference to Exhibit 4-1 shows that, for a 65 dBA indoor noise, conversation in a normal voice would be interrupted at distances greater than about 1.1 meters, or a little over three feet. A tabular description of the speech interference from intrusive noise is shown below.

Steady A-Weighted Noise Levels Allowing Outdoor Voice Communication With 95 Percent Sentence Intelligibility

Voice Level	Communication Distance in Meters/Feet					
	0.5/1.6	1/3	2/6.6	3/9.8	4/13	5/16
Normal Voice	72	66	60	56	54	52
Raised Voice	78	72	66	62	60	58

4.2 Evening and Nighttime Effects

Several factors lend to greater annoyance generated by late hour noise events, compared with daytime events of the same level. The background, or outdoor ambient, noise levels are lower at night. Noise monitoring at sites in the vicinity of TOA indicated minimum ambient noise levels 6-7 dBA lower during evening (1900 - 2200 hours) periods than during daytime hours. Noise levels during the night hour period (2200 - 0700 hours) may be even lower, with a reduction of approximately 10 dBA below daytime levels. A noise event which may be unnoticed during the day may be considered intrusive during the evening or night hours. As a result, the occasional late hour flights at TOA, based on curfew exemptions, may result in sleep disruption at some locations.

Sleep interference is a phenomenon particularly difficult to quantify. Noise events can extend the period of time required for falling asleep, awaken an individual from sleep, or change the level of sleep experienced at the time the noise event occurs. One series of experiments exposed subjects to the repeated playback of recorded truck noise. The results of these experiments are summarized in Exhibit 4-2.

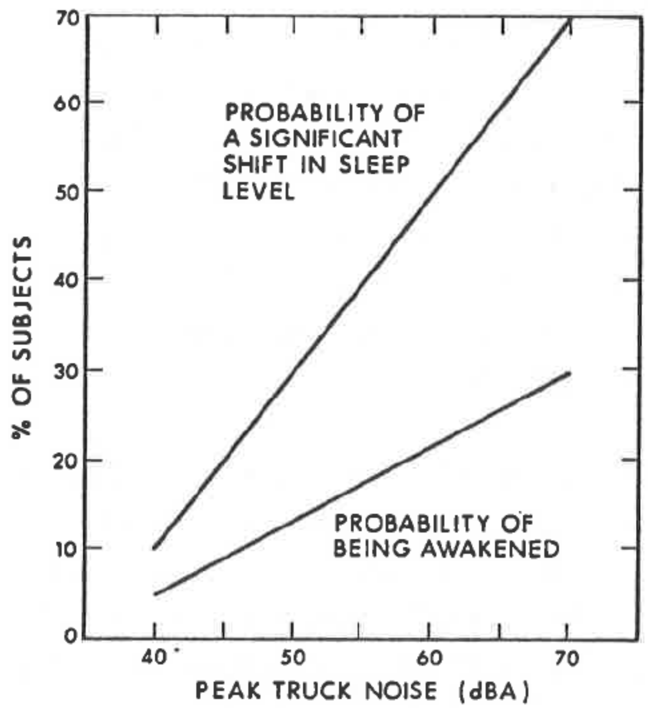
One should be most cautious in relating the data from Exhibit 4-2 to the potential for sleep interference produced by intrusive aircraft noise. The results of this experiment may, however, provide some cursory guidelines in attempting to determine the effects of aircraft noise on sleep patterns.

4.3 Annoyance from Aircraft Noise

The most difficult component of human response to aircraft noise to evaluate is that generally described as annoyance. This annoyance is a composite reaction produced by various

EXHIBIT 4-2

Sleep Interference Produced by Truck Noise



Source: Thiessen, G.D., and Olson, N., Sound and Vibration 2(4):10(1968) elements of the aircraft noise exposure such as level and duration of the noise, time of day or day of the week and frequency of repetition as well as the unique characteristics of some aircraft noise, e.g., helicopter noise.

The most extensive research into the relationship between annoyance and aircraft noise exposure has been carried out at London's Heathrow Airport.[1/] The aircraft noise in the Heathrow studies included mostly air carrier jets with less frequent occurrences of higher noise levels as compared with a general aviation airport such as Torrance. The noise exposure conditions have been expressed in terms of LDN values (virtually equivalent to CNEL) so that it provides an opportunity to compare responses received from the TOA environs with those from equivalent LDN/CNEL noise exposures in the vicinity of a larger air carrier airport.

Some results from the Heathrow studies are shown in Exhibits 4-3 through 4-6. Exhibits 4-3 and 4-4 show the percentage of people disturbed as a function of noise exposure level (LDN/CNEL) and the specific activity involved. For noise exposures up to LDN/CNEL 60, the percentage of people reportedly disturbed, depending on their activity, ranges between 20 percent and 70 percent. These seemingly high percentages of people reporting some degree of disturbance is tempered by the data from Exhibits 4-5 and 4-6. Noise exposures up to 60 LDN/CNEL produced opinions of the degree of annoyance ranging from "not at all" up to "little". Exhibit 4-6 shows up to 25 percent of the respondents reportedly "highly annoyed" at LDN/CNEL 60. These latter results were replicated in the United States six and nine years after the respective Heathrow studies

1/ "Noise - Final Report", H.M.S.O., Cmnd. 2056, London, July 1963.

EXHIBIT 4-3 PERCENTAGE OF PEOPLE DISTURBED BY AIRCRAFT NOISE FOR VARIOUS TYPES OF REASONS CONCERNED WITH REST AND SLEEP (Day-Night Equivalent Sound closely approximates the Community Noise Equivalent Level or CNEL value used as a scale for aircraft noise in California.)

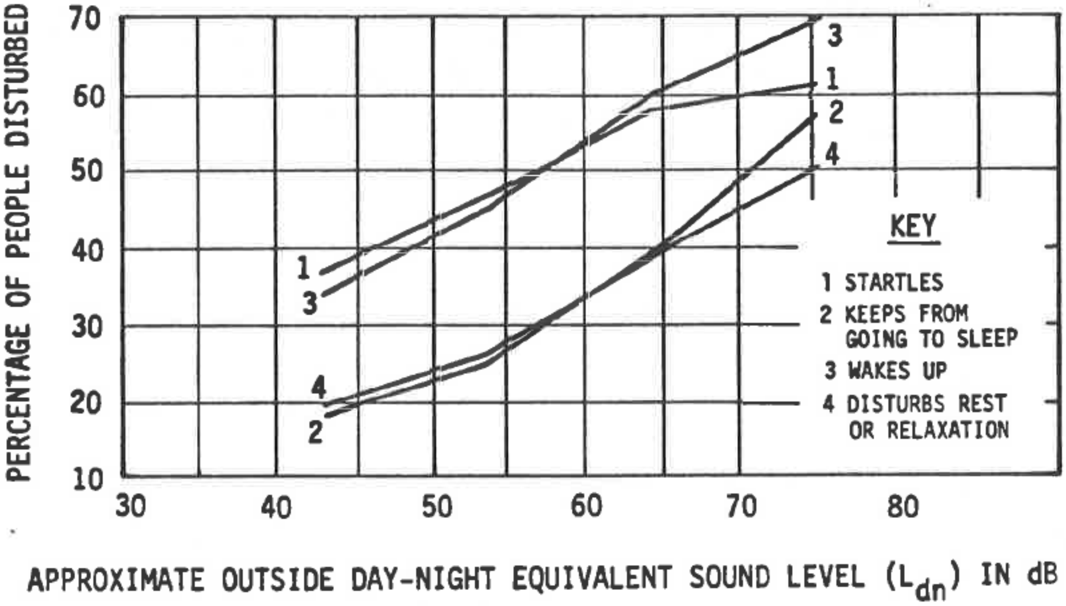


EXHIBIT 4-4 PERCENTAGE OF PEOPLE DISTURBED BY AIRCRAFT NOISE FOR VARIOUS TYPES OF REASONS CONCERNED WITH REST AND SLEEP (Day-Night Equivalent Sound closely approximates the Community Noise Equivalent Level or CNEL value used as a scale for aircraft noise in California.)

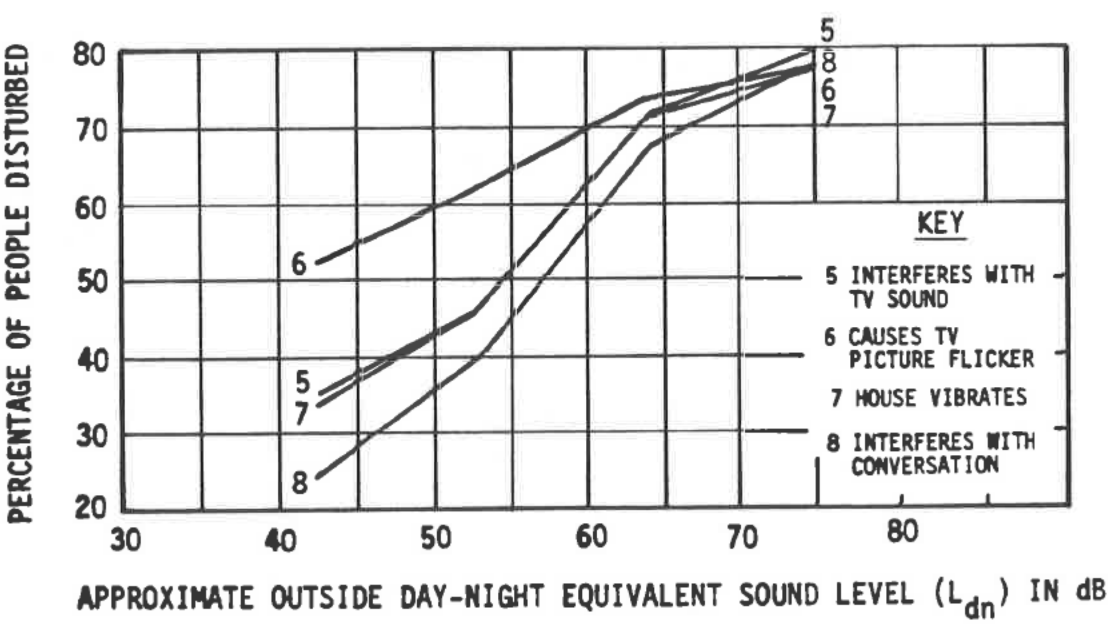


EXHIBIT 4-5 AVERAGE DEGREE OF ANNOYANCE AS A FUNCTION OF THE APPROXIMATE DAY-NIGHT NOISE LEVEL

(Day-Night Equivalent Sound close approximates the Community Noise Equivalent Level or CNEL value used as a scale for aircraft noise in California.)

(LONDON HEATHROW SURVEY)

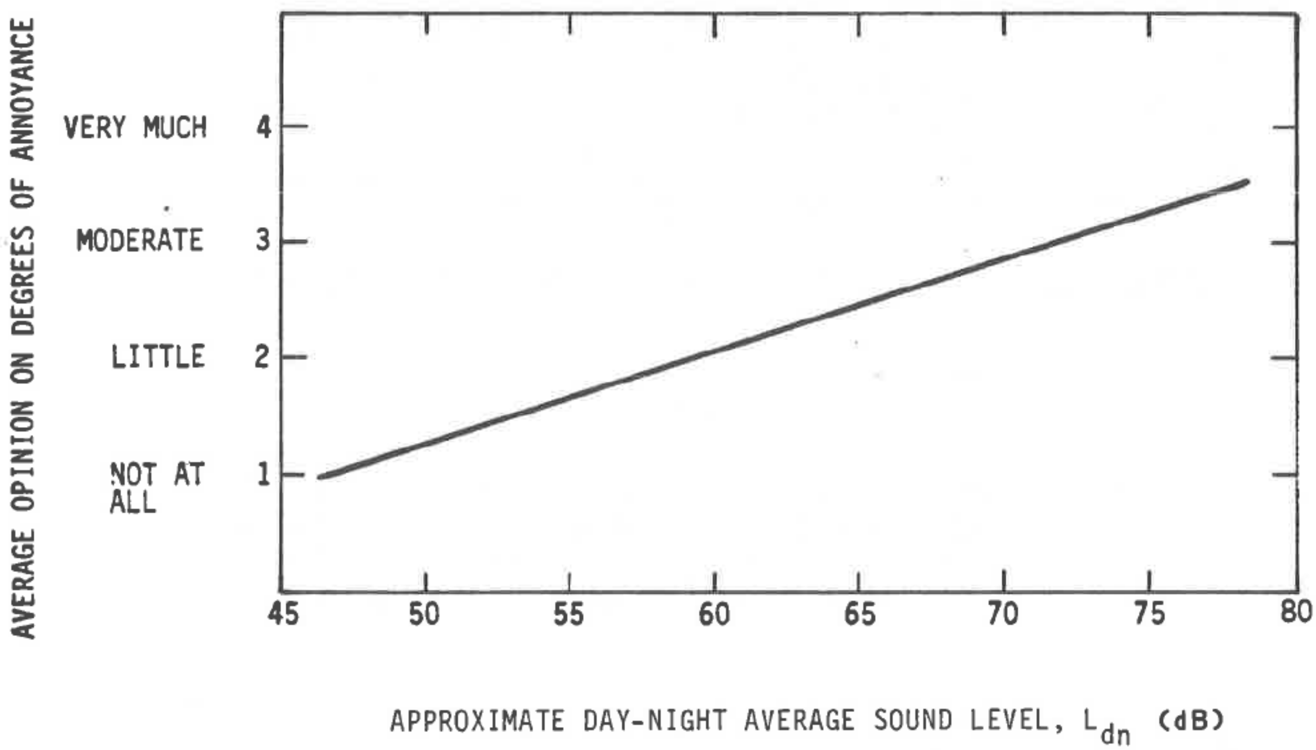
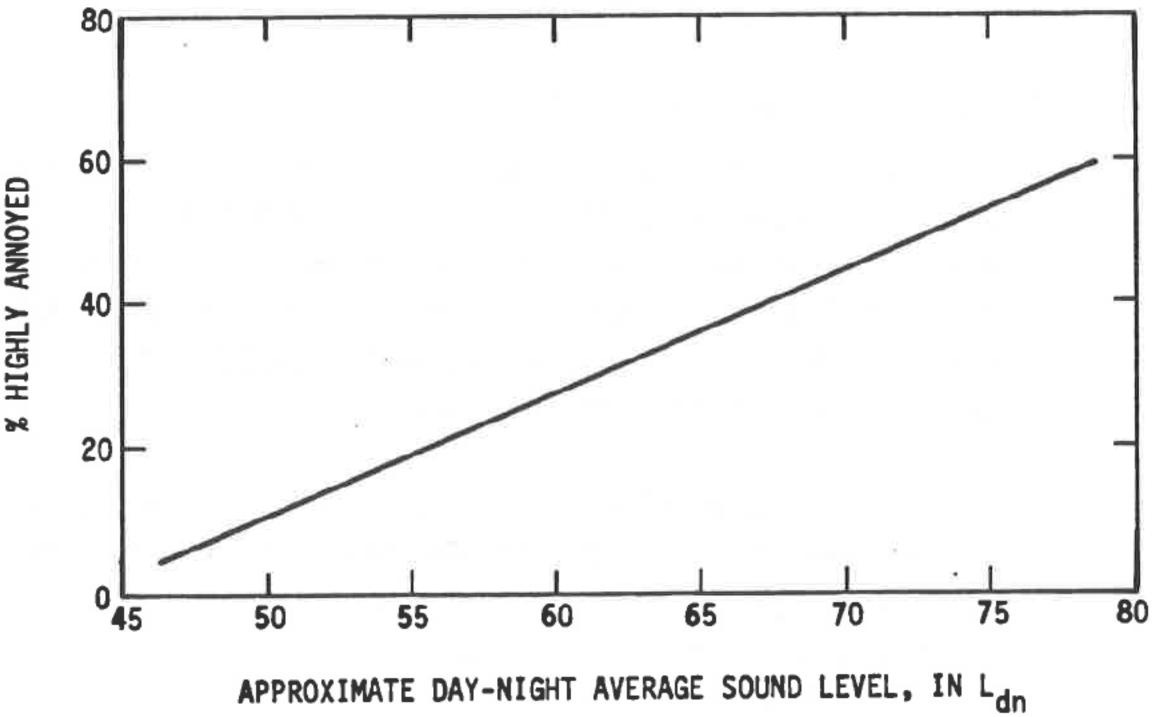


EXHIBIT 4-6 PERCENTAGE HIGHLY ANNOYED AS FUNCTION OF APPROXIMATE DAY-NIGHT NOISE LEVEL

(Day-Night Equivalent Sound closely approximates the Community Noise Equivalent Level or CNEL value used as a scale for aircraft noise in California.)

(LONDON HEATHROW SURVEY)



(Exhibit 4-7) with such consistency that an international convention has been adopted for the relationship between the percentage of people annoyed and the LDN/CNEL exposure level. This is expressed as:

$$\text{Percentage of annoyed people} = 2(\text{CNEL} - 50)$$

This would indicate that a sample of the population in the Torrance Airport environs all located, for example, along the 55 CNEL boundary would be expected to show about ten percent to be annoyed by the aircraft noise.

4.4 Community Noise Survey Questionnaire

One method used to assess community reactions to aircraft noise events is through a questionnaire survey. While there are limitations on the reliability of responses to these direct interrogations of residents, it does provide some insight into the attitudes of people concerning various aspects of the intrusive quality of airport operations.

A questionnaire, designed for mail distribution in the community, was prepared and circulated through interested City personnel for recommendations and revisions. The final version of the questionnaire is shown in Exhibit 4-8. The intent in distributing the questionnaire was to locate the residential areas most directly affected by aircraft operations. This meant that most of the effort was directed toward those neighborhoods lying along the arrival and departure flight tracks at TOA.

In selecting the specific addresses for the questionnaire mailing, the Los Angeles County Assessor's Map Book was used to specify districts for which pre-printed address labels were

EXHIBIT 4-7 COMBINED RESULTS OF BRITISH AND U.S. SURVEYS

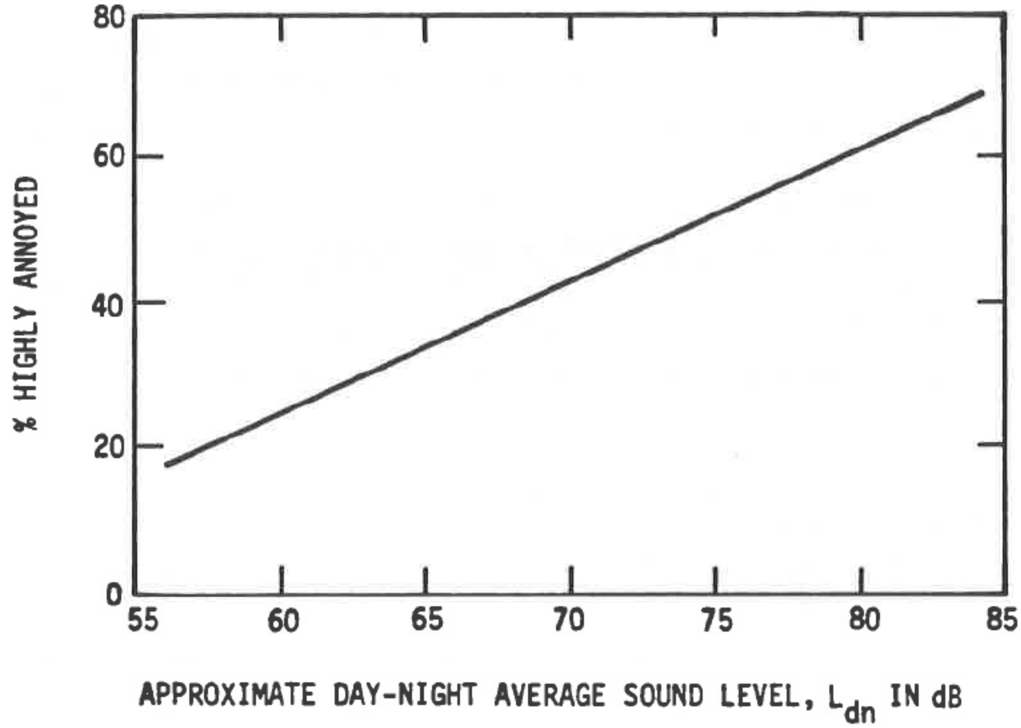


EXHIBIT 4-8. NOISE SURVEY QUESTIONNAIRE

TORRANCE MUNICIPAL AIRPORT
OPINION SURVEY

The City of Torrance is currently developing a plan to improve the compatibility between the Torrance Municipal Airport and the surrounding community. Data is now being collected relating to activities at the airport and the measurable effects on the surrounding properties. It will be helpful if we can supplement this information with some judgments and opinions from the residents most directly affected by aircraft operations. Your assistance in completing this questionnaire will be appreciated and all responses will be handled in confidence with no identification of individuals in our reporting. All information obtained from the community residents will be taken into consideration in developing a recommended plan for achieving compatibility.

Please check the answers which best describe your attitude in each statement. There are questions on both sides of this page so remember to complete each side. We have enclosed three identical questionnaire sheets, one for a different person at your residence. Again, we appreciate your assistance in this most important study.

Residence address: ____________________

Age: _____ Sex: M___1 F___2 Number of years at residence: ________

Approximate number of hours each day at residence: Weekdays ________
Weekends ________

Usually sleeping between hours of: Weekdays ________ Weekends ________

What percentage of your time at this residence do you spend outdoors:
Weekdays ______% Weekends ______%

Do you own or rent: Own _____1 Rent ________2

How many persons live in this residence, including yourself: ________

1. In general, what effect, if any, has the Torrance Municipal Airport had on the quality of your life?

Much effect, positive ________1
Some effect, positive ________2
No significant effect ________3
Some effect, negative ________4
Much effect, negative ________5

Comments: ____________________

2. During weekdays, I consider my residence to be:

----------- OUTDOORS --------------

_____1 Always very noisy
_____2 Always moderately noisy
_____3 Quiet with occasional loud noise
_____4 Always quiet

--------------- INDOORS ---------------

_____ 1 Always very noisy
_____ 2 Always moderately noisy
_____ 3 Quiet with occasional loud noise
_____ 4 Always quiet

3. During weekends, I consider my residence to be:

----------- OUTDOORS --------------

_____1 Always very noisy
_____2 Always moderately noisy
_____3 Quiet with occasional loud noise
_____4 Always quiet

---------------- INDOORS --------------

_____ 1 Always very noisy
_____ 2 Always moderately noisy
_____ 3 Quiet with occasional loud noise
_____ 4 Always quiet

4. How annoyed are you by noise in your area?

- ______ 1 Highly annoyed
- ______ 2 Considerably annoyed
- ______ 3 Medium annoyed
- ______ 4 Partially annoyed
- ______ 5 Not annoyed at all

5. If you are annoyed by noise in your area, what factors related to the noise events you experience are of greatest concern to you? (Please rank - 1,2,3, etc.)

- Loudness of the noise ______
- Number of noisy flights ______
- Time of day ______
- Day of week ______
- Others: (specify) ______

6. The noise which disturbs me the most is from:

- ______ 1 Automobile/truck/motorcycle
- ______ 2 Neighborhood activities
- ______ 3 Aircraft
- ______ 4 Not disturbed by noise
- ______ 5 Other: ______

7. The aircraft noise causes problems with:

- ______ 1 Talking with other people
- ______ 2 Sleeping
- ______ 3 Using the telephone
- ______ 4 Hearing radio/television
- ______ 5 Outdoor relaxation/recreation
- ______ 6 No problem with aircraft noise

8. I am most aware of aircraft operations during the following:

Day of the week: (Please circle) Sun Mon Tue Wed Thur Fri

Time of the day:
- ______ late night/early morning (10:00PM - 7:00AM)
- ______ morning (7:00AM - Noon)
- ______ afternoon (Noon - 5:00PM)
- ______ early evening (5:00PM - 10:00PM)

9. Are you familiar with the Torrance Airport noise abatement center and/or noise reduction programs? ______ 1 Yes ______ 2 No

10. Do you feel the noise abatement programs have reduced the noise?

______ 1 No reduction ______ 2 Some reduction ______ 3 Great reduction

11. Do you think any further changes should be made in the flight operations of the Torrance Airport?

- ______ 1 No changes
- ______ 2 Close airport
- ______ 3 Close runway (____S, ____N)
- ______ 4 Allow growth
- ______ 5 Ban noisy aircraft
- ______ 6 Further limit hours of operation Specify: ______
- ______ 7 No training
- ______ 8 Ban flight schools
- ______ 9 Set tougher noise limits
- ______ 10 Other: ______

12. Do you feel that flight operations from the Torrance Airport represents a safety hazard to you, your family or property? ______ 1 Yes ______ 2 No

13. What do you feel is the most important local problem faced by your community today?

- ______ 1 Aircraft noise
- ______ 2 Traffic noise
- ______ 3 Air pollution
- ______ 4 Aircraft safety
- ______ 5 Motor vehicle safety
- ______ 6 Other: (please specify) ______

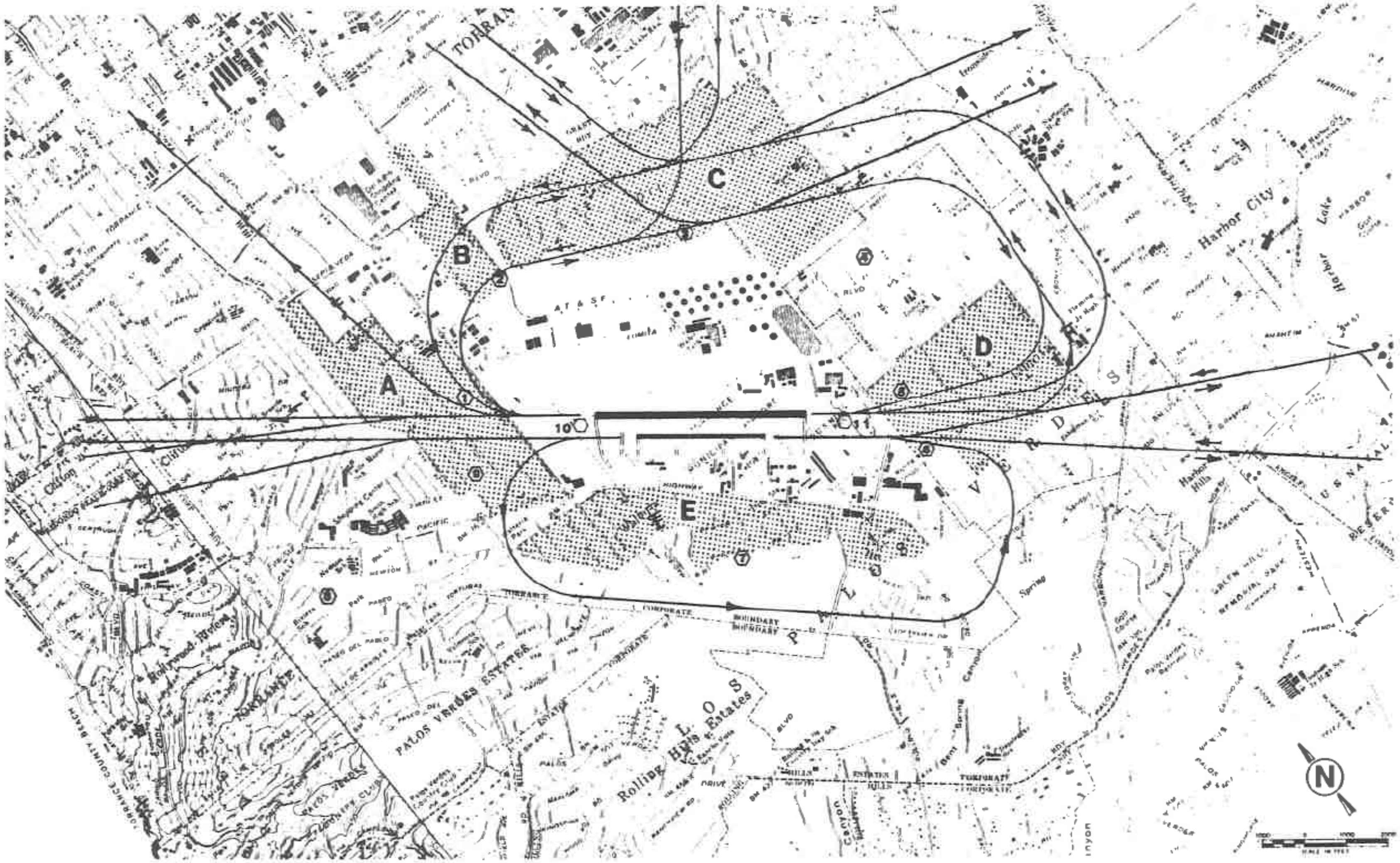
obtained. The list of tracts and the approximate center of the tract on shown on Table 4-I.

The geographic areas in the airport environs where the questionnaire mailings were concentrated were segregated into five districts using major roadway and neighborhood groupings to identify the separate areas. These districts are shown in Exhibit 4-9.

District	Description
A	This area west of Hawthorne Boulevard is affected principally by aircraft departing Runways 29L/R to the west, north and (in the local traffic pattern.) RMS 1 and RMS 9 are located in this district.
B	This area is located southeast of the Del Amo Center and is affected by operations in the local pattern including departure operations on Runway 29R and arrivals from the north to Runway 11L. RMS 2 is located in this district.
C	This district north of the airport lies under the intersection of flight paths for aircraft entering and leaving the pattern from and to the north as well as many of the training operations on Runway 29R. RMS 3 is located in the south central sector of this district.
D	This district lies in the City of Lomita and is overflown by arrivals on Runways 29L and 29R and departures from Runways 11R and 11L. RMS 5 and RMS 6 are located in the western sector of the district.
E	District E includes the Walteria community south of TOA and is enclosed entirely by the traffic pattern south of the airport. RMS 7 is located on the southern boundary of this district. The helicopter training pattern follows Airport Drive on TOA property just north of this residential district.

Table 4-I Los Angeles County Assessor's Tract Locations Selected for TOA Questionnaire Survey

Map Book Number	Approximate Center of Tract
7378	Hawthorne Blvd./Skypark
7529	Anza/236th
7534	Hawthorne/244th
7535	Newton/Coast Hwy
7536	Coast Hwy
7373	Cypress/255th (Crenshaw on west)
7375	Eshelman/254th
7553	Narbonne/259th
7374	Narbonne/242nd
7371	Arlington/236th
7370	Arlington/230th
7379	Crenshaw-Greenwood/230th
7369	Fonthill/229th
7377	Lomita/Telo
7529	West of Airport
7528	West of Airport
7368	West of Airport



prc
R. DIXON SPEAS ASSOCIATES, INC.

TORRANCE MUNICIPAL AIRPORT
AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC) STUDY

COMMUNITY QUESTIONNAIRE DISTRICTS

EXHIBIT 4-9

These districts were defined in accordance with several criteria:

1. Proximity to the nominal flight tracks.
2. History of complaints concerning aircraft noise.
3. Major roadway and/or neighborhood boundaries.

The specific working and format of the questions was developed by the City staff and representatives from CACAN through an extensive review process. The final questionnaire document was approved by the City and mailed out to 750 locations distributed through the five districts previously identified. Preaddressed postpaid envelopes were included in the mailings for returning the questionnaire responses.

Several guidelines for interpreting the responses were developed after reviewing some of the initial questionnaires which were returned. Some questions, e.g., Numbers 6 and 13, were intended to elicit a single response. Many respondents, however, either checked multiple responses or rank ordered the responses to these questions. For those cases where multiple items were checked with no ranking, each of the items was tabulated as a response based on the assumption that the individual considered the items equally important. When a rank order was included, only the first ranked response was tabulated.

One of the questions, Number 8, produced quite erratic responses from those people who returned the questionnaire. Question Number 8 asked the respondent to circle the day of the week then check the time of day when they were most aware of aircraft noise. Some confusion was introduced by the inadvertant omission of "Saturday" in the printed questionnaire form as an available "Day of the Week" response item. It appears from a review of all the responses to this question that the format may have been too complex and/or required an inordinate amount of time to answer. The question was left unanswered on many responses or, in some cases, comments were written in for this item. The question was omitted in the initial tabulation of responses but it may be possible to retrieve at least some cursory information through a more detailed review of this item.

Responses to each of the questions, by geographic district, are shown in Table 4-II. The percentages of the total number of responses allocated to each possible choice in the individual questions are presented in this table.

In the course of interpreting these responses to the questionnaire, some cautions should be kept in mind. The individual geographic districts are relatively small segments of the overall airport environs. It is the case, however, that within each of these districts the aircraft noise exposure conditions vary quite significantly. Some locations may be overflown directly by aircraft from TOA while the noise from these operations may be inaudible at other sites in the same questionnaire district. If the questionnaire mailings had been confined to locations close to the airport and directly under the aircraft flight paths it is likely that the pattern of responses would be different than those received in this case.

A follow-up survey was conducted at the end of the ANCLUC study in an attempt to identify any substantial changes in community attitudes concerning operations at the airport. The same questionnaire used in the original survey was sent to each of the five districts surrounding the airport. Two hundred and seven questionnaires were returned. Approximately equal numbers (35-42) of questionnaires were returned from Districts A, B, C and D with nearly twice as many returned from District E south of the airport. The same procedure used for tabulating responses in the original survey was applied to the follow-up survey. The percentages of respondents for each of the questions and the total number of respondents for each question are shown in parentheses in Table 4-II.

While recognizing that the numbers of respondents in the follow-up survey was generally smaller than the numbers in the original survey, there are some trends that appear to have changed over the course of the project. The question concerning the general effect of the airport on the quality of life shows more polarization, i.e., a slightly higher percentage of expressions of positive effects and a marked increase in strong negative responses for all districts except D (Lomita). Questions 2, 3 and 4 appear to show a general trend toward characterizing the enviornment as always noisy with greater percentages of respondents reporting annoyance resulting from noise. More respondents are reporting aircraft noise as the source of this annoyance, particularly in District E south of the airport. Awareness of the TOA Noise Abatement Program is greater (Question 9) while recommended actions still focus on banning noisy aircraft and establishing more stringent noise limits.

Question 1. The rating of a negative effect from the airport is strongest in the community to the west of the airport (District A) where the highest noise levels are experienced. A total of 73.6 percent of the respondents in District A indicated some degree of negative effect from operations at the airport. A large number (almost 72 percent) of the respondents from District C north of the airport also showed a negative rating for the effect of the airport on their lives.

Question 2. The weekday noise enviornment is characterized

TABLE 4-II

1. In general, what effect, if any, has the Torrance Municipal Airport had on the quality of your life?

District	Percentage of Total Responses				
	A	B	C	D	E
1. Much effect, positive	8.8 (5.7)	8.3 (2.9)	0.0 (8.6)	8.3 (4.8)	9.3 (13.1)
2. Some effect, positive	3.5 (2.9)	0.0 (8.8)	5.1 (5.7)	10.6 (14.3)	11.6 (19.7)
3. No significant effect	14.0 (17.1)	31.9 (50.0)	23.1 (28.6)	30.3 (23.8)	46.5 (18.0)
4. Some effect, negative	42.0 (34.3)	48.6 (23.5)	66.7 (31.4)	35.6 (40.5)	20.9 (26.2)
5. Much effect, negative	31.6 (40.0)	11.1 (14.7)	5.1 (25.7)	15.2 (16.7)	11.6 (23.0)
N	57 (35)	72 (34)	39 (35)	132 (42)	86 (61)

N: Total number of responses to each question

(Numbers shown in parentheses represent results of questionnaire responses from follow-up survey conducted at the end of the study.)

2. During <u>weekdays</u>, I consider my residence to be:

	Percentage of Total Responses				
District	A	B	C	D	E
OUTDOORS					
1. Always very noisy	14.0 (20.0)	17.9 (17.6)	2.7 (17.6)	5.1 (21.4)	11.1 (13.6)
2. Always moderately noisy	31.6 (48.6)	26.9 (26.5)	37.8 (29.4)	25.0 (26.2)	22.2 (28.8)
3. Quiet with occasional loud noise	50.9 (28.6)	50.7 (55.9)	54.5 (58.8)	64.7 (47.6)	55.6 (52.5)
4. Always quiet	3.5 (2.9)	4.5 (0.0)	0.0 (2.9)	5.1 (4.8)	11.1 (5.1)
N	57 (35)	67 (34)	37 (34)	136 (42)	81 (59)
INDOORS					
1. Always very noisy	10.5 (14.3)	8.6 (14.7)	2.5 (6.1)	3.0 (16.7)	6.3 (16.9)
2. Always moderately noisy	12.3 (31.4)	20.0 (26.5)	12.5 (24.2)	13.6 (11.9)	19.0 (22.0)
3. Quiet with occasional loud noise	68.4 (45.7)	61.4 (41.2)	72.5 (54.5)	65.9 (57.1)	43.0 (39.0)
4. Always quiet	8.8 (8.6)	10.0 (17.6)	12.5 (15.2)	17.4 (14.3)	31.6 (22.0)
N	57 (35)	70 (34)	40 (33)	132 (42)	79 (59)

3. During weekends, I consider my residence to be:

District	A	B	C	D	E
	Percentage of Total Responses				
OUTDOORS					
1. Always very noisy	44.3	38.2	8.1	17.5	20.2
	(52.9)	(32.4)	(15.2)	(20.0)	(23.2)
2. Always moderately noisy	18.0	30.9	45.9	24.8	19.0
	(23.5)	(35.3)	(45.5)	(30.0)	(25.0)
3. Quiet with occasional loud noise	34.4	26.5	45.9	51.8	51.2
	(20.6)	(20.6)	(36.4)	(45.0)	(37.5)
4. Always quiet	3.3	4.4	0.0	5.8	9.5
	(2.9)	(11.8)	(3.0)	(5.0)	(14.3)
N	61	68	37	137	84
	(34)	(34)	(33)	(40)	(56)
INDOORS					
1. Always very noisy	20.7	25.7	2.5	11.1	11.1
	(24.2)	(23.5)	(12.9)	(12.5)	(16.1)
2. Always moderately noisy	39.7	24.3	25.0	20.0	17.3
	(33.3)	(29.4)	(29.0)	(25.0)	(19.6)
3. Quiet with occasional loud noise	34.5	41.4	60.0	54.1	49.4
	(39.4)	(32.4)	(51.6)	(45.0)	(50.0)
4. Always quiet	5.2	8.6	12.5	14.8	22.2
	(3.0)	(14.7)	(6.5)	(17.5)	(14.3)
N	58	70	40	135	81
	(33)	(34)	(31)	(40)	(56)

4. How annoyed are you by noise in your area?

	Percentage of Total Responses				
District	A	B	C	D	E
1. Highly annoyed	39.3 (44.1)	23.3 (14.7)	10.5 (15.1)	23.9 (27.5)	21.2 (30.0)
2. Considerably annoyed	21.3 (20.6)	20.5 (17.6)	21.0 (21.2)	15.7 (22.5)	11.8 (15.0)
3. Medium annoyed	19.7 (11.8)	26.0 (26.5)	26.3 (30.3)	14.9 (15.0)	12.9 (10.0)
4. Partially annoyed	9.8 (17.6)	20.5 (29.4)	31.6 (27.3)	23.9 (22.5)	23.5 (25.0)
5. Not annoyed at all	9.8 (5.9)	9.6 (11.8)	10.5 (6.1)	21.6 (12.5)	30.6 (20.0)
N	61 (34)	73 (34)	38 (33)	134 (40)	85 (60)

5. If you are annoyed by noise in your area, what factors related to the noise events you experience are of greatest concern to you?
(Please rank, with 1 being the most annoying, 2 the next most, etc.)

	Percentage of Total Responses				
District	A	B	C	D	E
1. Loudness of the noise	35.8 (46.2)	47.7 (54.3)	21.3 (18.2)	47.6 (54.8)	46.7 (51.8)
2. Number of noisy flights	50.7 (41.0)	36.9 (34.3)	36.2 (39.4)	35.5 (26.2)	28.3 (32.1)
3. Time of day	7.5 (5.1)	13.8 (5.7)	19.1 (12.1)	8.1 (11.9)	3.3 (3.6)
4. Day of week	3.0 (7.7)	0.0 (2.9)	2.1 (21.2)	4.8 (4.8)	1.7 (0.0)
5. Other	3.0 (0.0)	1.5 (2.9)	0.0 (9.1)	4.0 (2.4)	20.0 (12.5)
N	67 (39)	65 (35)	47 (33)	124 (42)	60 (56)

6. The noise which disturbs me the most is from:

	District	A	B	C	D	E
		Percentage of Total Responses				
1.	Automobile/truck/motorcycle	20.6 (12.5)	23.1 (27.6)	50.0 (29.0)	28.7 (30.8)	63.8 (51.9)
2.	Neighborhood activities	1.5 (3.1)	2.6 (0.0)	2.3 (6.5)	5.6 (7.7)	4.3 (1.9)
3.	Aircraft	73.5 (78.1)	67.9 (69.0)	47.7 (58.1)	55.2 (59.0)	26.6 (42.3)
4.	Not disturbed by noise	1.5 (6.2)	6.4 (3.4)	0.0 (6.5)	4.9 (0.0)	2.1 (3.8)
5.	Other	2.9 (0.0)	0.0	0.0 (0.0)	5.6 (2.6)	3.2 (0.0)
	N	68 (32)	78 (29)	44 (31)	143 (39)	94 (52)

7. The aircraft noise causes problems with:

	Percentage of Total Responses				
District	A	B	C	D	E
1. Talking with other people	23.4 (33.3)	18.8 (22.4)	13.8 (17.5)	21.7 (22.5)	15.9 (22.8)
2. Sleeping	14.6 (10.3)	16.9 (10.5)	12.1 (7.5)	14.0 (9.9)	4.4 (5.9)
3. Using the telephone	14.0 (8.0)	11.2 (7.9)	5.2 (2.5)	10.5 (11.3)	8.0 (11.9)
4. Hearing radio/television	18.7 (13.8)	16.9 (21.0)	20.7 (15.0)	16.7 (15.5)	7.1 (10.9)
5. Outdoor relaxation/ recreation	25.7 (32.2)	25.6 (22.4)	34.5 (45.0)	23.3 (32.4)	24.8 (31.7)
6. No problem with aircraft noise	3.5 (2.3)	10.6 (15.8)	13.8 (12.5)	14.0 (8.5)	39.8 (16.8)
N	171 (87)	160 (76)	58 (40)	258 (71)	113 (101)

9. Are you familiar with the Torrance Airport Noise Abatement Center and/or noise reduction problems?

Percentage of Total Responses

	District	A	B	C	D	E
1. Yes		67.2	38.9	37.8	54.0	40.7
		(72.7)	(46.7)	(55.9)	(63.2)	(51.9)
2. No		32.8	61.1	62.2	46.0	59.3
		(27.3)	(53.3)	(44.1)	(36.8)	(48.1)
	N	61	72	37	137	81
		(33)	(30)	(34)	(38)	(52)

10. Do you feel the noise abatement programs have reduced the noise?

		Percentage of Total Responses				
	District	A	B	C	D	E
1.	No reduction	58.3 (44.8)	57.1 (59.1)	40.9 (42.3)	37.8 (38.7)	34.0 (44.2)
2.	Some reduction	35.4 (55.2)	37.3 (36.4)	59.1 (53.8)	53.3 (54.8)	50.0 (41.9)
3.	Great reduction	6.2 (0.0)	9.5 (4.5)	0.0 (3.8)	8.9 (6.5)	16.0 (14.0)
	N	48 (29)	42 (22)	22 (26)	90 (31)	50 (43)

11. Do you think any further changes should be made in the flight operations of the Torrance Airport?

	Percentage of Total Responses				
District	A	B	C	D	E
1. No changes	2.5 (1.1)	5.2 (5.3)	1.9 (5.1)	7.5 (4.2)	21.5 (17.2)
2. Close airport	11.2 (14.1)	5.9 (14.0)	14.8 (10.3)	1.8 (7.0)	5.8 (8.0)
3. Close runway (___S, ___N)	5.6 (2.2)	2.6 (1.8)	0.0 (2.6)	1.4 (5.6)	0.0 (4.6)
4. Allow growth	3.1 (1.1)	2.6 (5.3)	1.9 (0.0)	3.9 (2.8)	8.3 (4.6)
5. Ban noisy aircraft	21.7 (32.6)	24.8 (31.6)	35.2 (41.0)	32.5 (38.0)	27.3 (35.6)
6. Further limit hours of operation	9.3 (13.0)	10.4 (10.5)	7.4 (10.3)	5.4 (8.5)	4.1 (6.9)
7. No training	11.2 (6.5)	11.1 (7.0)	7.4 (5.1)	7.9 (11.3)	5.0 (3.4)
8. Ban flight schools	11.8 (5.4)	10.5 (3.5)	5.6 (5.1)	12.5 (11.3)	5.8 (3.4)
9. Set tougher noise limits	18.6 (21.7)	24.2 (21.0)	16.7 (17.9)	21.4 (11.3)	17.4 (16.1)
10. Other	5.0 (2.2)	2.6 (0.0)	9.3 (2.6)	5.7 (0.0)	5.0 (0.0)
N	161 (92)	153 (57)	54 (39)	280 (71)	121 (87)

12. Do you feel that flight operations from the Torrance Airport represents a safety hazard to you, your family or property?

	Percentage of Total Responses				
District	A	B	C	D	E
1. Yes	67.8 (69.7)	55.5 (41.9)	48.6 (43.3)	62.1 (66.7)	37.5 (49.1)
2. No	32.2 (30.3)	44.4 (58.1)	51.4 (56.7)	37.9 (33.3)	62.5 (50.9)
N	59 (33)	63 (31)	35 (30)	132 (36)	80 (53)

13. What do you feel is the most important local problem faced by your community today?

	Percentage of Total Responses				
Districts	A	B	C	D	E
1. Aircraft noise	46.2 (52.8)	30.0 (29.7)	27.4 (27.3)	30.6 (20.4)	12.7 (21.5)
2. Traffic noise	6.6 (5.7)	15.0 (13.5)	22.6 (25.0)	11.2 (14.3)	20.6 (13.9)
3. Air pollution	12.1 (11.3)	11.2 (13.5)	12.9 (9.1)	15.3 (12.2)	25.4 (17.7)
4. Aircraft safety	19.8 (22.6)	11.2 (8.1)	14.5 (9.1)	21.9 (26.5)	8.7 (12.7)
5. Motor vehicle safety	9.9 (7.5)	17.5 (10.8)	17.7 (18.2)	11.2 (10.2)	19.8 (17.7)
6. Other	5.5 (0.0)	15.0 (24.3)	4.8 (11.4)	9.7 (16.3)	12.7 (16.5)
N	91 (53)	80 (37)	62 (44)	196 (49)	126 (79)

Question 3. On weekends, the rating of the noise environment at the residences shifts toward the always noisy categories. This is consistent with the increase in hours spent at the residence, hours spent outdoors and possibly increased flight operations at the airport.

Question 4. The highest ratings of annoyance from noise are received from Districts A and B under the departure flight paths and District D under the landing approach path.

Question 5. The number of noisy flights category showed a slightly higher rating in Districts A and C while the other three Districts (B, D and E) rated the loudness of the noise events to be of greatest concern.

Question 6. Aircraft are indicated to be the most disturbing noise source in District A, B, and D where the lowest altitude over-flights are experienced.

Question 7. The problems resulting from aircraft noise identified most frequently are outdoor relaxation/recreation and talking with other people, respectively.

Question 9. Awareness of the Torrance Airport Noise Abatement Program appears to be concentrated in Districts A and D where the most severe problems have been encountered.

Question 10. There appears to be a perception of more success in reducing aircraft noise in District D under the landing approach paths than in Districts A and B under the departure paths.

Question 11. Of the ten choices in this question, the two selected most often were ban noisy aircraft and set tougher noise limits. Since these two choices reflect essentially the same sentiment, i.e., reducing the level of noise from individual overflights, there appears to be a willingness to accomodate the operations if the single event levels could be reduced.

Question 12. As might be expected, the perception of aircraft as a safety hazard is most prevalent in Districts A and D where the lowest altitude overflights occur.

Question 13. Aircraft noise and aircraft safety are rated as the predominant local problem in Districts A and D. Aircraft noise is also the highest rated item in District C.

5.0 AIRCRAFT NOISE AND LAND USE IN TOA ENVIRONS

Bldg. & Safety Dept.
City of Torrance
3031 Torrance Blvd.
Torrance, Calif. 90503

5.0 AIRCRAFT NOISE AND LAND USE IN TOA ENVIRONS

The principal objective of these ANCLUC projects at U.S. airports is to arrive at a stable compatible land use condition in the airport environs. In Torrance, as in many communities operating municipal airports, the increase in residential development around the airport over the years paralleled an increase in the number of daily flight operations. While the airport facilities existed long before the extensive residential encroachment, there was no widespread early recognition of the potential for the current high volume of operations or the resultant impact of aircraft noise in the community. There is a tendency at Torrance, as in other major airport communities, for proponents of the opposing interests, i.e., airport expansion and residential development, to suggest a higher priority for their respective points of view. Each side of the argument is correct on certain points, so that any semblance of a compatible land use condition will involve compromises on some important issues.

5.1 Incompatible Land Use

The first question to be addressed is that of identifying those land uses around TOA which meet generally accepted criteria for incompatible land uses. On the surface, this seems to be a simple and straightforward judgement. Most people in the community believe they can easily determine whether any given parcel of land is subject to an inordinate amount of aircraft noise. Those in municipal government who must make these decisions on a daily basis soon recognize that there is a great divergence of opinion in this matter. To begin with, individuals' responses to intrusive events such as noise or the presence of low-flying aircraft are distributed in the same way as many other human characteristics. There is some median level of aircraft noise above which half the population judges it to be more and more objectionable but, conversely, the other half judges it to be of increasingly less consequence. The important implication here relates to the residential housing market. Whenever any arbitrary criterion level for aircraft noise is specified with respect to land use constraints it does not delineate the absolute acceptability or non-acceptability of residential land use in the designated aircraft noise environment. Rather, it implies that there is some portion of the general population constituting a market for the land use in question. This means that a particular parcel in the TOA airport environs need not be either accepted or rejected as potential residential property. Instead, the necessary information concerning housing demand, construction requirements, etc., should be addressed to determine whether the restricted market is sufficient to ensure occupancy of the units.

This process of determining the acceptability of various land uses in the airport environs is more difficult at Torrance than at those locations where state or federal regulations containing CNEL limits on different land use categories are in effect. The aircraft CNEL values are relatively low (less than 60 CNEL) for all residential property in Torrance and Lomita so that only small segments of these communities would appear to be candidates for development restrictions. The first step in the evaluation of land use compatibility around TOA is an inventory of different land uses contained within the geographic boundaries of the CNEL contours computed for airport operations. A summary of the land use inventory for both Torrance and Lomita is shown in Tables 5-I and 5-II. A total of 1801 single family and 656 multi-family residential units are in the 55-60 CNEL area. In this range, aircraft noise becomes the principal contributor to the CNEL environment and the compatibility of land uses with airport operations becomes an issue.

The prevailing criteria in the state for residential land use exposed to aircraft noise are related to the CNEL procedures adopted by the California legislature in 1970. This evaluation method is potentially applicable to all certificated airports in the State but it addressed principally jet air carrier airports in arriving at a proposed method for predicting land use compatibility around the airports. The ANCLUC project at TOA is the first opportunity to evaluate the applicability of the land use guidelines at a general aviation airport with a permanent noise monitoring system.

The criteria included in the State Airport Noise Regulations may be supplemented with guidelines for airport related land use developed by the Federal Aviation Administration. One of the key elements of the ANCLUC study for Torrance Municipal Airport is the definition of land use objectives for the surrounding community. These objectives should identify goals for development in noise sensitive areas as well as goals for remedial actions to reduce noise impacts on existing land use.

5.2 Generalized Land Use Guidelines

Land use guidelines for application in the vicinity of airports

TABLE 5-I LAND USE SUMMARY FOR TORRANCE AIRPORT ENVIRONS: CITY OF TORRANCE

Land Use Description	FAA Land Use Category	CNEL 55-60	CNEL 60-65
Single-Family Dwelling Units	1	1182	
Multi-Family Dwelling Units	2	526	
Vacant R-1 Parcels	1	13	
Vacant R-3 Parcels	2	0	
Retirement Homes	4	1	
Church	6	1	
Elementary Schools	6	2	
Adult Education Center	6	1	
General Hospital	7	1	
Psychiatric Hospital	7	1	
Hemodialysis Center	7	1	
Office Buildings	8,9	17	3
Vacant Commercial	8,9,10,11	5	
Commercial Retail 1/	10	24	2
Restaurant/Bars	11	8	5
Manufacturers	14	11	23
Vacant Mfg.	14	4	
Construction/Repair Service	16	5	1
Athletic Clubs	19	2	
Parks	20	2	
Golf Course	22	1	
Electric Utility Substation	23	1	
Flood Control Sump	23	1	

1/ Includes 3 small Shopping Centers

TABLE 5-II LAND USE SUMMARY FOR TORRANCE AIRPORT ENVIRONS: CITY OF LOMITA

	FAA Land Use Category	CNEL 55-60
Single Family Dwellings	1	619
Multiple Family Units	2	130
Vacant R-1	1	1
Vacant R-3 and A-1	2	3
Motels	5	2
Churches	6	4
Pre-School/Day Care Centers	6	2
Office Buildings	8	10
Commerical Retail[1/]	8,9	29
Vacant Commercial	8,9	4
Restaurants/Bars	11	3
Construction/Repair Services	16	6
Utilities	23	1

1/ Contains two Shopping Centers

have been published by the Federal Aviation Administration. These criteria are explicitly identified as guidelines only, requiring additional consideration within the planning study process. Other sets of guidelines associating land uses with cumulative noise levels have been prepared by other public agencies, both in the United States and abroad.

The guidelines found in the different public agencies' recommendations have several themes in common:

- Most noise sensitive uses (such as schools, churches, and hospitals) are recommended for location in zones of lower cumulative noise exposure levels.
- Most commercial office and industrial uses are recommended for location in zones of higher noise exposure levels.
- Land uses with extremely low levels of human occupancy per acre (agriculture, forestry, mining, water bodies, undeveloped land) are recommended for location, regardless of the noise exposure level; these uses are considered to be largely insensitive to aircraft noise exposure.
- The noise exposure calculation procedure to be utilized is a cumulative noise exposure evaluation, which averages noise levels during a typical 24 hour period, and generally includes a penalty for nighttime operations. This takes the form of the Community Noise Equivalent Level (CNEL) in California. The CNEL procedure has both evening and night hour penalties.
- The guidelines are intended to be tailored to circumstances specific to the individual community under study.
- Noise insulation in structures is usually identified as a partially effective means of reducing noise impact; provision of noise insulation may render a land use acceptable for a higher level of noise exposure than otherwise would have been the case.

5.3 Federal Aviation Administration Land Use Guidelines Within Noise Zones

The Federal Aviation Administration has recently published a set of land use guidelines for noise exposure zones.[1/] These guidelines appear in Exhibit 5-I. It should be noted that in many instances more than one noise zone is identified as the highest for which the particular land use is recommended. Such instances reflect the different characteristics of specific land uses found within the overall category. The appropriate noise zone would have to be determined on a case-by-case basis.

These guidelines suggest the highest noise zone in which each identified land use is suggested for location. Noise zones are broken down into 10 dB groupings: LDN 0-55 (Zone A); LDN 55-65 (Zone B); LDN 65-75 (Zone C) and LDN 75 and higher (Zone D). The day nightAverage Sound Level (LDN) metric is assumed to be directly equated to the CNEL metric used in California. Any difference would be less than one LDN/CNEL unit.

The FAA guidelines indicate that the soundproofing of structures may allow some land uses to be located in higher noise zones than would otherwise be acceptable.

The FAA guidelines emphasize that the guidelines represent "suggested" relationships of aircraft noise to categories of land use....<u>the term "suggested" is important since it is intended that these relationships be used only as starting points</u>. Specific relationships should be established for each study via citizen involvement and the consideration of community goals.[2/] The

---

1/ Advisory Circular (150/5050-6, Airport-Land Use Compatibility Planning, December 30, 1977).

2/ Advisory Circular (150/5050-6, Airport-Lande Use Compatibility Planning, December 30, 1977), Page 11 (italics shown as found in the original source).

EXHIBIT 5-I. FAA LAND USE RECOMMENDATIONS FOR AIRPORT NOISE ZONES

LAND USE GUIDANCE CHART I: AIRPORT NOISE INTERPOLATION

LAND USE GUIDANCE ZONES (LUG)	NOISE EXPOSURE CLASS	INPUTS: AIRCRAFT NOISE ESTIMATING METHODOLOGIES				HUD NOISE ASSESSMENT GUIDELINES	SUGGESTED NOISE CONTROLS
		L dn DAY-NIGHT AVG. SOUND LEVEL	NEF NOISE EXPOSURE FORECAST	CNR COMPOSITE NOISE RATING	CNEL COMMUNITY NOISE EQUIVALENT LEVEL		
A	MINIMAL EXPOSURE	0 TO 55	0 TO 20	0 TO 90	0 TO 55	"CLEARLY ACCEPTABLE"	NORMALLY REQUIRES NO SPECIAL CONSIDERATIONS
B	MODERATE EXPOSURE	55 TO 65	20 TO 30	90 TO 100	55 TO 65	"NORMALLY ACCEPTABLE"	LAND USE CONTROLS SHOULD BE CONSIDERED
C	SIGNIFICANT EXPOSURE	65 TO 75	30 TO 40	100 TO 115	65 TO 75	"NORMALLY UNACCEPTABLE"	NOISE EASEMENTS, LAND USE, AND OTHER COMPATIBILITY CONTROLS RECOMMENDED
D	SEVERE EXPOSURE	75 & HIGHER	40 & HIGHER	115 & HIGHER	75 & HIGHER	"CLEARLY UNACCEPTABLE"	CONTAINMENT WITHIN AIRPORT BOUNDARY OR USE OF POSITIVE COMPATIBILITY CONTROLS RECOMMENDED

Source: FAA Advisory Circular 150/5050-6.

NOTES FOR LAND USE GUIDANCE CHART I

LUG - Land Use Guidance Zone (see paragraph 21).
LUG Zones are inputs to the compatibility planning process and are not intended for use in making direct comparisons of the various noise estimating methodologies.

L_{dn} - Day-Night Average Sound Level (see Appendix 2, paragraph 4).

NEF - Noise Exposure Forecast (see Appendix 2, paragraph 5.)

CNEL - Community Noise Equivalent Level (see Appendix 2, paragraph 6).

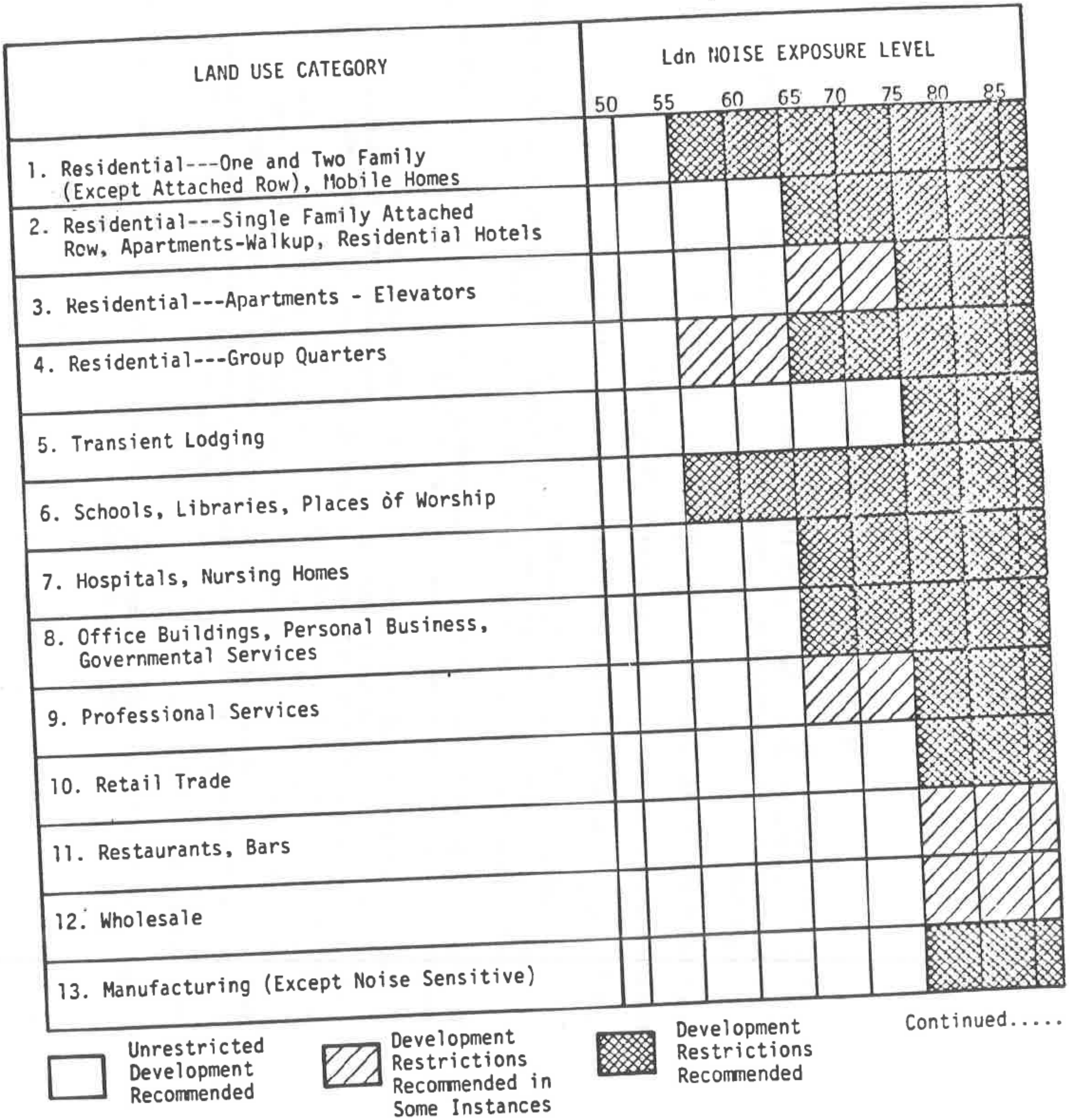
CNR - Composite Noise Rating (see Appendix 2, paragraph 9).
Note: Caution is suggested in applying CNR methodology to general aviation airports since in such use it tends to exaggerate indications of noise impacts.

The DOT/FAA Integrated Noise Model (INM) will produce contours for Ldn, NEF, and CNEL, as well as additional measures (see Appendix 2, paragraph 3).

HUD Noise Assessment Guidelines - Acceptability guidelines for site exposure to aircraft noise. The Department of Housing and Urban Development (HUD) promulgated a policy (Circular 1390.2, July 1971) and published Noise Assessment Guidelines (TE/NA-171, August 1971) for establishing noise levels and acceptability guidelines for site exposure to noise to be used for screening mortgaging guarantees and other HUD assistance. These acceptability categories are interpolated from Table I of TE/NA-171 and are shown for illustrative purposes to assist planners in relating HUD screening guidelines to the compatibility planning process. Although the guidelines control HUD assistance, they do not necessarily inhibit the actions of other financial institutions.

Suggested Noise Controls - These suggestions are generalized; see Chapter 3 for developing specific controls.

EXHIBIT 5-I (Continued)



Continued.....

EXHIBIT 5-I (Continued)

LAND USE CATEGORY	Ldn NOISE EXPOSURE LEVEL <50	50–55	55–60	60–65	65–70	70–75	75–80	80–85	>85
14. Manufacturing---Noise Sensitive					XXX	XXX	XXX	XXX	XXX
15. Communications			///	///	///	///	///	///	///
16. Construction, Repair Services and Amusements							XXX	XXX	XXX
17. Cemeteries					XXX	XXX	XXX	XXX	XXX
18. Auditorium, Concert Halls, Music Shells			XXX	XXX	XXX	XXX	XXX	XXX	XXX
19. Sports Arenas, Spectator Sports			XXX	XXX	XXX	XXX	XXX	XXX	XXX
20. Playgrounds, Neighborhood Parks			///	///	///	///	XXX	XXX	XXX
21. Extensive Natural Recreational Areas			///	///	///	///	///	XXX	XXX
22. Golf Courses, Riding Stables, Water Recreation					///	///	XXX	XXX	XXX
23. Utilities									
24. Agriculture (Except Livestock), Mining, Fishing and Forestry									
25. Livestock Farming, Animal Breeding							XXX	XXX	XXX
26. Transportation, Right of Way									

(blank) Unrestricted Development Recommended

/// Development Restrictions Recommended in Some Instances

XXX Development Restrictions Recommended

FAA states that the land use objectives for a community may be more or less stringent than the suggested guidelines.

5.4 Land Use Conflicts in the TOA Environs

In applying the FAA land use guidelines at TOA, it is apparent that some restrictions on development would be appropriate for the CNEL 55-60 area enclosed by these respective contour boundaries. In particular, the area in Torrance west of the airport and a section of Lomita to the east are candidates for special land use considerations as defined by the CNEL 55-60 range. The history of noise complaint information from the TOA noise abatement office is consistent with this determination. These residential areas in Torrance and Lomità are shown in Exhibit 5-2.

There are, however, two areas in Torrance as well as locations in Lomita and Harbor Hills where community complaints about aircraft noise are not consistent with the ANCLUC CNEL criteria. One of the locations in Torrance is the area between Crenshaw and Maple, north of the airport, where there is a convergence of flight tracks for aircraft arriving from and departing to the north as well as for aircraft in the local training pattern. The other area is in Walteria, south of Pacific Coast Highway and adjacent to the local helicopter pattern south of the airport. The CNEL values in each of these areas is less than 55. No restrictions on residential land use for exposures less than CNEL 55 are shown in the ANCLUC land use guidelines. There is the recognition in the FAA planning process that the guidelines may require adjustment to accomodate local conditions.

The CNEL computation is, of course, based on the same concept for general aviation propeller aircraft as for air carrier jets where most of the supporting data for the procedure were derived. The apparent low correlation between complaints in these areas and the

EXHIBIT 5-2

TORRANCE MUNICIPAL AIRPORT ANCLUC STUDY

CNEL NOISE IMPACT AREAS

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

prc SPEAS ASSOCIATES

CNEL criteria may suggest that the components of the total noise energy may not have equivalent effects on the community for these dissimilar aircraft classes. Jet aircraft produce relatively higher noise levels with fewer occurrences than is the case with smaller propellar aircraft. Thus, the smaller aircraft may be responsible for many more repetitions of the noise event without sufficient noise energy per event to reach the CNEL 55 criterion level. This increased rate of repetition, either overall or per small unit of time, may be responsible for a disproportionate level of annoyance in the community, such that it is not predicted through the CNEL land use guidelines. The extent to which considerations such as safety related to numerous overflights outweighs the effects of the noise is an open question at this time. The community survey showed that 15 to 20 percent of the respondents expressed concerns over aircraft safety in these areas under the most heavily used flight paths. Complaints about aircraft noise were expressed about twice as frequently in the survey. It is apparent, then, that supplemental criteria based on local conditions should be used to augment the ANCLUC Land Use Guidelines (LUG's).

The only previous effort towards recognizing an area of influence for the airport has been the definition of a boundary within which aviation easements were required for changes in land use. This boundary was intended to correspond approximately to the FAR Part 77 height obstruction map. This easement included a reference to creating noise as well as the right to overfly the properties. Although the use of such avigation noise easements is commonplace for airport communities, their validity for restricting flight operations has not been tested extensively in the courts. This area proposed for avigation noise easements is shown in Exhibit 5-3.

Based on the combined criteria from the FAA ANCLUC guidelines and the complaint data relating to frequent overflights in Torrance,

EXHIBIT 5-3

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

AVIGATION NOISE EASEMENT AREA

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

prc SPEAS ASSOCIATES

Lomita and Redondo Beach, two levels of action are recommended for a land use control program in the TOA environs.

- Creation of an Airport Planning District
- Designation of Property Subject to Mandatory Noise Control Procedures.

5.5 Torrance Airport Planning District

Using the flight track corridors as the primary guideline, boundaries for a proposed Airport Planning District (APD) have been defined. The boundaries generally follow existing street patterns. This APD is shown in Exhibit 5-4. The airport related restrictions on land use within the APD may be accomplished through a policy of disclosure together with an official review process for any proposed changes in land use.

Disclosure - This concept is basically a public information program designed to create an awareness in the community of the nature of the activity at the airport and the resulting effects on the residents. Several avenues for this disclosure process have been implemented at other airports and have proved helpful in lessening the conflicts between the community and airport operations.

- Attachment of a Notice of Disclosure to Property Deeds. All parcels withing the APD would have a notification of the proximity to airport operations with a brief explanation of the implications relative to land use in the area.
- Agreement for Disclosure from Local Realtors. Working through the local real estate board, it is possible to convey the information concerning airport noise and overflights to prospective home buyers.
- Roadsigns Delineating the APD. Installation of roadside signs identifying the area as an APD could carry a statement indicating the APD is subject to overflights and noise from operations at TOA.
- Publication of APD Boundaries in Local Newspapers and Maps.

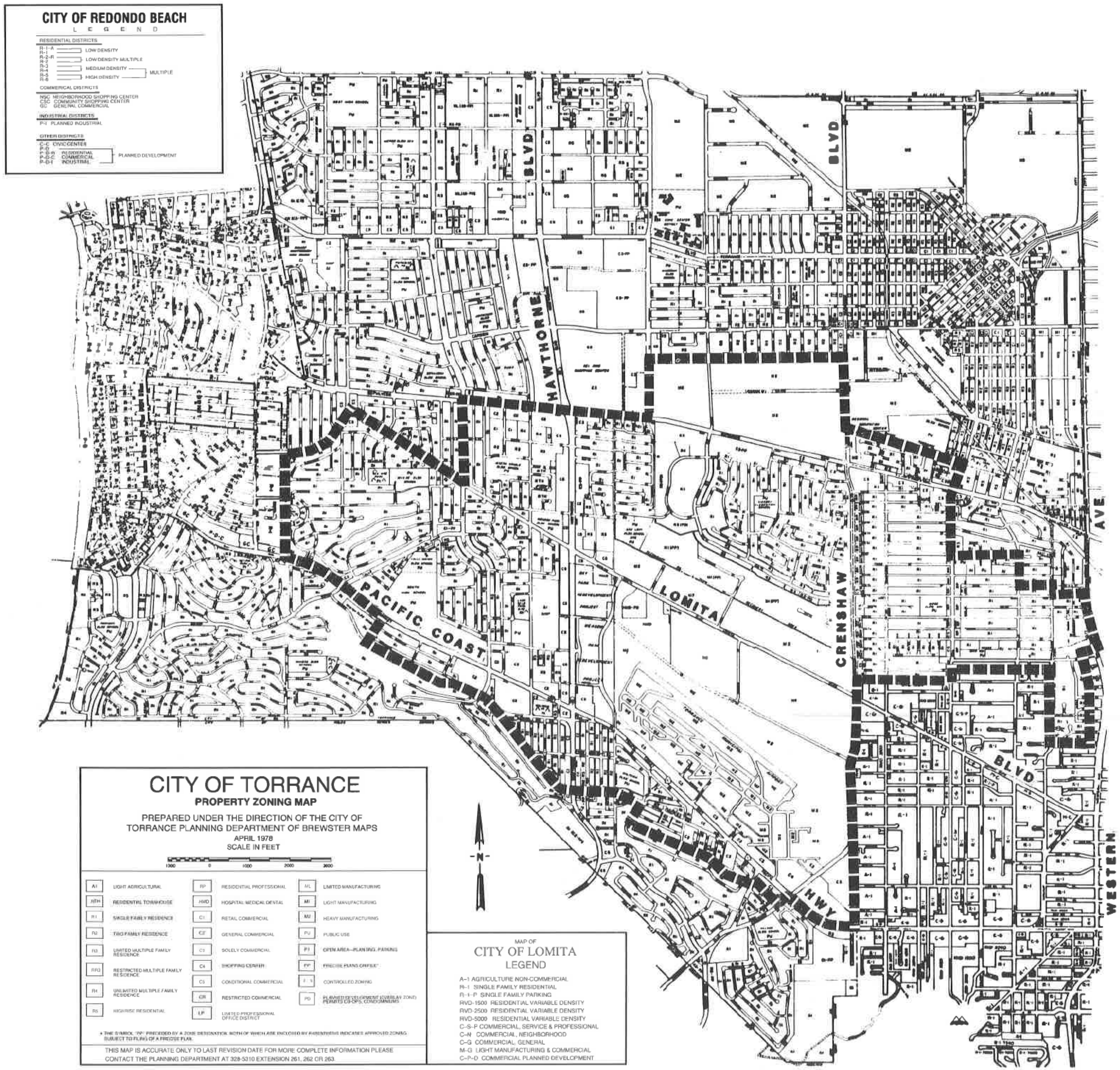


EXHIBIT 5-4

TORRANCE MUNICIPAL AIRPORT ANCLUC STUDY

PROPOSED AIRPORT PLANNING DISTRICT

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC)

prc SPEAS ASSOCIATES

Official Review Process - The objective is to have each request for a change in land use in the APD be subject to a review by City Staff personnel who are knowledgeable concerning the effects of aircraft noise and overflights on various land uses. Because of the relatively large area involved, this should not be implemented in such a way as to cause an extensive review and possible environmental report for individual parcels. Instead, the applications would be checked against the APD overlay and, if located in the designated area, forwarded to the appropriate reviewer, e.g., the Environmental Quality Department. The applicant would then receive the appropriate notice of disclosure together with recommendations for necessary building noise control procedures. The staff reviewer would make recommendations appropriate for the exact location of the subject parcel within the overall APD.

The cities of Lomita and Redondo Beach might consider a similar APD along the flight corridors passing through each community. A review of building permit applications would allow the staff reviewer in each city to alert the residents to potential problems and recommend appropriate noise control measures.

5.6 Mandatory Noise Control Procedures

The neighborhood in Torrance west of the airport lying underneath the departure paths from Runways 29L/R and the section of Lomita under the approach paths to Runway 29L/R are exposed to the highest aircraft noise levels and the most frequent low altitude overflights of any area in the airport environs. Maximum single event noise levels in this area may reach the 82 dBA limit set by City Ordinance. This will require an outdoor-to-indoor noise reduction (NR) of 25 dBA to maintain normal speech communications across a distance of 8-10 feet. This amount of noise reduction may be achieved only by introducing building noise control procedures as shown in Section 6 and Appendix C from this report. The boundaries of this area recommended for mandatory noise control treatment are shown in Exhibit 5-5. This area is designated as the maximum impact area with requirements for mandatory acoustical insulation as a condition of building permits. New residential land use should consider multi-family units with appropriate

EXHIBIT 5-5

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

MANDATORY STRUCTURAL NOISE CONTROL AREA

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC)

prc SPEAS ASSOCIATES

noise control components in the structure to be more appropriate than single family development which tends to emphasize outdoor activities to a greater extent.

In Torrance, this requirement for mandatory structural noise control affects residential and commercial property west of the airport as shown in Exhibit 5-5. The commercial parcels along Pacific Coast Highway south of the airport are not included because of less rigorous requirements for noise control and the shielding effect from airport structures adjacent to the runways. The area in Lomita immediately east of Crenshaw Boulevard and located under the flight paths should be investigated as a candidate for creation of a mandatory noise control area.

Applications for land use changes within this mandatory noise control area would require specifications for noise control procedures prepared by a qualified acoustical engineer.

6.0 NOISE CONTROL IN THE AIRPORT PLANNING DISTRICT

6.0 NOISE CONTROL IN THE AIRPORT PLANNING DISTRICT

Requirements for structural noise control within the APD will cover a wide range depending on the proximity to the aircraft flight paths. Based on the existing single event noise limit, it is determined that noise insulation procedures specified for the mandatory Noise Control area within the APD should be designed to achieve a 25 dBA outdoor to indoor noise reduction. Specific noise control techniques sufficient to ensure this level of noise reduction were developed in an extensive residential soundproofing program carried out by the Los Angeles Department of Airports in 1970. This project included modifications of existing structures located near Los Angeles International Airport. The prodecures described in this section are based on requirements for a minimum of 25 dBA of noise reduction.

The basic principles of structural noise control are presented in Appendix C.

6.1 Noise Insulation Procedures

<u>Windows</u>

Most local building codes require that every habitable room in a house must have a certain area of openable windows, this area usually being proportional to the floor area of the particular room. This requirement is stipulated so as to provide adequate ventilation to the room as well as providing a possible exit in times of emergency. Its effect on the soundproofing of a house lies in its prohibition against permanently sealing all windows even though an adequate air supply system may be installed. Consequently, in this section, it is assumed that the windows described, or at least a part of them, are openable unless otherwise specified.

Wood double hung windows require a form of operable seal at the periphery of the movable section(s). This can be provided by including a strip of foam tape in wood or metal channels. The top panel should be firmly fixed in place and sealed with a silicone rubber sealant.

Aluminum slider windows require an operable edge seal for the movable section(s) similar to that described under Item 1. The adjacent panel should be sealed in place with a silicone rubber sealant.

Casement windows require an operable seal. It is not advisable to attach foam tape in such a way that it is compressed upon closure of the window because of the difficulty in effecting the closure. A more practical method is where the foam tape is placed so as to form a small lined duct.

Jalousie windows should never be used in any stage of modification and, if encountered in the house to be modified, should be replaced by any one of the recommended openable or fixed types.

Fixed glass windows, such as "picture" windows, are good noise-barrier windows since they have no air gaps at their edges, but care should be taken during installation. The best installation is one where the window is firmly fixed in its frame with a resilient mounting material, such as silicone rubber or vinyl glazing beads, at all four edges. There should be no "rattling" whatsoever if the work has been done properly.

In some cases, it may be possible to seal an existing openable window completely if allowed by the building code. Such windows should be firmly fixed and sealed at the edges with a silicone rubber sealant.

Doors

Hinged doors should be of a solid lumber construction, or solid core, and incorporate the following edge seals:

a. Drop seals which are automatically actuated to seal the gap at the bottom of the door as it closes. The seal lifts up when the door is opened.

b. Edge seals at the top and sides of the door, which may be either metal strip weatherstripping, or consist of a continuous vinyl bulb inserted in an aluminum strip screwed to the frame. To avoid installation difficulties, the latter is preferred.

General Notes:

(1) Three hinges must be used to support the door, and the lock hardware should be of good quality since it will be subjected to unusual stress when holding continuous pressure against the stops.

(2) The threshold should be smooth hardwood and must be flat so that the drop seal on the door bottom can easily come in continuous, even contact. The reason for the smooth wood threshold is that during the last half or quarter inch of door swing, the drop seal is sliding horizontally on the threshold so that any grooves or bumps would cause the door to drag.

(3) Since these doors are heavy, the door frame construction must be substantial, although normal high quality residential construction is usually sufficient. Since the jamb on the hinged side carries the weight of the door, it must be firmly attached to the wall framing.

(4) All seals on doors must be very carefully adjusted so that firm contact with the door is obtained at all points. A simple method of checking is to close the door and view the seals from the interior of the building; there should be no light visible.

(5) Combination doors must be replaced with solid-core types.

(6) Doors on the side of the building shielded from the aircraft require no treatment.

Sliding glass doors should incorporate acoustic seals at the three sides that come into contact with the main frame, together with the addition of absorption at the center joint.

(A) Ceilings

No modifications are necessary to any type of ceiling.

(B) Floors

No modifications are required for any type of floor system provided that it is of sound construction.

(C) Walls

No modifications are required to any type of wall provided that it is of sound construction.

(D) Ventilation

In order to obtain the maximum benefit from the soundproofing methods described, it is necessary to effect temporary closure of all windows. Thus, some form of mechanical ventilation is required to make the interior of the house habitable in the summer months.

The types of air-handling systems that can be utilized are as follows:

- Forced air heating
- Forced air ventilation
- Forced air heating and ventilation
- Air conditioning

Any of these systems can in addition incorporate a combination of fresh and recirculated air using single or dual speed motors. Experience has shown that an adequate system is one incorporating forced air ventilation utilizing a two speed motor with a pro-vision for adjusting the combination of fresh and recirculated air. In areas having a high summer temperature and humidity, however, and air conditioning system will be necessary.

General Notes:

(1) The fan for the ventilation system should not be placed in the room space directly above a living room or bedroom. It is recommended that it should be placed above a hallway or bathroom. In addition, it should be either suspended from the roof or placed in high quality resilient mounts as an aid to preventing vibration being transferred to the ceiling and walls below.

(2) Air ducts, connectors, and elbows should contain an interior lining of at least 1/2 inch of fiberglass to provide absorption. The length of such a lined duct from the fan to the grille should not be less than 5 feet.

(3) For the ventilation cycle, a blower must be chosen that will change the air in each room at least eight times per hour.

(4) Only those manufacturers that supply sound power ratings for their products should be considered. The sound power produced by a blower depends, of course, on the amount of air it delivers. An example of an acceptable blower delivering 1400 cfm at a 0.5 inch static pressure in terms of sound power rating is:

Frequency (Hz)	125	250	500	1000	2000	4000	8000
Sound Power (dB)	71	64	63	62	60	56	52

where the sound power levels are expressed in dB referred to 10^{-12} watts, in the octave bands centered on the given frequencies.

(5) Ceiling mounted air supply grilles are the most efficient, and to provide an adequate air circulation, a complementary air exhaust/return grille should be provided in each room. It is recommended that the vanes in the grilles be non-adjustable.

(6) In some cases, an exhaust vent will penetrate a side wall or roof where it is not practical to incorporate a lined

sheet metal duct of sufficient length to provide the necessary attenuation. In this event, a plywood baffle box must be installed over the exterior end of the exhaust vent and lined with 1/2 inch rigid fiberglass absorbent.

(7) Care should be taken to ensure that air is distributed evenly to all areas of the house.

Fireplace chimneys are a direct path for noise entry into a house. They can be treated by installing a steel damper, but it is sometimes difficult to ensure a tight fit between the damper and the frame. If the damper does not provide sufficient sound attenuation, an additional modification may be made. A one foot section of lined duct can be added to the chimney top. A simple method of determining whether this step is necessary or not is to listen at the hearth for any significant sound coming down the chimney during an aircraft flyby, with the damper closed.

Patio Walls

Exterior patios that are situated between two closely spaced houses, or between a house and a high wall may have high sound levels on account of multiple reflections occurring at the wall surfaces.

Some decrease in the levels can be obtained by placing absorption on the wall surfaces. The absorbent must be porous and be of a waterproof material that requires little maintenance. A suitable material is one consisting of chemically treated, mineralized wood fibers bonded together with cement and manufactured in panels 1 or 2 inches thick.

7.0 ALTERNATIVE OPERATIONS AT TORRANCE MUNICIPAL AIRPORT

7.0 ALTERNATIVE OPERATIONS AT TORRANCE MUNICIPAL AIRPORT

7.1 Business Jet Operations at Torrance Municipal Airport

Business jet activity at TOA is extremely infrequent at present. A current City Council resolution discourages the operation of jet aircraft at the airport by prohibiting jet fuel sales at TOA, thereby reducing the numbers of operations by this class of aircraft. There are occasional business jet aircraft operations at the airport with the current frequency estimated at a level of one flight per day.

One of the alternative planning considerations of TOA concerns the potential noise impact resulting from any significant level of increase in business jet operations in the future. This evaluation was not undertaken to encourage the operation of jet aircraft at Torrance. It is, instead, a logical planning tool which will allow the City to evaluate this particular contingency if there is a compelling reason to change the existing policy concerning business jet aircraft.

In setting up an evaluation of business jet aircraft noise at TOA, it is important to recognize the wide variation in noise levels generated by different aircraft types. This difference ranges from the relatively quiet Cessna Citation to aircraft such as the relatively noisy Grumman Gulfstream II. Thus, these two business jet aircraft types were selected for the evaluation in order to show the extremes in the impact on CNEL noise exposures at TOA.

Each of these two jet aircraft types were added to the July 1979 - June 1980 operations data base for TOA. Three levels of activity, 5, 15 and 30 flights per day, were included in the analysis. Each flight included both a takeoff and a landing so that the addition to total daily operations was 10, 30 and 60 respectively. A straight in landing approach track and straight out departure track were assumed for all jet operations. The CNEL contours with business jet aircraft included in the data base, as described above, are shown in Exhibits 7-1 through 7-6. The contribution of the cessna citation operations to the aircraft noise exposure is based on typical operating data for this aircraft under realistic gross weight and weather conditions. The occasional Citation measured by the monitors at TOA were probably at lower gross weights and may well be flown with the noise monitor system in mind. This has resulted in some unusually low noise levels recorded for the Citation at TOA. While it is a relatively quiet aircraft, particularly for the business jet category, it is not quieter than most small propeller type aircraft at the same distances. The increase in the CNEL contour boundaries produced by adding the Citation to the operations data base are based on this assumption of typical operating conditions for the Citation.

The increase in noise exposure areas is shown in Table 7-I for CNEL values of 55, 60 and 65. The baseline CNEL 65 contour for 1979-1980 non-jet operations at Torrance Municipal Airport lies entirely within the airport boundaries. The CNEL 65 is extended into residential properties by the GII class jet for 15 and 30 flights per day. The Citation class jet produces a much smaller noise impact with the CNEL 65 extended 78 feet beyond the baseline condition by 5 flights (10 operations) per day. Fifteen flights (30 operations) of the Citation extends the baseline CNEL by 351 feet. Thirty flights per day (60 operations) by the Citation extends the CNEL 65 out 1289 feet beyond the baseline with the entire boundary remaining on airport property.

It is reasonable to assume there would be more negative reaction in the community to the Gulfstream II operations than would be produced by the Citation flights. This is, of course, analogous to the

Table 7-I CNELA AREA (IN ACRES) RESULTING FROM INTRODUCTION OF BUSINESS JET AIRCRAFT OPERATIONS AT TORRANCE MUNICIPAL AIRPORT. DATA ARE SHOWN FOR TWO AIRCRAFT CLASSES AND THREE LEVELS OF OPERATION.

		CESSNA CITATION			GRUMMAN GII		
CNELA	NO JET BASELINE	5/DAY	15/DAY	30/DAY	5/DAY	15/DAY	30/DAY
65	32	77	90	109	141	256 1/	422 1/
60	243	269 (+11%)	307 (+26%)	378 (+56%)	435 (+79%)	704 (+190%)	1107 (+356%)
55	979	1050 (+7%)	1171 (+20%)	1389 (+42%)	1466 (+50%)	2291 (+134%)	3578 (+265%)

1/ Departure end of CNELA 65 contour extends to residential areas west of Hawthorne Boulevard for Jetstar/GII class at levels of 15 and 30 flights/day

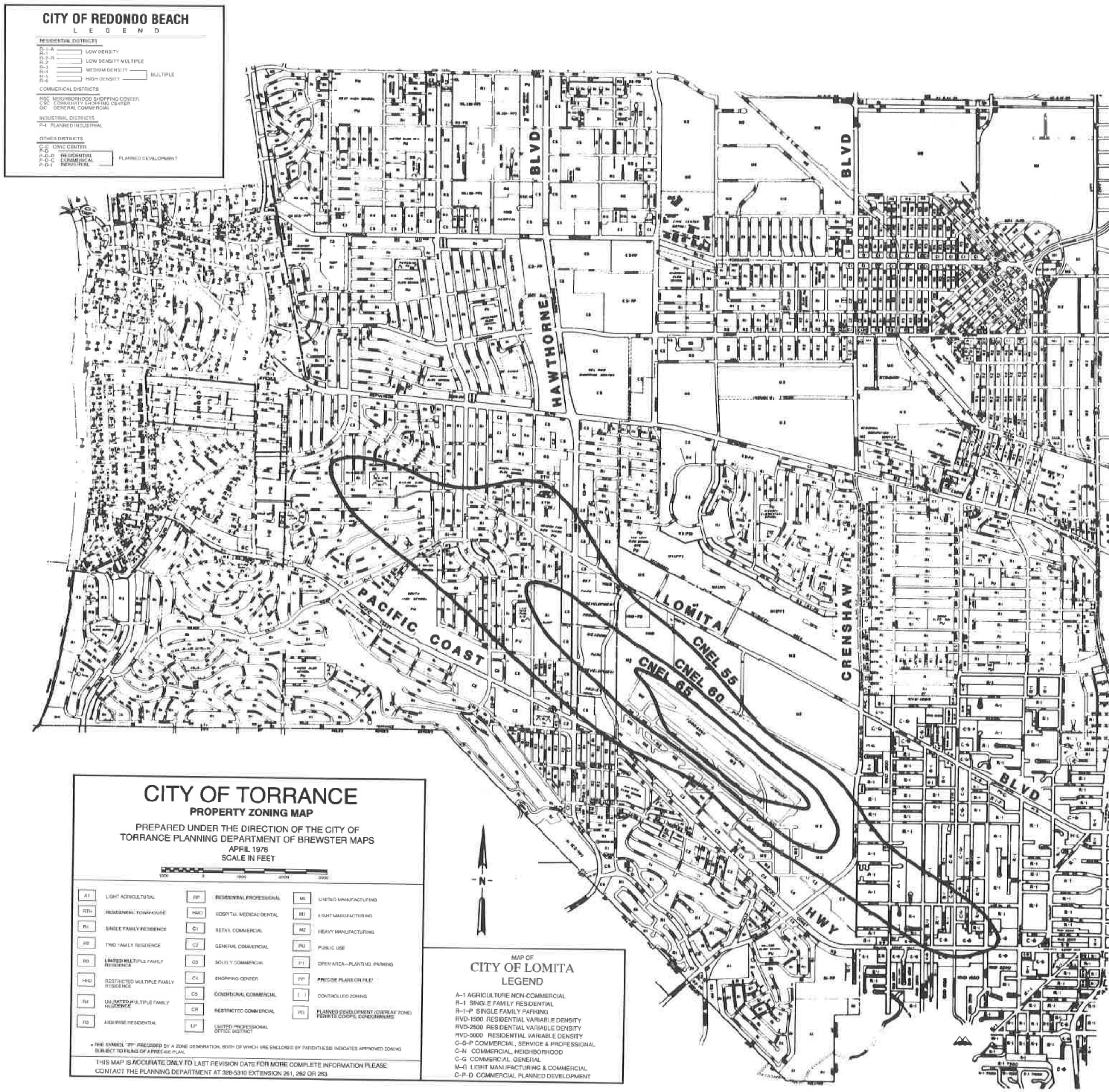


EXHIBIT 7-1

TORRANCE MUNICIPAL AIRPORT ANCLUC STUDY

CNEL CONTOURS FOR JET AIRCRAFT OPERATIONS CITATION II CLASS 5 FLIGHTS PER DAY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC)

prc SPEAS ASSOCIATES

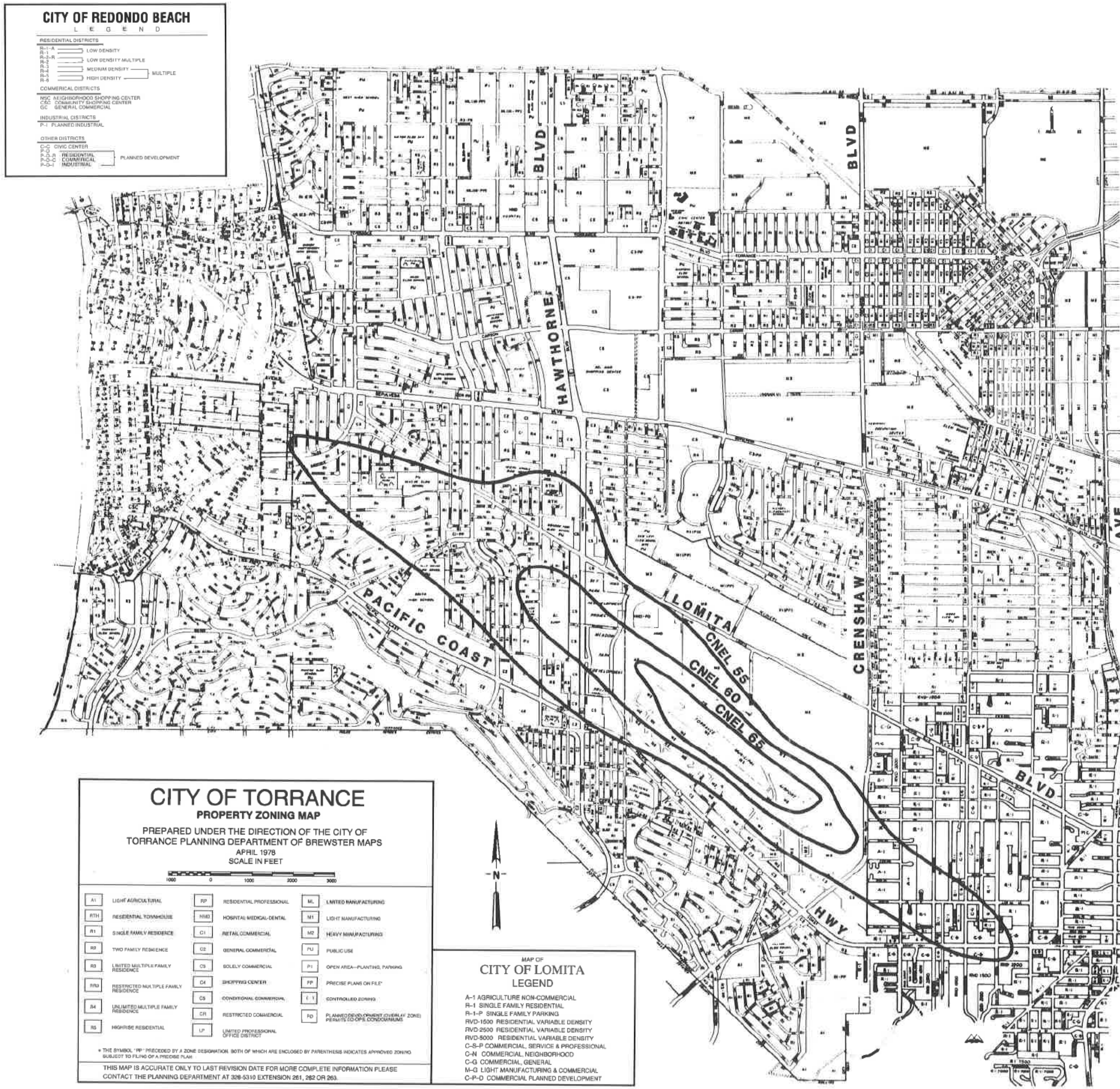


EXHIBIT 7-2

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

CNEL CONTOURS FOR JET AIRCRAFT OPERATIONS
CITATION II CLASS
15 FLIGHTS PER DAY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC)

prc SPEAS ASSOCIATES

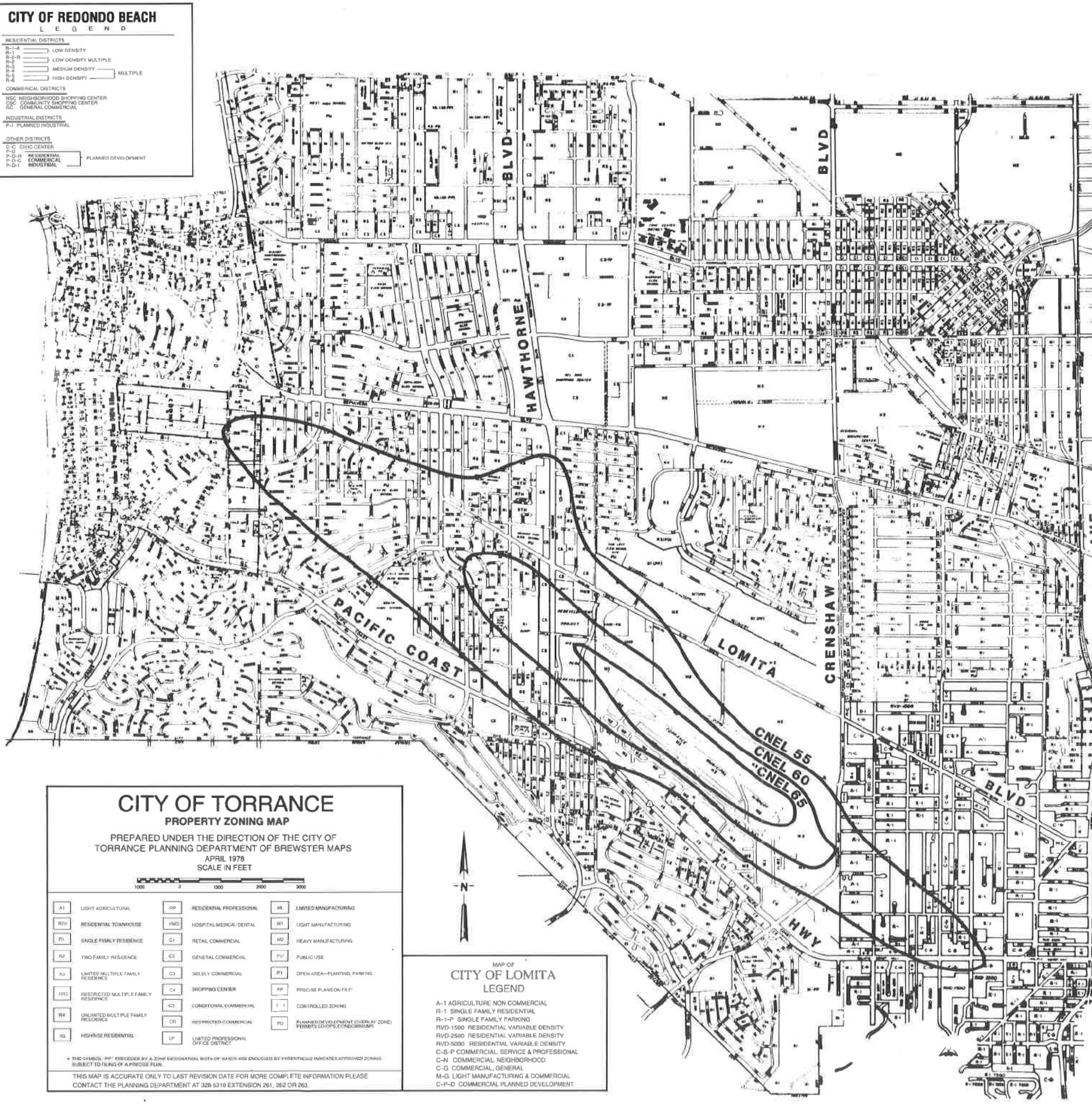


EXHIBIT 7-3

TORRANCE MUNICIPAL AIRPORT ANCLUC STUDY

CNEL CONTOURS FOR JET AIRCRAFT OPERATIONS CITATION II CLASS 30 FLIGHTS PER DAY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

PRC SPEAS ASSOCIATES

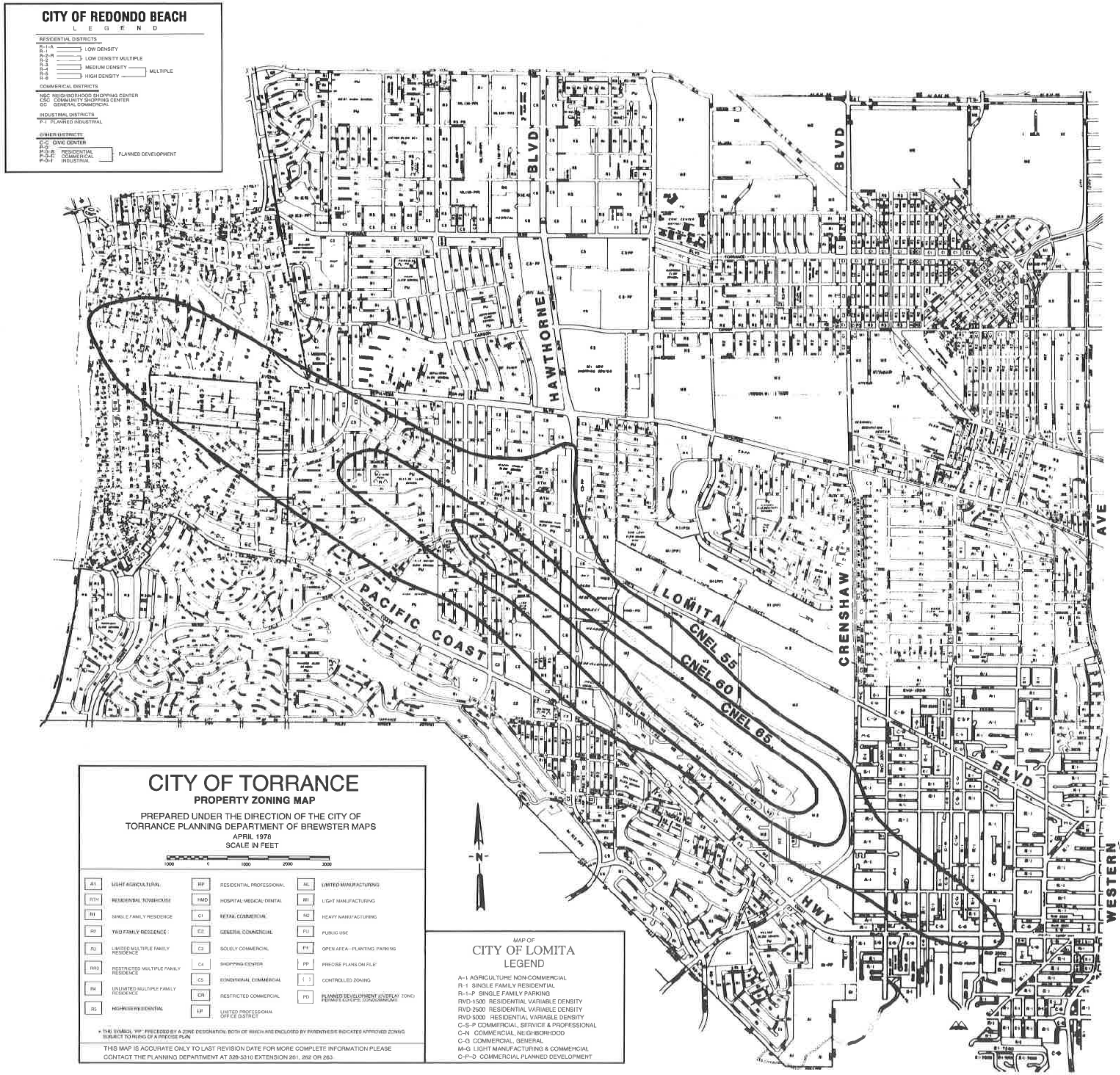


EXHIBIT 7-4

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

CNEL CONTOURS FOR
JET AIRCRAFT OPERATIONS
GULFSTREAM II CLASS
5 FLIGHTS PER DAY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

prc SPEAS ASSOCIATES

EXHIBIT 7-5

TORRANCE MUNICIPAL AIRPORT ANCLUC STUDY

CNEL CONTOURS FOR JET AIRCRAFT OPERATIONS
GULFSTREAM II CLASS
15 FLIGHTS PER DAY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL AND LAND USE COMPATIBILITY (ANCLUC)

prc SPEAS ASSOCIATES

EXHIBIT 7-6

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

CNEL CONTOURS FOR
JET AIRCRAFT OPERATIONS
GULFSTREAM II CLASS
30 FLIGHTS PER DAY

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

prc SPEAS ASSOCIATES

situation with the current fleet of propeller aircraft where some types are much noisier than others. This leads to the conclusion that any acceptance of jet aircraft at Torrance should require that the specific type comply with the prevailing single event noise limits at the airport. This should ensure that a small number of daily flights, e.g., 5-10, would not produce a significant increase in the CNEL noise exposure areas.

7.2 Effects of Increasing/Reducing Operations at Torrance Municipal Airport

The level of annual operations at TOA has remained relatively constant since 1968. The annual operations have varied within ± 10% of 400,000 throughout this period. The trend during calendar year 1980 has been to lower operations each month compared to the previous years. At the current rate of decline, it appears that the year end total will be down 10-15 percent below the average for the past five years. This is accompanied by an equivalent decrease of slightly less than one CNEL unit in the noise exposure conditions. Evaluating the change in aircraft noise exposure levels in terms of CNEL values follows the procedure inherent in the current California Aircraft Noise Regulations. It may prove useful to examine the impact of aircraft noise on a more detailed time of day basis than the three periods (day, evening and night) included in the CNEL computation procedure. This could be accomplished by computing Hourly Noise Equivalent Level (HNEL) values as prescribed in the CNEL documentation. The HNEL value is simply an hour-by-hour Equivalent Sound Level (LEQ) based on the level of individual aircraft noise events and the number of times they occur during the one hour time period. The HNEL values may be obtained from the permanent aircraft noise monitoring system at TOA or they may be estimated as described in Section 3 by using the SENEL vs. distance values for different aircraft types operating during the hour.

Assuming that operations at TOA increase or decrease by the same percentage on all flight tracks, the reduction in the CNEL energy average noise exposure simply follows the logarithmic ratio of the new level of operations to the baseline level. It is possible, therefore, to estimate the change in terms of CNEL units above or below the baseline levels. The precise shape of the contour lines are obtained by executing the INM prediction model for the desired multiple of baseline operations. A baseline annual operations level of 400,000 would show the following increase/decrease in CNEL units:

YEAR(S)	ANNUAL OPERATIONS	PERCENTAGE OF TOTAL	CHANGE IN CNEL UNITS
1961	100,000	25%	-6.0
1962-63	200,000	50	-3.0
1965-66	300,000	75	-1.2
1968	400,000	100	0
	500,000	125	+1.0
	600,000	150	+1.8

The effects of this change in CNEL value for levels above CNEL 65 may be determined from the FAA Land Use Guidelines in Section 5. Small changes such as 2 CNEL units are difficult to assess because of the difference between the simple dB change in a noise level and the more conceptually complex CNEL which involves a long term accumulation of noise energy.

The assumption of equal changes in operations on all flight tracks appears to be warranted on the basis of the history of training vs non-training operations at TOA. This relationship held at 53 percent vs 47 percent, respectively, over the past two years. There is evidence, however, that this ratio is reversing over the most recent six months.

7.3 Change in Landing Approach Profile

The requirement for investigating the landing approach profiles for aircraft arriving on Runway 29L at TOA was raised by complaints of low-flying aircraft over the City of Lomita and further out in Harbor Hills. Discussion of this issue led to an examination of the effects of installing a VASI system to further standardize the landing approach slope. A cooperative effort between the FAA, the City of Torrance and PRC Speas was employed in the measurement and analysis program for the VASI evaluation.

Vertical guidance for aircraft approaching Runway 29L is currently achieved through a series of minimum altitude checks specified for the landing approach. The inbound minimum altitude is 1800 feet Above Sea Level (ASL) at the Outer Marker located five nautical miles from the airport. After passing the Outer Marker the minimum altitude is 505 feet Above Ground Level which is 606 feet ASL at Torrance. The ground elevation between the Outer Marker and the airport is highest in the Harbor Hills area, approximately 200 feet ASL. This provides a minimum altitude of 400 feet for aircraft passing over residential areas in Harbor Hills on a landing approach to Runway 29L at TOA.

The nominal average landing approach angle used in the prediction model for general aviation propeller aircraft, derived from measurements conducted at other airports, is 4.7°. Values of 5.0° have been reported by other analysts in carrying out general aviation noise exposure computations. These landing approach angles exceed the typical VASI angle settings. The virtue of a VASI at TOA set at 4°, for example, would be to raise the altitudes of those aircraft which occasionally approach at a shallower angle. It is probable that the aircraft normally operating above the 4° approach angle would not necessarily approach at slightly lower altitudes as a result of following the VASI slope. It is more likely that they would continue to come in at the higher approach angles. If this is assumed, then no significant change would occur in the CNEL values.

The landing altitude measurements for Runway 29L approaches were conducted on March 29, 1980. Three measurement locations, designated Sites 1,2 and 3, were established under the landing flight path.

Site Number	Distance From Landing Threshold (Feet)
1	5100
2	9200
3	14150

Altitudes were measured using calibrated photographs and the known fuselage lengths and wingspans for each aircraft type. Aircraft identifications were achieved through radio communications with an observer at the airport. Noise levels for these overflights were measured at each of the three sites. The average altitudes of the aircraft over the three sites are summarized in Table 7-II. The individual altitudes and noise levels for each recorded overflight are shown in Table 7-III.

The effect of these variations in altitude may be assessed using the ratio of the nominal or average altitude (whichever is appropriate) to the higher or lower measured altitude.

$$\text{Noise Level (dBA)} = 20 \log \frac{\text{Reference Altitude}}{\text{Measured Altitude}}$$

This will provide a close approximation of the change in noise level for observers located relatively close to the flight track where the aircraft change in altitude is essentially the same as the change in slant distance to the aircraft.

7.4 Effects of Increasing Pattern Altitudes

The prevailing recommended altitudes for the traffic patterns for Runway 29R and Runway 11L are 700 feet AGL for single engine aircraft and 1500 feet AGL for twin engine aircraft. These traffic patterns north of the airport are described in Appendix A for conditions observed during documentation of the radar flight tracks. A differentia-

TABLE 7-II

AVERAGE ALTITUDE FOR AIRCRAFT ON LANDING APPROACH FOR RUNWAY 29L

AIRCRAFT CATAGORY	SITE #	AVERAGE ALTITUDE (Feet)		AVERAGE ANGLE
TRAINING (1)	1	414		
			∠ = 287	4.0° SEGMENT
	2	701		
			∠ = 353	4.1° SEGMENT
	3	1054		
HIGH PERFORMANCE (2)	1	455		
			∠ = 273	3.8° SEGMENT
	2	728		
			∠ = 367	4.2° SEGMENT
	3	1095		
TWIN ENGINE (3)	1	296		
			∠ = 312	4.4° SEGMENT
	2	608		
			∠ = 367	4.2° SEGMENT
	3	975		

(1) Includes Runs # 1,3,9,11,12,13,21,30,33,39,54,55 & 59.

(2) Includes Runs # 7,14,20,27,31,41,44,48 & 58.

(3) Includes Runs # 6,8,23,32,36,40,45 & 57.

∠ = Change in altitude between measurement locations (in feet)

TABLE 7-III

Noise Levels and Altitudes for Individual Aircraft Landings on Runway 29L

RUN	MODEL	RMS 6	SITE 1-5,100'			SITE 2-9,200'			SITE 3-14,150'		
		dB(A)	dB(A)	ALT	DEG	dB(A)	ALT	DEG	dB(A)	ALT	DEG
1	Piper Cherokee	63	68	462	5.2	67	654	4.1	64	1094	4.4
2	Cessna 172	62	66	577	6.5	66	748	4.6	63	1094	4.4
3	Cessna 150	56	57	519	5.8		748	4.6	55		
4	Cessna 172	56	58	404	4.5		561	3.5	63	683	2.8
5	VOID										
6	Piper Seneca	65	66	346	3.9		561	3.5	60	1094	4.4
7	Navion	63	78	288	3.2		561	3.5	74	957	3.9
8	Piper Commanchee	71	73	173	1.9	68	280	1.7	64	547	2.2
9	Cessna 150	62		346	3.9	52	561	3.5	63	957	3.9
10	VOID										
11	Cessna 150	58	56	404	4.5	55	654	4.1	55		
12	Cessna 150	58	53	519	5.8	52	654	4.1	52	957	3.9
13	Grumman AA5	57	52	462	5.2	46	842	5.2		1369	5.5
14	Beech 35	62	61	462	5.2	64	467	2.9	64	683	2.8
15	Grumman	63	63	288	3.2	52	748	4.6		1232	5.0
16	Cessna 172	60	61	346	3.9	48	561	3.5		957	3.9
17	VOID										
18	VOID										
19	VOID										
20	Cessna 182	57	59	231	2.6	50	561	3.5		1232	5.0
21	Cessna 150	62	55	346	3.9	52	748	4.6	54	820	3.3
22	VOID										
23	Beech Baron	69	70	231	2.6	64	467	2.9	58	820	3.3
24	Ercoupe	68	65	231	2.6	54	654	4.1			
25	VOID										
26	VOID										
27	Cessna 177	67	68	404	4.5	61	467	2.9		820	3.3

TABLE 7-III (Continued)

RUN	MODEL	RMS 6 dB(A)	SITE 1-5,100' dB(A)	ALT	DEG	SITE 2-9,200' dB(A)	ALT	DEG	SITE 3-14,150' dB(A)	ALT	DEG
28	Piper	71	71	346	3.9		842	5.2		1369	5.5
29	VOID										
30	Piper Cherokee	66	55	288	3.2		654	4.1		1232	5.0
31	Piper Lance	62	52	404	4.5	50	654	4.1		957	3.9
32	Piper Seneca	77	79	288	3.2	67	748	4.6	75	820	3.3
33	Cessna 150	61	60	404	4.5	56	748	4.6		1094	4.4
34	Cessna 172	60		346	3.9	52	654	4.1		1232	5.0
35	Mooney	59	60	231	2.6	58	467	2.9	53	820	3.3
36	Piper Commanchee	65	68	231	2.6	62	561	3.5	67	820	3.3
37	Cessna 150	61		519	5.8	60	1030	6.4	70	1232	5.0
38	Steerman	61	60	519	5.8	62	748	4.6	62	957	3.9
39	Cessna 150	71	74	288	3.2	68	561	3.5	60	957	3.9
40	Beech Baron	71	62	346	3.9	60	654	4.1	59	1094	4.4
41	Beech 35	64	60	462	5.2	60	936	5.8	57	1507	6.1
42	Thorpe T-18	76	66	462	5.2	50	748	4.6		1094	4.4
43	VOID										
44	Cessna 177RG	62	64	577	6.5	74	936	5.8	68		
45	Beech Baron	71	71	519	5.8	66	936	5.8		1369	5.5
46	VOID										
47	VOID										
48	Cessna 210	67	62	694	7.7	60	1030	6.4	64	1507	6.1
49	Cessna 172	56	53	810	9.0	60	1219	7.6	50	1645	6.6
50	Mooney	63	64	231	2.6	62	467	2.9		683	2.8
51	VOID										
52	VOID										
53	VOID										
54	Cessna 150	60	58	346	3.9	53	654	4.1	57	957	3.9
55	Piper Cherokee	60	58	462	5.2	51	654	4.1	53	1094	4.4

TABLE 7-III (Continued)

RUN	MODEL	RMS 6 dB(A)	SITE 1-5,100' dB(A)	ALT	DEG	SITE 2-9,200' dB(A)	ALT	DEG	SITE 3-14,150' dB(A)	ALT	DEG
56	Grumman	70	60	462	5.2	55	561	3.5	53	957	3.9
57	Cessna Conquest		65	231	2.6	68	654	4.1	54	1232	5.0
58	Beech 35	61	56	577	6.5	50	936	5.8	54		
59	Piper Cherokee	59	54	462	5.2	50	561	3.5	52	820	3.3
60	Cessna 172	65	69	519	5.8	60	936	5.8			

tion was made between single and twin engine aircraft with observations showing mostly single engine aircraft in the training pattern. Arrivals to and departures from the area showed a larger proportion of twin engine aircraft in the pattern.

Two principal effects might result from an increase in the recommended pattern altitudes. The increase in altitude will increase the distance from the noise source to those observers under the flight paths with a resulting decrease in noise levels. At the same time, the pattern will be extended to the west and east in order to accomodate the climb to the higher altitude. This would result in aircraft in the pattern overflying more residential areas of the City. An increase in the pattern altitudes to 1200 feet (AGL) and 2000 feet (AGL) for single engine and twin engine aircraft, respectively, would probably increase in the pattern dimensions out to the vicinity of Anza Avenue.

The change in noise levels for areas lying under the downwind track may be estimated in the following manner:

$$\text{Change in Noise Level (dBA)} = 20 \log \frac{\text{Current Pattern Altitude}}{\text{Proposed Pattern Altitude}}$$

Thus, an increase in the pattern altitude from 700 feet AGL to 1200 feet AGL for single engine aircraft would reduce the noise level by about 4.7 dBA.

$$\Delta \text{dBA} = \log \frac{700}{1200} = -4.68$$

There will also be a change in the relationship between the peak dBA level (above) and the SENEL value.

The noise exposures for those areas not previously overflown prior to expansion of the pattern may be estimated using the single event noise computation procedures described in Section 3.3 of this report.

7.5 Effect on Noise Exposure from Increasing the Number of Based Aircraft

The present number of based aircraft at TOA is estimated to be 825. There is some difficulty in arriving at a precise count due to conditions relating to long-term hanger leases negotiated in the past. There is an accurate count of based aircraft using designated tie-down spaces but some ambiguity relating to aircraft using transient tie-downs on a long-term basis. In addition, based on the estimate for based aircraft a limit for aircraft based at the airport is established at 825 by City Council Resolution.

The relationship between local or itinerant operations and the number of based aircraft is difficult to assess due to the fact that it is virtually impossible to document flights by based aircraft at Torrance. This might be accomplished through a survey if all based aircraft were registered but this is not the case at TOA. Experience at other general aviation airports has shown there is not a one-to-one relationship between the number of based aircraft and the number of flight operations. That is, a twenty percent increase in the number of based aircraft does not necessarily produce a twenty percent increase in flight operations.

The amount any new based aircraft increase flight operations appears to be related more to the type aircraft involved and the purpose for which it is used. The latter point, the purpose for which the aircraft is used, is the more important determinant of the increase in total operations.

In considering an increase in based aircraft at TOA it is important to differentiate the potential uses for different type aircraft. Small single engine aircraft operated by flight schools will be the largest source of new operations. For California airports, single engine based aircraft show approximately 80 percent of the total operations in the local traffic pattern. It is important, therefore, to determine the specific type aircraft to be added to those already based at TOA. One flight by a single large noisy twin engine aircraft may produce far more intrusive noise than twenty flights by a light quiet single engine aircraft.

The other determination to be made is which flight tracks will be utilized by any new based aircraft. For example, adding ten new flights to a track where only one already exists will increase the aircraft noise exposure by 10 CNEL. Adding ten new flights to a pattern where there are ninety existing daily flights will produce an incremental increase of only 0.5 CNEL. While the overall CNEL is, of course, higher in the latter case, the incremental change may be imperceptible.

With these considerations in mind, a determination should be made as to which aircraft types would be the most beneficial additions to the based aircraft fleet in terms of economic benefits and minimal noise exposure problems in the community. It is then possible to develop strategies for encouraging the presence of the most desireable aircraft types. Considerations such as hanger size, lease rates, fuel flowage fees or noise penalties may be used to attract the most beneficial aircraft types.

7.6 HELICOPTER NOISE

Helicopter noise causes a significant amount of annoyance in the residential areas just south as of TOA as well as sections of Redondo Beach in the higher elevations to the west. Communications between City officials and residents of the area indicate that a substantial portion of the populace is concerned about the frequency of occurence and the loudness of helicopter noise events they experience while at home or when visiting neighbors. The Noise Abatement Office staff has investigated the matter at various times and determined that few helicopter operations result in exceedances of the Airport's maximum dBA or SENEL noise limits. The Noise Abatement staff has recorded fewer than twenty instances in which a non-military, non-law enforcement helicopter has violated the daytime aircraft noise limits (82 dBA maximum sound level and 88 dBA SENEL) in effect at TOA. And only one (1) exceedance of the nighttime limits (76 dBA maximum sound level and 82 dBA SENEL) has been recorded in more than two (2) years of continuous monitoring. Yet complaints about helicopter noise are received frequently. Many times the complaintants refer to a particularly low overflight or the fly-by of a particularly noisy type of helicopter (such as a Bell UH-1). With the respect to complaints of this type, it would seem that the best remedy would be creation and implementation of prescribed routes and altitudes for helicopters approaching and/or departing TOA. Ideally, taking this action would ensure adequate distance between helicopters not using the training pattern and residents in particularly noise sensitive areas. Since non-pattern helicopter operations do occur frequently at TOA, prescribing more acceptable helicopter routes and altitudes should improve airport-to-community compatibility for approaching and departing helicopters.

Describing and dealing with the noise impacts of helicopters in the local pattern is a more complex task. While helicopters account for relatively few (less than 2%) of the operations at TOA, a sizeable proportion of those which do occur are conducted in the local helicopter traffic pattern south of Runway 29L/11R. For the most part, these flights are conducted for pilot training or flight testing purposes and involve the operation of small 2-3 place helicopters such as the Hughes Model 300 and the Robinson Model R-22. Since aircraft of this type are normally considered to be relatively quiet, it would seem that some other factor or combination of factors is causing the high levels of annoyance reported by local residents.

As part of the research into the helicopter noise situation, a series of demonstration helicopter flights was conducted at TOA on 2 October 1980. The purpose of these flights was to allow ground observers to locate the training pattern flight path and carry out recordings of the noise exposure levels during these flights. A total of nine (9) passes were recorded for a 3-place Hughes 300 helicopter operated by Peninsula Aviation. These flights occurred between 1505 and 1528 Hours. The measurements covered a period between 1450 and 1530 Hours and, during this time, two (2) flights by a second Hughes 300 helicopter and eleven (11) flights by a Robinson R22 helicopter occurred in the south pattern. It should be noted that Peninsula Aviation and Robinson Helicopters generate the major portion of helicopter operations in the local pattern at Torrance Airport. Noise levels were measured for all additional flights which occurred during the test period.

Measurements of Helicopter Noise

Measurements were conducted with a Bruel and Kjaer (B&K) Type 2206 Precision Sound Level Meter with a B&K Type 4146 one-half inch condenser microphone. The noise events were recorded on a Sony Model 142 portable magnetic tape recorder. The system was calibrated with a B&K Type 4230 Acoustical Calibrator. The recordings were subsequently analyzed using a B&K Type 2306 Graphic Level Recorder.

Ambient noise levels at the measurement location on Raintree Drive, typically ranged between 44 and 58 dBA with a ten (10) minute energy average between 1440 and 1450 Hours of 50.5 dBA. This ambient noise, with no visible sources in the immediate area, was attributable mostly to motor vehicle traffic on Pacific Coast Highway with additional contribution from other remote roadways and from operations at TOA. Automobiles, trucks and motorcycles operating on Raintree or Cricklewood produced transient noise exposures with peak levels between 62 and 78 dBA.

The noise levels produced by these helicopter operations are summarized in Table 7-IV. It is important to note that the Peninsula Aviation flights, following the nominal training pattern, overflew a ground track along Airport Drive. On two occasions the pattern was extended to the south in order to achieve a higher pattern altitude. The flights by the Robinson R-22 and the second Hughes 300 appeared, from the ground observation location, to follow a ground track located

TABLE 7-IV

RECORDED HELICOPTER NOISE LEVELS
FROM RAINTREE DRIVE LOCATION

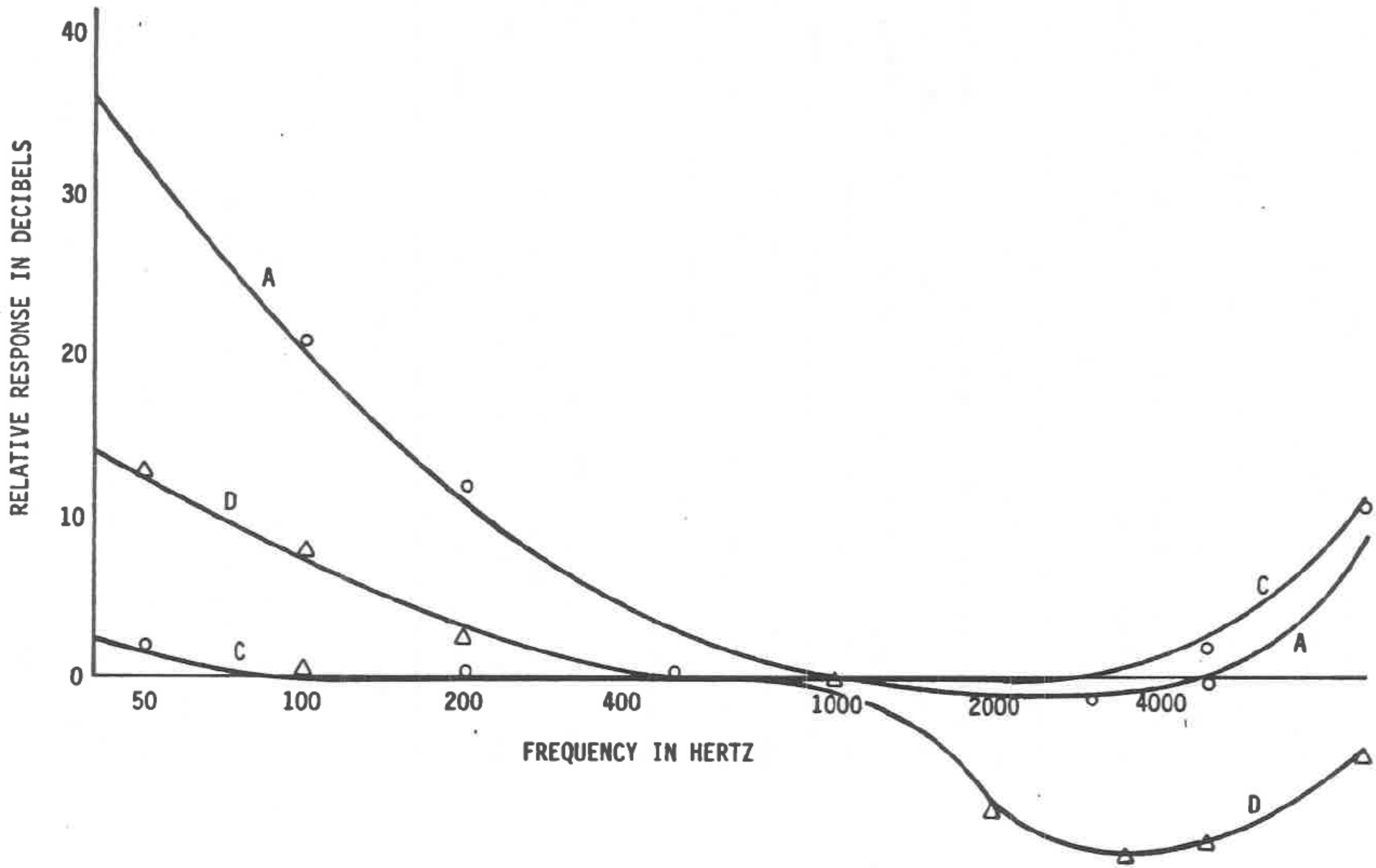
Time	Event	Peak dBA	Peak dBC	Peak dBD
1458	R-22 OVER PCH	70	77	80
1501	R-22 OVER PCH	70	77	81
1502	HUGHES 300 OVER AIRPORT	69-70	77	79
1503	R-22 OVER PCH	70-71	78	80
1504	R-22 OVER PCH	69-70	77	79
1505	PA HUGHES 300/600 FT ASL	68-69	76	79
1506	R-22 OVER PCH	71	78	80
1507	PA HUGHES 300/600 FT ASL	68	76	79
1508	R-22 OVER PCH	70-71	78	81
1509	PA HUGHES 300/600 FT ASL	68-69	77	79
1510	R-22 OVER PCH	68-69	76	79
1512	HUGHES 300 OVER PCH	68	76	79
1512	R-22 OVER PCH	70	77	79
1515	PA HUGHES 300/600 FT ASL	--	--	--
1515	R-22 OVER AIRPORT	--	--	--
1518	PA HUGHES 300/900 FT ASL	67-68	75	76
1519	R-22 OVER PCH	70	77	80
1521	PA HUGHES 300/600 FT ASL	70-71	77	80
1523	R-22 OVER PCH	70-71	78	79
1524	PA HUGHES 300/700 FT ASL	70-71	77	80
1527	R-22 OVER PCH	71	78	81
1528	PA HUGHES 300/900 FT ASL	67-68	75	77
1529	R-22 OVER PCH	70	77	80

farther to the south, closer to Pacific Coast Highway. These were probably closer to the measurement location on each pass.

The question of how the helicopter noise should be measured has come up for discussion on several occasions at TOA. The noise from fixed-wing aircraft is measured using the A-weighted Sound Pressure Level as the basis for all computations. This concept of a weighted sound pressure level is based on the various curves shown in Exhibit 7-7. These curves represent human judgements of equal loudness (or, in one case, "noisiness") under different experimental conditions. The A-weighting curve is essentially the frequency sensitivity curve for the human ear and has been adopted, over many years, as the basis for virtually all environmental noise measurements. The C-weighting curve is based on equal loudness judgements at high sound pressure levels where most frequencies audible to humans are equally loud and there is very little discrimination against lower and higher frequencies. The important issue is that more low frequency energy is included in the C-weighting scale.

The D-weighting scale has been developed for exclusive application to aircraft noise. It originated with a small bit of equivocal research in 1944 and was resurrected for use with aircraft noise during the 1950's and 1960's. It is based on the premise that people are disproportionately sensitive to higher frequencies in the audible spectrum, resulting in their experiencing a sensation of greater "noisiness". During the 1960's, this D-weighting was incorporated in a scheme for measuring aircraft noise termed the Effective Perceived Noise Level (EPNL). This EPNL scale was then adopted as the standard metric for aircraft noise certification by the Federal Aviation Administraiton (FAA). Thus, the entire history of noise certification for aircraft is based on this scheme and it is clearly impractical to alter the process at this time. The procedure for FAA certification of helicopter noise, due to be published in 1981, will also use the EPNL scheme. The noise characterisitics for heli-

EXHIBIT 7-7 FREQUENCY WEIGHTING CHARACTERISTICS FOR A,C AND D SCALES



copters (noise level vs distance) will, however, be entered in the FAA prediction model as both EPNL (D-weighted) and NEL (A-weighted) values.

This brief background discussion is included to assist in interpreting the measurement data and the recommendations derived from this evaluation. Note that the D-weighting curve introduces an arbitrary penalty for noise energy over part of the audible spectrum.

Analysis of Community Response Characteristics

For purposes of scaling aircraft noise and comparing one aircraft noise event with another, it really does not matter which scale is used. The absolute levels will be different but, for similar sources, such as aircraft, there will be a consistent and predictable relationship between all of the scales. The reason for choosing one metric over another is related to the requirement for predicting community response. If there is some unique annoying characteristic associated with noise from certain aircraft, such as helicopters, then we wish to select the scale that will best identify this characteristic and allow us to forecast adverse effects in the community.

There are two distinct aspects of the helicopter noise events which may be examined in an attempt to understand the effects on community response. First is the noise level and frequency composition, i.e., the physical description of the noise. The second consideration is the context of the noise events, e.g., the time of day when events occur, the day of the week, the prevailing ambient (non-aircraft) noise and the number of repetitions of the noise event per unit of time. This latter contextual characteristic has been mentioned frequently by residents as one significant source of annoyance.

Physical Measurements of Helicopter Noise

In examining the physical characteristics of helicopter noise, it is apparent that a significant amount of low frequency energy, particularly in the 135 HZ octave band, is present in the noise. The frequency spectrum for Hughes 300 helicopter is shown in Exhibit 7-8. Energy in this part of the frequency spectrum is responsible for the excitation of structures on the ground. This shaking of residential units results in the generation of secondary acoustic phenomena inside the house when the vibration is re-radiated as noise. This leads to speculation that the C-weighting scale may be a useful metric for describing these low frequency phenomena and predicting at least one annoying component of the helicopter noise.

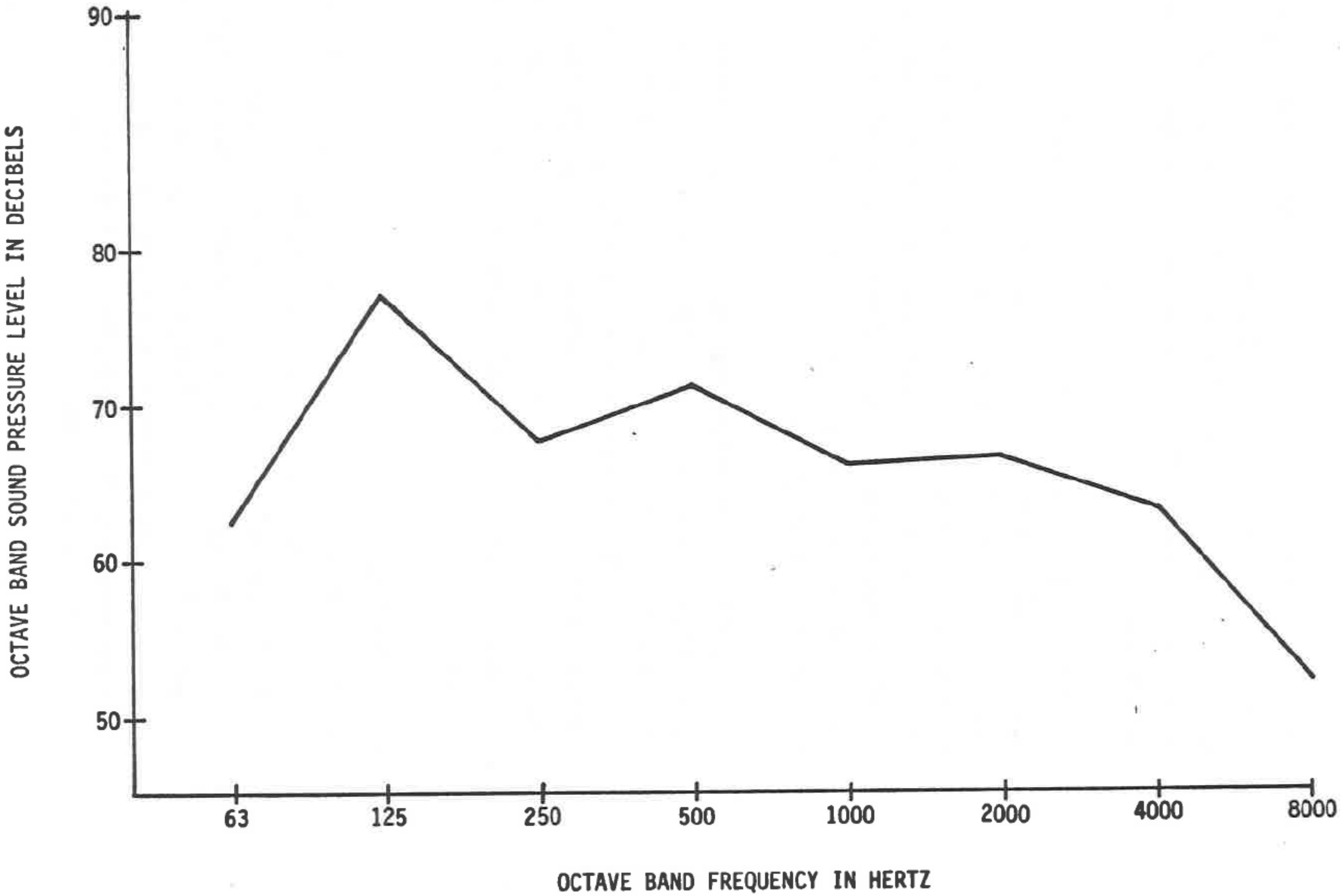
The D-weighting scale appears to follow the A-weighting scale consistently and falls between the A and C-weightings in describing the low frequency energy components. There is no compelling argument for using the D-weighting scale for measurements of helicopter noise, since the D-weighting penalty factor covers a frequency range which is not particulary significant with respect to the noise produced by light helicopters.

Operational Characteristics of Helicopters at TOA

Peninsula Aviation consistently attempts to adhere to the recommended flight path which follows a ground track along Airport Drive at a pattern altitude of 600 feet Above Sea Level (ASL) or 500 feet Above Ground Level (AGL). This track is approximately 700 feet north of the measurement location on Raintree, resulting in a slant distance to the aircraft of about 860 feet. Pacific Coast Highway is approximately 400 feet from the measurement location so that the Robinson helicopter in the pattern was somewhat closer with the slant distance estimated at about 640 feet. For the same helicopter operating under similar altitude and power conditions, this difference in distance produces approximately 2.5 dB difference in the noise level.

The two passes made by the Peninsula Aviation Hughes 300 at 900 feet ASL produced a 3 dB reduction in the maximum noise exposure levels. Discussions with Peninsula Aviation personnel indicated that a pattern altitude of about 800 feet MSL might be achieved under typical training

EXHIBIT 7-8 FREQUENCY SPECTRUM FOR HUGHES 300 HELICOPTER DURING LEVEL FLYOVER AT 500 FEET



conditions but that this would result in increased operating costs. In addition to the increased fuel consumption, the time required for a single loop in the pattern would be increased, resulting in a reduction in the number of landings and departures per hour of instruction.

This latter point, increasing the time to complete a training cycle, would probably assist in reducing the complaints in the community concerning the repetition rate of the helicopter noise events. This would be accompanied, however, by the increased operating costs incurred by Peninsula Aviation. Peninsula Aviation currently attempts to reduce the repetition rate for the helicopter overflights by introducing a series of touch and go maneuvers along the runway as part of a training loop in the pattern.

The possibilities for relocating the helicopter training operations to the north side of TOA or to another airport, e.g., Long Beach, have been explored but do not appear to be feasible at this time. It is not possible to integrate the helicopters into the fixed wing aircraft traffic north of TOA. Attempts to take the training operations to another airport would not be practical in that most of the students training hours would be consumed enroute to a remote location.

Recommendations

1. City staff should continue to measure helicopter noise using the A-weighted sound level with some consideration given to using the C-weighted sound level as a predictor of community response in the CNEL scheme. Use of a C-weighted SENEL for helicopters only would, in effect, add a seven or eight dB penalty to account for the increased low frequency energy in the helicopter noise spectrum. This should be explored with appropriate deliberation, of course.

2. Some experimentation with the higher pattern altitude for

helicopters should be explored if some procedure that is fair to both the community residents and the helicopter operator can be worked out. The potential noise reduction from this modification is estimated at 2-3 dBA. While this is a just perceptible reduction in noise level, there is an additional consideration. Experimental data from NASA tests conducted at the Wallops Island test site indicate that helicopter noise levels of 65 dBA or less were judged by observers to be "of no significance". The current noise levels from Peninsula Aviation flights occurring at the Raintree Drive location are of the order of 70-71 dBA. If the higher pattern altitude were used, they would approach the 65 dBA value cited in the NASA tests as the limit of objectionability. Keeping in mind that community residents regard the repetition of the noise events as being as important as the noise level, reductions in both these areas could possibly improve the existing situation.

3. All helicopters using the training pattern should follow the Airport Drive ground track now used by Peninsula Aviation.

4. The number of helicopters in the training pattern at the same time should be kept at a practical minimum. For example, if test flight operations at the Robinson facility can be scheduled with more flexibility than student training operations, some attempt should be made to develop a scheduling procedure among the different Fixed Base Operators at TOA.

5. If necessary in order to assure compatibility with the community, an absolute limit on use of the helicopter traffic pattern limiting its use to perhaps one helicopter at any given time should be imposed.

With the exception of Recommendation #5, the above measures should be implemented and evaluated simultaneously on a trail basis. Then it would be possible to determine both the benefits to the community and the costs to the operators. A judgement might then be made concerning a fair resolution to the current problem. If additional helicopter noise reduction appears to be necessary at the end of the trial period, Recommendation #5 should be implemented at that time and other courses of action, such as further restrictions on the hours during which helicopter pattern work at TOA should be investigated.

8.0 TOA NOISE ABATEMENT PROGRAM

8.0 TOA NOISE ABATEMENT PROGRAM

The ongoing noise abatement program at TOA is among the most comprehensive for any airport in the United States. A wide range of activities on the part of City Council, community representatives and City Staff directed toward the identification of airport noise problems and the reduction of the adverse community impact have been implemented. The magnitude and diversity of activities has grown to such an extent that it is now necessary to assess the relative effectiveness of the different activities and assign priorities for future work in this office.

The Torrance Airport Noise Abatement Program is a prototype operation for general aviation airports. Many of its activities over the past ten years have been unique and innovative in working with the aircraft noise problems. Some of these actions are summarized below.

May 1, 1973 - City Council Resolution No. 73-84 prohibits the sale of jet fuel at TOA. This does not preclude use of the airport by jet aircraft but does act as a deterrent by eliminating TOA as a refueling location or a site for based jet aircraft.

July 4, 1977 - Portable noise measurement equipment was used to establish the first single event aircraft noise limits at 88 dBA(SENEL) and 82 dBA (Peak). This was the beginning of the City's intensive aircraft noise monitoring program. Aircraft noise in the community has been sampled continuously since this date.

October 25, 1977 - City Ordinance No. 2784 was adopted by City Council establishing:

- Single event noise limits, day and night.
- Touch and go training restrictions.
- Departure curfew effective between 2300 and 0630 hours.

At this same meeting, Council approved purchase of facilities for a permanent noise monitor system.

October 31, 1977 - The first issue of the Torrance Airport Aircraft Noise Abatement Newsletter was distributed.

November, 1977 - City Council approved purchase of permanent noise monitor systems.

November, 1977 - Requirements in airport noise ordinance broadcast on Automatic Terminal Information Service (ATIS).

November, 1977 - City Ordinance requiring registration of all aircraft was established.

May 23, 1978 - City Council formed Citizens Advisory Committee on Airport Noise (CACAN).

June 27, 1978 - Contract awarded for permanent noise monitor system.

January, 1979 - Contract awarded for ANCLUC project.

May, 1979 - Permanent noise monitor system installed and operating.

April, 1980 - Noise Abatement Ordinance No. 5157 prohibits use of training pattern by transient aircraft.

During the past year, efforts by the City have concentrated on enforcement of the ordinances and regulation developed for aircraft noise abatement at TOA. This includes notifying pilots of exceedences of the noise limits and following through with pilot education programs or remedial action with persistent violators.

8.1 Community Coordination

The effectiveness of the airport noise abatement program will be determined, to a large extent, by the extent to which people in the community are involved in the program and are able to assist in effecting some meaningful changes in airport noise conditions. The noise abatement program has progressed to the point where most available controls over flight operations have been implemented in the interest of reducing noise in the community. From this point, future noise abatement efforts will probably involve numerous small reductions in the aircraft noise impact rather than large changes resulting in the complete elimination of problems. With the level of flight operations remaining constant at about five hundred overflights per day, and the existing restrictions on night operations and training activities, there is a continuing significant aircraft noise impact on several neighborhoods around the airport. Assuming the airport will continue to operate at this level of activity, these problems in the community will continue to exist.

It is apparent, then, that all efforts toward aircraft noise reduction must be responsive to the community residents' perception of the problem. There is a tendency to continue to work on noise abatement activities proven effective at other locations and under different conditions and in doing so, fail to recognize the aspect of the problem which would produce the most benefit in the community. It is extremely important to include a provision in the noise abatement program for determining those changes in airport operations capable of the greatest reduction in adverse community impact.

8.2 Citizens Advisory Committee on Airport Noise

The existing Citizens Advisory Committee on Airport Noise has the responsibility for representing the interests of the community in matters concerning the effects of aircraft noise. The committee is asked to respond to problems in all areas of the community and take actions which will alleviate the problems. There are, at present, at lease four separate and unique problem areas around the airport, each with different conditions requiring actions designed specifically for that area. The efforts of the Committee would be facilitated if the problems could be evaluated and presented to the Committee in a systematic format. This may be accomplished by providing the community groups with a procedure for identifying complaints of aircraft noise intrusion and presenting the complaints to the Committee.

There are some existing community organizations that are concerned with the effects of aircraft noise in the TOA environs. Comparable groups should be identified in each of the problem areas around the airport and provided with a procedure for presenting complaints to the City for either an action which will reduce the problem or identify an impasse which must be arbitrated.

8.3 Pilot Training

One of the most promising possibilities for reducing the noise from individual aircraft overflights is in the area of training individual pilots to operate their particular aircraft in order that they achieve the lowest possible noise exposure conditions in the community. An informal procedure for pilot education has been used with operators who exceed the single event noise limits. A review of the records of these training sessions shows noise reductions of the order of 6-9 dBA in some cases. These training procedures have been conducted for departures on Runway 29 with measurement obtained from RMS-1.

These training sessions have not included standardization of the flight path so that some deviation may result from changes in the ground flight track as well as changes in the altitude profile and engine power schedules. Adoption of a formal pilot education program would include procedures for flying a nominal ground track, e.g., continuing departures on a runway heading, for a series of departures using systematic variations of propeller speed, manifold pressure, etc. This is a difficult procedure to implement but could be useful for those operators with multiple exceedances of noise limits faced with impending court action.

A system of incentives for pilots completing this training program should be investigated. This might include preferential access to the training pattern or use of the airport during semi-restricted periods. This particular approach to aircraft noise reduction may be implemented at all general aviation airports. The Torrance airport would be an excellent location to carry out such a demonstration program and document the results for various aircraft types. A specific example of the advantage of preferential access to the training pattern would occur if there is a decision to limit the number of based aircraft in the pattern in order to restrict the size of the ground flight track over the community. Also, if use of the local pattern during early hours on weekends were limited to operators with noise abatement training, this could prove to be a strong incentive.

8.4 Airport Noise Monitor System

The permanent noise monitor system operating at TOA has produced a detailed definition of the aircraft and community noise environment at the eleven monitor locations. The system has been valuable in documenting exceedence of the single event noise limits and is capable of a wide range of data storage and analysis procedures. After analyzing data from the monitor system for over eighteen months, it is possible to identify some aspects of the system that may need revision.

The costs of operating the system over this period should be identified so that judgments could be made concerning the cost efficiency of obtaining comparable data using alternative methods for other airport locations. This cost accounting should identify the acquisition costs, cost of adding remote sensor units and the cost of personnel required to operate and maintain the system. This latter point should identify the staff time required to carry out various data acquisition, storage/retrieval and analysis tasks. The level of training required to perform these tasks would also be an issue of considering staff costs.

It is apparent that the selection of the remote monitor locations may need to be revised in the interest of more cost efficient use of the system. The relative portability of the remote sensors and transmitters should be investigated. Stations 1, 5, 6, 9, 10 and 11 have produced consistently useful data while the remaining stations might be more productive in other locations. One concept that might be explored is the location of the monitor stations in pairs along critical flight corridors such as the turn to the north pattern following departures on Runway 29R. This technique would create a flight corridor and the monitors would be used to determine compliance with the nominal flight tracks used as a noise abatement procedure.

Another consideration for this system would be its use as a central processing location for remote sensor locations at other airport locations in the area such as Hawthorne or Long Beach. The system has sufficient capacity for this type operation and data transmission over telephone lines would be practical within the area. The cost of staff technical personnel could then be amortized over a broader base.

8.5 Staff Requirements

The Environmental Quality Division of the Building and Safety Department currently has the responsibility for assessing and investigating the adverse effects of airport operations on the community. The staff personnel assigned to this program are well trained in the use of monitoring equipment and interactions with aircraft operators to implement noise abatement procedures. There is a normal trend at airports for these responsibilities to come into conflict with the management of the airport which has a responsibility for supporting and promoting aviation. These divergent responsibilities are not necessarily irreconcilable. A close working relationship between the Department of Transportation Airport Division Staff and the Environmental Staff from Building and Safety should maintain the balanced approach to aircraft noise problems currently in effect at the airport.

8.6 General Objectives for Noise Abatement Program

The noise abatement program at Torrance Airport has been most effective in arresting the trend toward increased numbers of aircraft operations with a high percentage of excessively noisy aircraft flying routes which do not reflect a concern for the effects of noise on the community. The staff Personnel from the Environmental Quality Division and the Airport Division have been continuously effective in carrying out City policies designed to control aircraft noise exposure. Future improvements in community aircraft noise exposure conditions will require either new procedures for reducing aircraft noise or arbitrary decisions in cases of severe conflict between community interests and airport operations. These conditions where arbitration is required will generally result in either an economic penalty for the aircraft operator or continued adverse noise impact for the community. The philosophy governing these decisions may be established as a matter of continuing policy in the City or each case may be considered on its relative merits.

There is no prospect of changing the sources of significant community complaints without a major change in operating conditions at the airport. Using the exceedence reductions as an example is instructive. If there were 100 violations in July 1980 and they were reduced by 25% (the reduction in exceedences reported in 1980 compared with 1979), 2 5 violations per month are eliminated. Subtracting this 2 5 exceedence reduction, the baseline for the 1981 comparison becomes 75 violations. The reported reductions in exceedences this year (1981 compared with 1980) was 50%. This means an additional 37.5 violations were eliminated. While the program effectiveness has improved by 100%, the absolute number of violations eliminated only increased by 50%. This effort toward reducing violations is important because the trend continues toward a better noise environment. It is not, unfortunately, the sort of change in conditions that will produce a marked change in community response to airport operations. There are other aspects of aircraft noise exposure that affect community attitudes more dramatically. Continuing aircraft noise limit enforcement will be an important aspect of the airport noise abatement program. It is also essential, however, that some significant effort should be directed toward developing a procedure for the major policy decisions concerning airport operations and their impact on the community. Examples include helicopter training operations over Walteria or local pattern flying on weekend mornings. These activities either continue or they are eliminated since there does not seem to be an acceptable compromise that will satisfy the conflicting interests.

8.7 Aircraft Noise Control

An effort should be made to achieve as much reduction as possible in the noise generated by individual aircraft overflights. One possible approach to this objective would be the pilot training program combined with a staged reduction in the single event noise limits at TOA. A five-year program with the current limit reduced by two dBA is suggested. This would reduce the SENEL limit to 86 dBA (day) and 80 dBA (night) and the peak instantaneous limit to 80 dBA (day) and 74 dBA (night). The effect would be to reduce the number of noise exceedences by excluding the nosiest aircraft. The pilot training program would be mandatory for operators who continuously exceed the single event limits. This phased reduction of single event noise limits would be prohibitive on a more accelerated basis due to the difficulty in publicizing and enforcing the regulation.

Some form of incentive for quiet aircraft operation should be established. Assessment of noise-related fees may be considered but could be complicated by prohibitive administrative costs. Another form of incentive would be preferential access to the training pattern, particularly if the number of aircraft in the pattern at one time is limited in the future. Having restricted the local pattern to based aircraft, the principal sources of activity are probably flight school operations. A voluntary scheduling acheme between the Fixed Base Operators would be an effective approach. This preferential access could be extended to early hours of operation, particularly on weekends. Restrictions of departures could be implemented in stages for early morning or late evening hours.

The permanent monitoring system could be used effectively as an adjunct to controlling the nominal noise abatement departure tracks in selected corridors. Installation of the monitor sensors in pairs at either permanent or portable stations would allow for tracking the direction of deviations from the nominal noise abatement flight track.

Some improvement is required in recognizing the characteristics of general aviation aircraft noise exposures which might be modified to reduce the negative impact in the community. Responses to the questionnaire survey indicated that the continuous repetition of overflights and the occurrence during early morning or late evening hours were particularly annoying factors. Better information from residents in the community would allow the noise abatement office to direct a proportional effort to the most sensitive issues.

8.8 Land Use Compatibility Planning

The levels of noise from individual flight operations by general aviation aircraft in the TOA environs are such that there is no clear indication for acquisition of additional property, redevelopment programs or extensive re-zoning. The principal actions available for reducing the aircraft noise impact through land use alternatives are through disclosure and review of building permit applications for the control of interior noise environments through structural modifications.

Identification of areas in the airport community affected by aircraft noise may be facilitated by creating an Airport Planning District. The boundaries of the recommended Airport Planning

District are shown in Section 5. These boundaries enclose the area overflown by aircraft at altitudes sufficiently low to create problems from aircraft noise. The most severely affected areas located adjacent to the airport are identified in Section 5 as maximum impact areas requiring mandatory noise insulation for any land use changes. Any new residential development in this maximum impact area should be recommended for multi-family use with appropriate noise insulation in the structures.

Acoustical insulation procedures appropriate to the specific aircraft noise environment should be made available as part of the disclosure process for building applications.

APPENDIX A

AIRCRAFT FLIGHT PATTERNS AT TORRANCE MUNICIPAL AIRPORT

AIRCRAFT FLIGHT PATTERNS

Flight patterns at Torrance have been adjusted in recent years with the objective of avoiding conflicts between flight operations and residential land use in the community. Exhibit A-1 presents the flight procedures currently recommended by the City of Torrance.

The two runways at Torrance are oriented in a northwest/southeast direction. Runway 11L/29R is 5,000 feet long. Runway 11R/29L is separated from the principal runway by 500 feet and is 3,000 feet long. The estimated distribution between runways is based on the prevailing weather and traffic conditions (see Exhibit A-1.)

Although recommended flight patterns are described in detail as shown in Exhibit A-1 actual flight patterns flown by the pilots are found to vary considerably. In order to determine the location of the actual aircraft flight tracks over the ground, a three day survey was conducted using the FAA radar monitor located at the Coast TRACON radar center. Actual tracings of radar targets were developed as aircraft approached and departed the Torrance Airport. As tracings were being developed, a spotter at the airport recorded each aircraft identification and type. This allowed aircraft types to be associated with each track developed. Additionally, aircraft which transmitted with a Mode C transposer displayed radar targets with alpa-numeric data, allowing aircraft altitude information to be collected. The results of the radar tracings are shown in Exhibit A-2.

An evaluation of the actual flight track tracings revealed several interesting features. First, the flight patterns flown are obviously not consistent among the pilots nor do they strictly adhere to the recommended procedures described in Exhibit A-1. For example,

EXHIBIT A-1

NOISE ABATEMENT ARRIVAL/DEPARTURE & PATTERN PROCEDURES
VFR ONLY

All Arrivals/Departures and Patterns are Monitored Continuously at 9 Monitor Sites
(Random Monitoring Occurs in Other Residential Areas)

In the interest of safety, traffic flow and noise abatement during VFR conditions, and unless:

- Required by the applicable distance from cloud criteria, or
- Required by the presence of other adverse weather phenomena, or
- Otherwise directed by ATC

We request you fly the following:
AIRPLANE

- Runway 29R
  Arrival:
  - Pattern Entry: Plan entry pattern midfield from Mobil Refinery and using Control Tower as the aiming point.
  - Straight In: Recommend at least 1500' MSL until reaching Union 76 sign inbound (during hours of Tower operation expect straight in to 29L).
  - * : Recommend at least 1500' MSL until intercepting VASI.

  Departure:
  - North: Best rate of climb, 45° right turn prior to Hawthorne Blvd., cruise climb power and climb to 1500' MSL.
  - Straight Out: (Non-Standard) Best rate of climb to Hawthorne Blvd.; after Hawthorne Blvd. cruise climb power and climb to 1500' MSL before turning on course. No turns prior to shoreline.

- Runway 29L
  Arrival:
  - Straight In: Recommend at least 1500' MSL until reaching Union 76 sign inbound.
  - * : Recommend at least 1500' MSL until intercepting VASI. Avoid flying south of 29L centerline due to higher terrain.

  Departure:
  - Straight Out: Best rate of climb to Hawthorne Blvd.; after Hawthorne Blvd. cruise climb power and climb to 1500' MSL. No turn prior to shoreline. Avoid overflying hill to south due to rising terrain.

EXHIBIT A-1
(continued)

- Runway 11R
  Arrival:

Straight In:	Recommend at least 1500' MSL until reaching shoreline inbound. Avoid flying south of 11R centerline due to higher terrain.
* :	Recommend at least 1500' MSL until intercepting VASI. Avoid flying south of 11Rcenterline due to higher terrain.

  Departure:

Straight Out:	Best rate of climb to Crenshaw Blvd. After Crenshaw Blvd. cruise climb power and climb to 1500' MSL. Avoid overflying hill to south due to rising terrain.

- Runway 11L
  Arrival:

Pattern Entry:	Plan entry pattern midfield from Harbor General Hospital area using the Control Tower as the aiming point.
Straight In:	Recommend at least 1500' MSL until reaching shoreline inbound (during hours of Tower operation expect straight in to 11R).
* :	Recommend at least 1500' MSL until intercepting VASI.

  Departure:

North:	Best rate of climb, 45^{o} left turn prior to Crenshaw Blvd.; cruise climb power and climb to 1500' MSL.
Straight Out: (Non-Standard)	Best rate of climb to Crenshaw Blvd.; cruise climb power and climb to 1500' MSL before turning on course.

- 29R/11L Traffic

Pattern:	Best rate of climb. Conditions permitting, turn prior to airport boundary. Keep downwind leg over industrial area as close to airport as possible. Recommended pattern altitudes: single engine 700' AGL; Twin engine 1500' AGL.

In addition, we recommend:

- All departing twin-engine aircraft and those single engine aircraft at maximum GWT utilize 29R/11L.
- Avoiding overflight of Palos Verdes Hill to south due to rapidly rising terrain.
- Higher altitude over beach and cliff area from El Segundo south to Marineland due to lack of emergency landing areas. (Note applicable FAR's regarding terrain clearance.)

EXHIBIT A-1
(continued)

*NOTE: Check appropriate publications for activation of VASI. Prior to activation maintain at least 3^{o} approach angle.

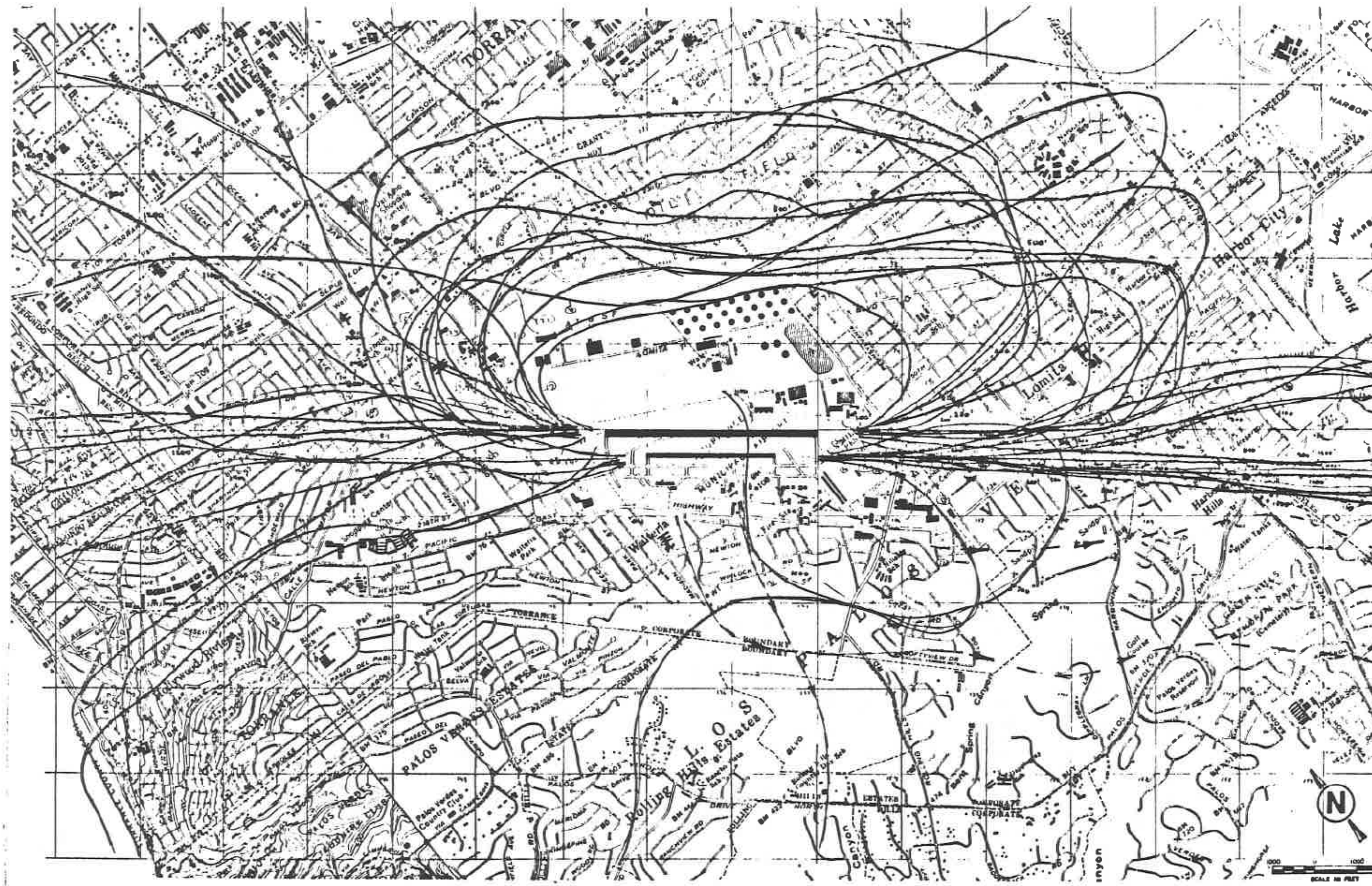


EXHIBIT A-2 RADAR TRACINGS OF GROUND FLIGHT TRACKS straight-out departures from Runways 29L and 29R do not appear to be following the recommendation to avoid turns prior to the shoreline. Based on the tracings collected, it appears pilots display a tendency to begin turning south before reaching the shoreline in order to shorten their route of flight.

Evaluation of the local pattern tracks reveals the local pattern north of the airport is not rectangular in shape, but rather wider at the southeast end. Logic seems to support this in the (1) the pilots most likely are influenced by the alignment of surface streets and property boundaries, and (2) pilots may have a tendency to fly a wider turn in a right-hand pattern to allow more time to align the aircraft on the base and final approach legs prior to landing. This results from the fact that the pilot in command usually sits in the left seat of the aircraft and has a slightly poorer view of reference points in a right-hand pattern.

One segment of the aircraft flight paths of primary concern was the point west of the airport where itinerant operations and local touch and go operations diverge. This occurs at the approximate location of Remote Monitor Station Number One (RMS-1). The concentration of flights over this section of the residential community requires an accurate location of the various flight paths in order to produce a realistic description of aircraft noise exposure in the area. For this reason, a series of observations was conducted at RMS-1 to supplement the radar tracking data. Calibrated photographs were taken to aid in assessing aircraft altitudes as they passed over this location.

A final point illustrated by the flight track analysis concerns the straight-in approach patterns flown to Runways 29L and 29R. These tracks do not appear to follow the extended runway centerline as first might be expected, but rather appear to cross at a distance of roughly one mile east of the runway ends. This can possibly be attributed to either Air Traffic Control directives or to pilot techniques on final landing approach.

When developing the input data for the computerized noise prediction model, the actual flight tracks illustrated in Exhibit A-2 were consolidated into a set of representative, or nominal, flight tracks. These tracks were tailored to reflect the actual geometry indicated by the radar tracings. The nominal flight tracks are shown in Exhibit A-3.

FLIGHT PATH DISTRIBUTIONS

After developing a set of nominal flight tracks describing the typical flight pattern at Torrance, aircraft operations are distributed among the tracks based on a set of generalized assumptions. These assumptions were developed with the guidance of Torrance FAA control tower personnel and noise abatement center representatives. Exhibit 2-1 from this report lists the basic assumptions utilized in assigning the flight operations to specific tracks. The assumptions listed in Exhibit A-4 are combined with the assumptions listed in Exhibit 2-1 to calculate flight operations for each nominal track. Operations for each track are further categorized by day, evening, and night periods and by the two fixed wing aircraft types previously described. These data are then coded and utilized in the noise prediction computed model.

EXHIBIT A-3

TORRANCE MUNICIPAL AIRPORT
ANCLUC STUDY

NOMINAL GROUND FLIGHT TRACKS

TORRANCE MUNICIPAL AIRPORT
TORRANCE, CALIFORNIA

AIRPORT NOISE CONTROL
AND
LAND USE COMPATIBILITY
(ANCLUC)

SPEAS ASSOCIATES

EXHIBIT A-4

TORRANCE MUNICIPAL AIRPORT
FLIGHT TRACK DISTRIBUTION ASSUMPTIONS

- Runways 29

Arrivals:	60 percent arrive from harbor area 40 percent arrive from north side Runway 29L has 50 percent arrivals from north and 50 percent arrivals from south Runway 29R has 40 percent arrivals straight in and 60 percent downwind entries
Departures	60 percent depart right runway 40 percent depart left runway Runway 29R has 50 percent straight-out and 25 percent downwind and 25 percent to LAX area Runway 29L has 80 percent straight-out and 10 percent right downwind, and 10 percent crosswind
Touch & Goes:	99 percent of touch and goes occur in northeast pattern 1 percent of touch and goes occur in southwest pattern

- Runways 11

Arrivals:	50 percent arrive right runway 50 percent arrive left runway 50 percent arrive straight-in 50 percent arrive downwind No downwind entry is assumed for Runway 11R
Departures:	65 percent depart right runway 35 percent depart left runway Runway 11R has 80 percent straight-out and 20 percent left turn Runway 11L has 40 percent downwind, and 60 percent easterly.
Touch & Goes:	100 percent of touch and goes occur in northeast pattern

APPENDIX B

AIRCRAFT NOISE ANALYSIS METHODS

This Appendix includes a brief review of the characteristics of aircraft noise and some of the terms used in the description and analysis of these sounds. A discussion of factors related to building noise control procedures is also included. The glossary of terms at the end of this section will supplement the definitions presented in the discussion.

Aircraft Noise Exposure

In the most basic terms, any noise may be characterized as sound pressure as a function of frequency, i.e., a pressure level (in decibels or dB) for each frequency (in cycles per second or Hertz, abbreviated Hz) present in the sound. A quantitative description of these parameters describes the basis of the subjective qualities of loudness and pitch, respectively. These are the components of the noise which, together with the duration of the sound, are most essential to the evaluation procedure. If pressure values for each frequency are plotted, a sound spectrum is described. This specifies the character of the noise for a single point in time.

It is also possible to specify the aircraft noise by incorporating the spectral (frequency) information into a single number. This is done by applying weighting characteristics to the noise spectrum similar to the response of the human hearing mechanism. This quantity, which may be measured directly with an instrument, is designated as the A-weighted sound pressure level with scale division of A-weighted decibels (dBA). Using this technique, the approximate subjective loudness of different aircraft noise spectra may be estimated. These instantaneous dBA values may be integrated or summed over the brief audible duration (typically 20-40 seconds) of an aircraft overflight to produce what is termed a Sound Equivalent Level (SEL) expressed as a time-integrated dBA value. This represents the acoustic energy from a single aircraft flight received at a designated observation point on the ground. This introduces the concept of the equivalent sound level (LEQ), defined as the constant level that, over a specified time period, produces the same amount of acoustic energy as an actual time-varying sound such as aircraft noise.

These SEL values are summed over a selected time period, in the case of aircraft noise 24 hours, to produce the composite values which are one of the principal products of this study. These values are presented as isolines of equal noise levels around the aircraft ground flight tracks. It is most important to keep in mind that the development of a precise energy summation value for aircraft noise is predicted on the actual continuous measurement of sound levels in accordance with the technical specifications for a measurement/integrating system set forth by the United States Environmental Protection Agency (EPA). This is a prohibitively expensive procedure for most airports. Even for those airports capable of supporting an aircraft noise monitoring system, the number of measurement stations is relatively limited. Considering the large areas of interest around the airport, this results in somewhat limited information on the aircraft noise environment.

The alternative is to utilize a series of assumptions relating to the noise sources (aircraft), their locations and sound propagation under local conditions to predict the energy equivalent values. These predictions may then be verified through a series of selected sound level measurements around the airport. The requirements for monitoring equipment and personnel time are such that even this limited verification technique may be expensive and usually dictates a simplified estimation procedure. The assumptions required in the estimation procedures are discussed in the body of the report and are presented in further detail in this Appendix.

A variety of energy summation scales have been developed throughout the world for the purpose of rating aircraft noise. The first scale in the United States which used the time-integrated A-weighted Sound Pressure Level as an aircraft noise descriptor was developed for the State of California Airport Noise Law.

The Daily Community Noise Equivalent Level (CNEL) is given in the California Airport Noise Standard (Title 4, Subchapter 6) as:

$$CNEL = 10 \log 1/24 \left[\sum \text{antilog} \frac{HNLD}{10} + 3 \sum \text{antilog} \frac{HNLE}{10} + 10 \sum \text{antilog} \frac{HNLN}{10} \right]$$

Where: HNLD are hourly noise levels 0700-1900 hours
HNLE are hourly noise levels 1900-2200 hours
HNLN are hourly noise levels 2200-0700 hours

If the HNL values are not measured and integrated directly, it is necessary to rely on some simplifying assumptions to develop estimates to be used in the CNEL computation.

This basic analysis method, utilizing the time-integrated dBA descriptor, was adopted on a national scale in the United States as the Average Day-Night Sound Level (LDN). The LDN scale differs slightly from the

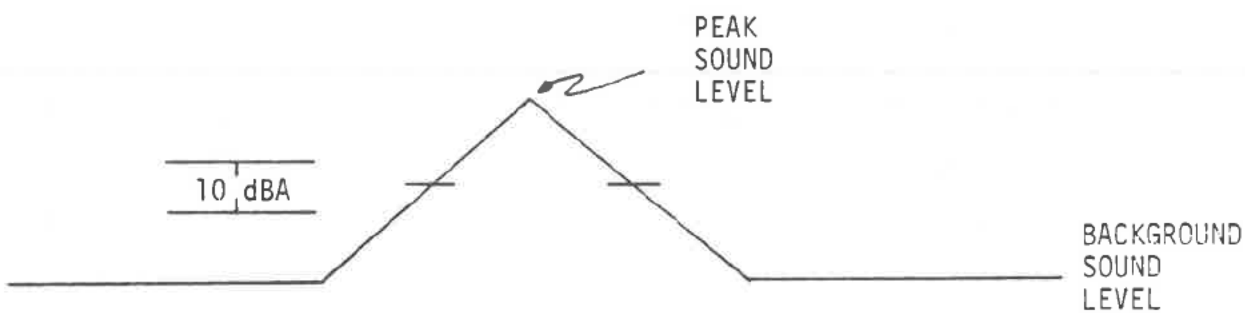
CNEL procedure in that the evening weighting period from the CNEL is assigned to the day hour (unweighted) period in the LDN method. The LDN value is then computed by:

$$LDN = 10 \log_{10} \left[0.625 \times 10^{(1_d/10)} + 0.375 \times 10^{(L_n + 10/10)} \right] dB$$

Where: L_d = LEQ for day hour period (0700-2200)
L_n = LEQ for night hour period (2200-0700)

Again, if the LEQ values are not obtained through continuous measurements, estimating procedures must be used to predict the LDN values at a specified observer location. Both the LDN and CNEL values are available for the FAA Integrated Noise Model (Aircraft Noise Prediction Model).

The noise from an aircraft flyover may be described graphically in terms of the so-called pressure time history of the noise event. This displays the series of instantaneous sound pressures (levels) as a function of time. This series of sound pressures includes continuous fluctuations above and below an increasing average value. If these small rapid flucturations are averages, then the pressure time history may be reasonably represented as a triangular pattern similar to the one shown below:



Under actual conditions, this pattern varies slightly for each different operation, even for the same aircraft. The only practical approach to an estimating procedure is to assume the patterns are the same, at least for broad categories of operations such as landing, takeoffs or stationary ground engine runups. If this pressure time history pattern is fixed, then a single function for SEL vs. distance may be developed for each category of operations.

The process of developing an SEL value from the flyover event requires a definition of the duration or integrating period. This period is closely approximated by the time (in seconds) during which the sound levels are within 10 dBA of the peak sound level. The effective integrating duration (D_{eff}) for a triangular pressure is approximately ½ the total duration specified above. This produces a relationship between the SEL and the peak sound level.

$$SEL = \text{Peak Sound Level} + 10 \log D_{eff}$$

The one hour LEQ and LDN values for aircraft noise represent an average one second level over 3,600 or 86,400 seconds, respectively. Accordingly, the LEQ is given by:

$$LEQ = SEL + 10 \log n - 35.6 \text{ (dBA)}$$

Where: n = number of operations per hour

This value is readily estimated for a single aircraft type on a single flight path. The values for multiple aircraft types on multiple flight paths are then summed on an energy basis to obtain a composite one hour LEQ at a specified location. This is accomplished by summing sequentially (from the lowest pair to the highest) all separate LEQ values using the expression:

$$L_T = L_1 + 10 \log \left[1 + 10^{-\left(\frac{L_1 - L_2}{10}\right)} \right]$$

Where: L_T = combined level for two sounds
L_1 = highest of two sound levels
L_2 = lowest of two sound levels

It is more expedient to estimate the LDN value directly using the expression:

$$LDN = SEL + 10 \log N_{eq} - 29.4$$

Where: N_{eq} = equivalent daily operations obtained by weighting the night (x10) flights then recombining with the day flights.

This provides an LDN value for single aircraft types on single flight paths. The total or combined LDN is obtained through the summing procedure described above.

Building Noise Control

The variation in human response to noise and the differences in priorities among local governments illustrate the need for some flexibility in land use planning around airports. There are transitional areas between obviously unacceptable aircraft noise environments and those properties completely unaffected by the noise from flight operations. One of the techniques used to resolve conflicts in this region is the addition of structural noise control procedures to residential units. This can produce an acceptable living environment for those individuals who are less sensitive to the negative impact of aircraft noise. Even within the general procedure of building noise control, there are graduations of treatment depending on proximity to the noise source. The general planning procedures are outlined in this section. Each of the structural elements identified may be designed for varying amounts of noise reduction (at varying costs) depending on the requirements of a specific location.

Exterior Walls

- Surface Weight
- Depth
- Finishing
- Interior Surface
- Sheathing
- Insulation

Windows

- Thickness/Multiple
- Weather Stripping
- Sealants
- Total Area

Doors

- Structure/Thickness
- Sliding Door Specifications
- Glazing
- Perimeter Treatment

Ceilings

- Joists/Ceiling Material
- Insulation

Floors

- Material
- Openings

Ventilation

- Mechnical Systems
- Fan Specifications
- Baffle Plates
- Gravity Vent Openings
- Duct Lining
- Fireplaces

Specification for each of these structural elements may be progressively increased depending on the noise reduction (NR) required for a specific location. The range of combination for selected NR values should be incorporated into the building code and be subject to verification when specified. This could be accomplished by setting forth a set of specification, for example, for NR values of 25, 30 and 35 dBA. The typical residential structure (without special noise control design) will provide approximately 15-20 dBA of sound attenuation, which is insufficient to exclude the higher level intrusive aircraft noises.

APPENDIX C

NOISE CONTROL IN STRUCTURES

NOISE CONTROL IN STRUCTURES

The basic idea behind the techniques for limiting a person's exposure to aircraft noise is simple and straightforward. The elements in noise reduction are the aircraft sound source, the sound wave path, and a sound wave receiver which, in common circumstances, is an ear or a microphone that is used for measurement.

The best means of reducing noise levels is to reduce the source sound output. This approach receives a substantial amount of attention at TOA in the form of attempts to eliminate the noisier aircraft from the airport as well as training pilots to operate their aircraft in the quietest possible manner. In dealing with noise control in structures, there is an attempt to partially block the sound pathway, thereby reducing the indoor noise levels.

Sound can reach a listener's ears by several different routes. The most obvious for internal noise sources is the direct path, a straight line through the air from source to receiver. In a given structure, reflections from walls, ceiling, floor, or any solid objects may contribute as much or more to the sound pressure level than the direct path. As sound travels through solids and air, it may travel an indirect route through floors and walls and arrive at the receiver after reradiation.

Paths for external sound include penetration through and/or around open or closed doors, partitions, walls, windows, roofs, ceilings and floors. The effectiveness of a well-designed acoustical wall can be largely destroyed by the presence of a relatively small opening.

In actual conditions when a sound wave strikes a surface it is partially reflected, partially transmitted through the surface, and partially absorbed. These interactions of sound waves and surfaces will be examined in turn.

The practical approach to noise control takes into account the noise sources, paths, and receivers. The following items must be determined successively to accomplish noise control:

1. Noise criteria for each occupied space.
2. Sound power level of the noise produced by each source.
3. Noise levels at typical employee positions in that space.
4. Attenuation of the noise by walls, ducts, etc., between each source and the space in question.
5. Required additional attenuation (Item 3 minus Item 1).
6. Identify aircraft noise source characteristics and select noise control treatment.
7. Any special mountings of the devices necessary to control flanking noise.
8. Any noise induced structural vibrations which may be transmitted to some other structural member causing it to become a noise radiator.

Since there is a situation where the acoustical properties of an item are frequency dependent and there are many numbers to describe these properties, it is desirable to reduce these data to a single number. In the case of TL[1/] properties, this single-number rating is called Sound Transmission Class (STC). The STC is determined by comparing the set of transmission losses at all 16 frequencies to a set of standard STC contours as decribed in ASTM[2/] Standard E413-70T "Tentative Classification for Determination of Sound Transmission Class." Briefly stated, the STC contour must be chosen which fits

1/ TL - Transmission Loss: Reduction in sound pressure level transmitted through a panel.

2/ ASTM - American Society for Testing Materials

TABLE C-I

SOUND TRANSMISSION CLASS
OF SOME COMMON BUILDING MATERIALS

Material	STC
24-gauge steel	26
1/8-inch plate glass	28
1/4-inch plate glass	30
3/16-inch steel plate	35
4-inch two-cell concrete block	41
4-inch two-cell concrete block (filled with sand)	43
Two layers of 5/8-inch gypsum board on 2x4-inch studs 16 inches on center	43
8-inch lightweight hollow concrete block	46
8-inch hollow core concrete block	50
4-inch brick wall with 1/2-inch plaster	50
8-inch brick wall	52
6-inch dense concrete	54
12-inch brick wall	59

the TL curve in such a way that in no event is the TL curve more than 8 dB below the STC contour at any frequency, and the sum of the deviations of the TL values which are below the contour shall not exceed 32 dB. The highest contour to which the specimen TL curve can satisfy these requirements is used as the STC curve. The value of this curve at 500 Hz is then chosen as the STC of the specimen.

The STC values of some common materials are shown in Table C-I. The values shown in Table C-I are representative because the weights and densities of these materials vary and some of the items are porous even though they are heavy.

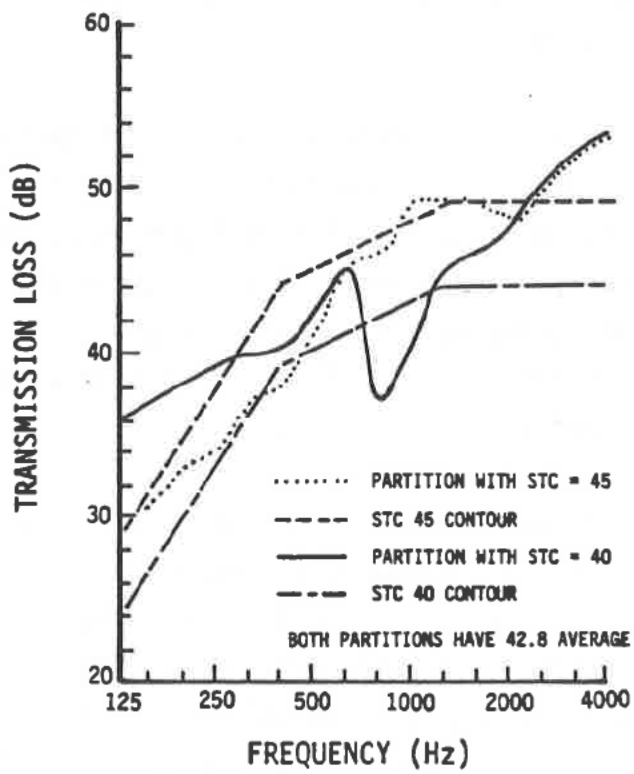
In general these curves provide a good comparison between specimens, but due to the way deviations from the standard curve are handled poor comparisons can be made as shown in Exhibit C-1. The partition shown by the solid line has TL values that are higher than those for the dashed curve except between about 600 to 2000 Hz and yet has a STC 5 dB lower than for the dashed curve. This only points out that STC is a convenience and should be used with care in selection of any particular item.

WALLS AS BARRIERS

In general, walls can be classified as nonload-bearing partition-type walls, load-bearing, and masonry type walls. Masonry walls are made up of bricks, or various types of concrete and may be plastered or painted.

Plasterboard walls are relatively light, inexpensive, and easy to erect. A typical plasterboard wall consists of two plasterboard leaves, separated by an air space and a system of studs or framing members. The sound transmission loss of such as wall depends on the

EXHIBIT C-1. DETERMINATION OF SOUND TRANSMISSION CLASS



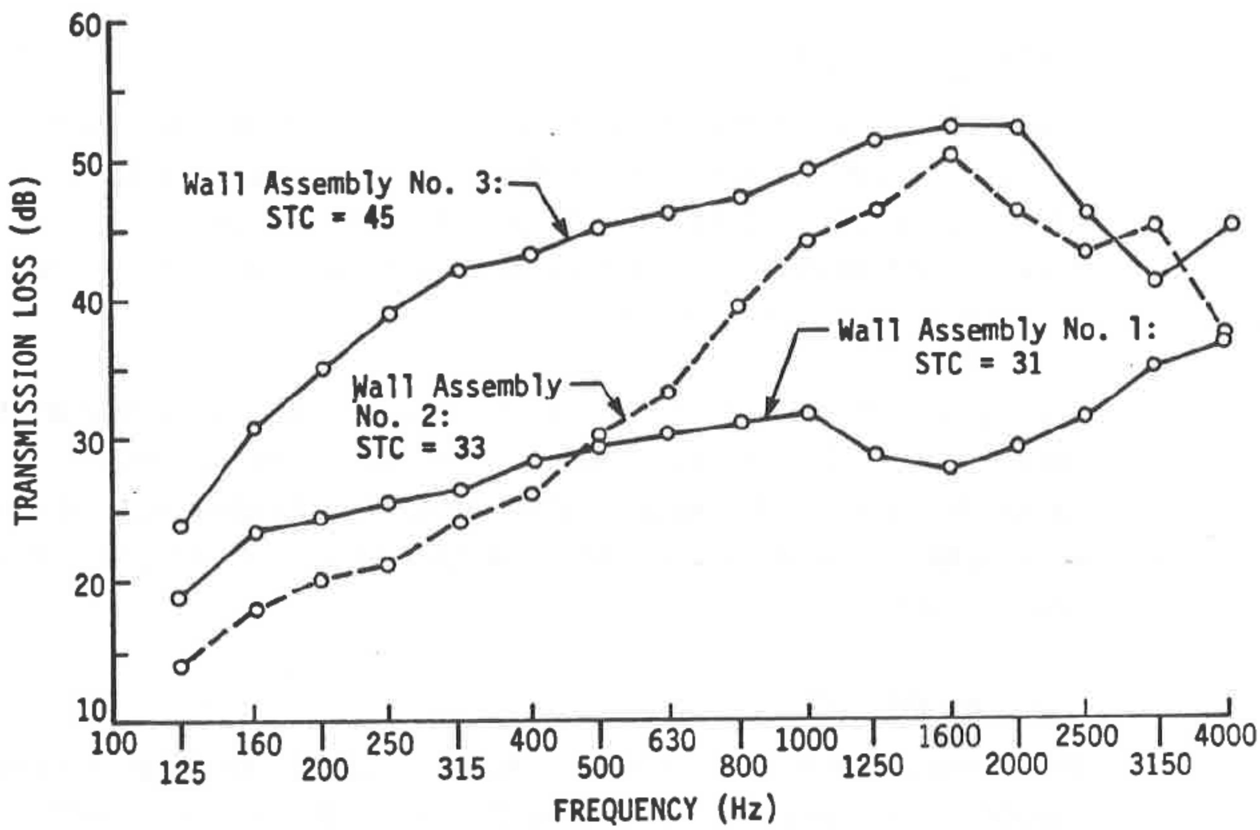
transmission losses of the individual leaves and on the degree of coupling introduced by the intervening air space and stud system. The studs can sometimes act as vibration conductors and thus may degrade the performance of a wall assembly. If the studs have low torsional rigidity (e.g., steel channels) transmission via the studs appears to be negligible. If proper construction techniques are used, it is possible to get a transmission loss greater than that predicted by the mass law. The main factor in achieving this enhanced performance is to construct what is referred to as a "double wall." In a double wall arrangement the two sides of the wall are independent of each other (there are no connecting braces, and each side uses its own set of studs).

Exhibit C-2 shows the transmission losses of three wall assemblies as functions of frequencies. Wall assembly number 1 has the lowest STC even though its density is slightly higher than the other two assemblies. It can be seen from the figure that a significant increase (14 dB in this case) in transmission loss can be achieved by separating the two leaves of a wall and putting a sound absorbent batt in the wall cavity.

Load-bearing walls made from concrete or bricks are heavier than the plasterboard wall and consequently they can provide increased sound attenuation. For instance, the Brick Institute reports STC from 39 to 59 for specific walls made from structural clay tiles or bricks, with their weights ranging from 107.41 to 566.36 kg/sq.m. (22 to 116 lb/sq.ft.). Concrete walls also provide similar attenuation and in general the dense, heavyweight concrete walls perform better than the lightweight concrete walls, particularly at low frequencies.

In addition to plasterboard and masonry many other types of wall materials are used and the wall construction also ranges from a

EXHIBIT C-2. IMPROVEMENT IN WALL TRANSMISSION LOSS BY SPACING SIDES, AND BY ADDING ABSORBING MATERIAL IN THE CAVITY.



Wall Assembly No. 1: Two layers of 1/2 -inch plasterboard with joint compound. Weight--4.6 lb/sq.ft.

Wall Assembly No. 2: Two 1/2-inch plasterboard leaves with 3-5/8-inch space, no studs. Weight--4.2 lb/sq.ft.

Wall Assembly No. 3: Two 1/2-inch plasterboard leaves with 3-5/8-inch space, 2-inch thick absorption. Weight--4.2 lb/sq.ft.

simple brick wall to walls with a complex stud system combined with acoustical and thermal batts. Plywood, hardboard, steel, etc., are other commonly used wall materials. In all cases, it can be said that increased mass and decreased coupling between different components along the path of sound result in high transmission loss.

GLASS AS A BARRIER

Glass windows are often the weak link in an otherwise good sound barrier. Acceptable sound transmission loss can be achieved in most cases by a proper selection of glass. Mounting of the glass in its frame should be done with care to eliminate noise leaks and to reduce the glass plate vibrations.

Acoustical performance of glass is often improved by a laminated plastic inner layer or an air gap. Table C-II shows the comparison of STC values for glass and laminated glass of various thicknesses. Table C-II also compares the monolithic glass plate with air spaced glass of equal thicknesses.

DOORS AS BARRIERS

Sound transmission loss of a door depends upon its material and construction, and the sealing between the door and the frame. Most doors are of wood or steel construction with various stiffnesses and barrier batts added to hollow cavity inside the door if one exists. It is usually difficult to specify the STC of a door because the sealing between the door and the frame is not a precisely controlled variable. The variations in STC of two doors as the sealing was improved by increasing the deflection of gaskets, by adding extra gaskets, and by changing the gasket materials, are shown in Exhibit C-3. In each case, the improved sealing improves the performance such that the STC approaches its maximum possible value shown by the completely

EXHIBIT C-3. EFFECTS OF IMPROVED SEALING OF DOORS ON SOUND TRANSMISSION CLASS. (Based on a series of tests on two different types of door.)

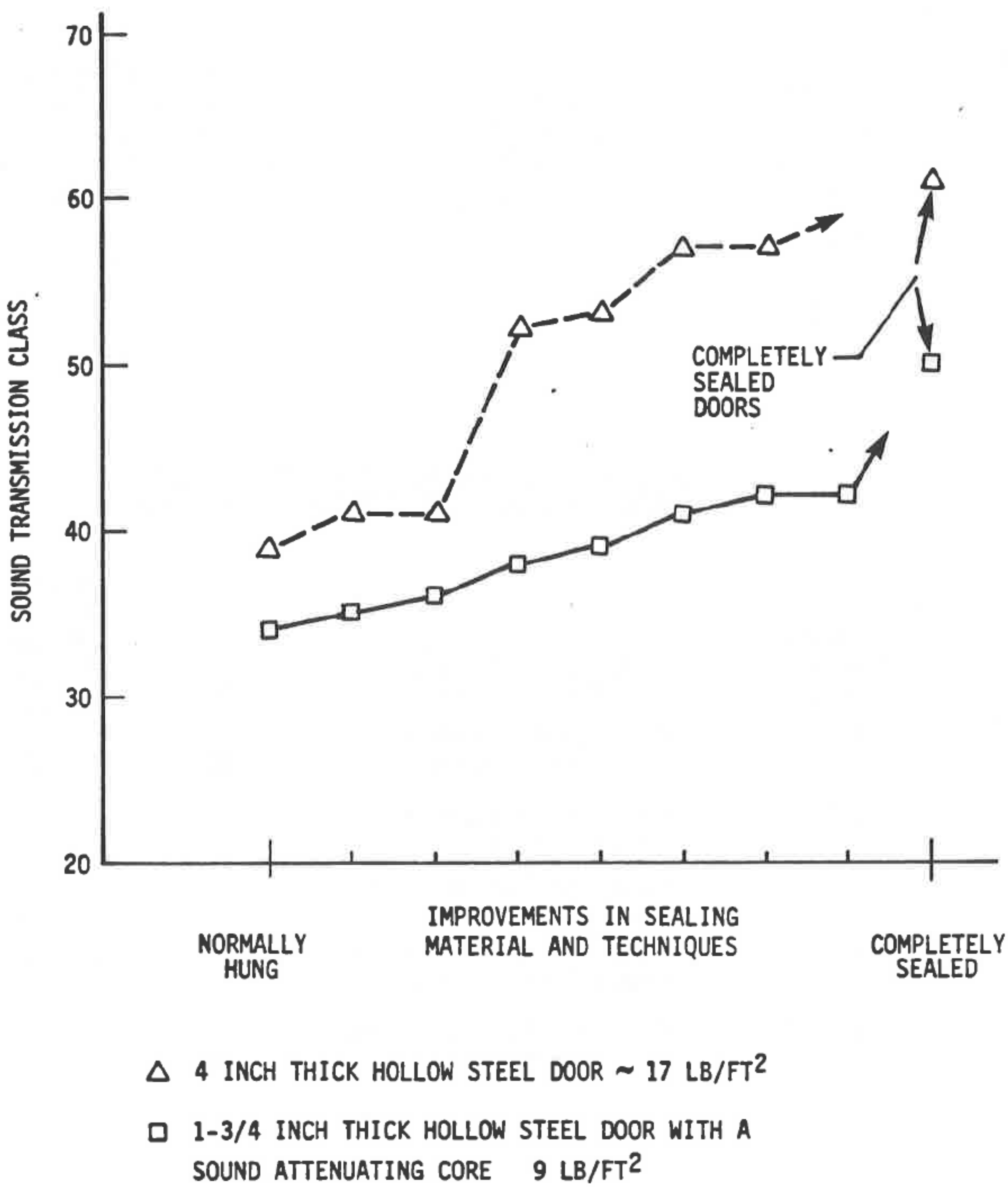


TABLE C-II

SOUND TRANSMISSION CLASS OF MONOLITHIC AND LAMINATED GLASS

Overall Thickness Inch	Monolithic Glass STC	Two Equally Thick Layers Glass With 0.030-Inch Plastic Inner Layer STC
0.125	23	--
0.25	28	34
0.5	31	37
0.75	36	41
1.00	37	--

SOUND TRANSMISSION CLASS OF AIR SPACED GLASS AND MONOLITHIC GLASS OF COMPARABLE THICKNESS

Overall Thickness Inch	Air Spaced Glass Construction	STC	Comparably Thick Glass Without Air Space STC
1.0	Two 0.25-inch plates with 0.50-inch airspace	32	31
1.5	Two 0.25-inch plates with 1-inch airspace	35	31
2.75	0.25- and 0.5- to 8-inch with 2-inch airspace	39	36
4.75	0.25- and 0.5-inch plates with 4-inch airspace	40	36
6.75	0.25- and 0.5-inch plates with 6-inch airspace	42	36

sealed case.

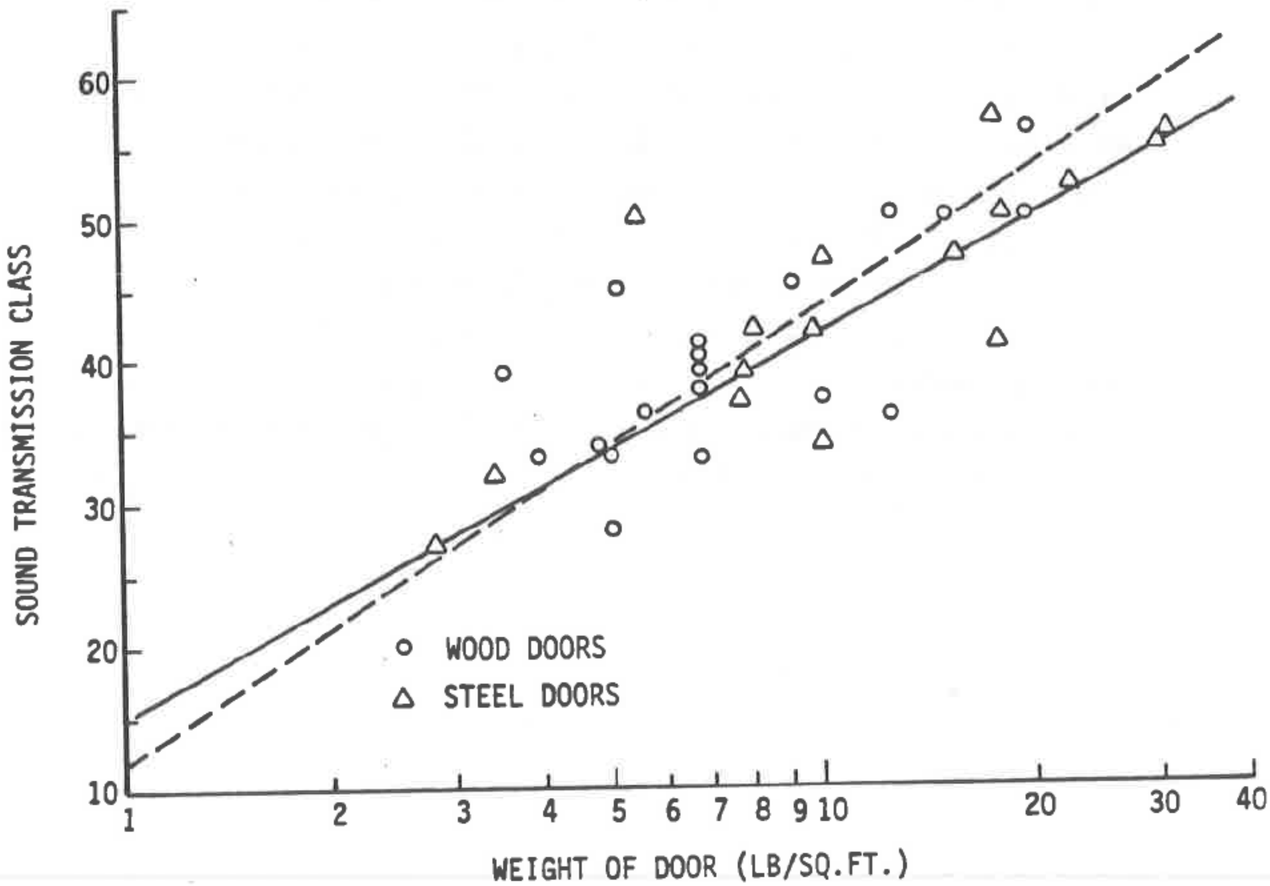
This figure points out improvements that can be made by attacking the weakest link. If better sealing does not offer sufficient improvement selecting a better door design becomes necessary. Generally, the heavier doors provide increased attenuation. Wood and steel doors behave essentially in a similar manner as shown in Exhibit C-4, which shows a form of the mass law dependence of STC on weight (in lb/sq.ft.) for wood and steel doors. These data which are based on many tests conducted in an acoustical laboratory, indicate an increase of 8 to 9 dB in STC for a doubling of the weight. Note: The effects of better design, better sealing, etc., are also reflected in this figure. The approximate relationships are:

For steel doors: $STC = 15 + 27 \log W$

For wood doors: $STC = 12 + 32 \log W$

where W = weight of the door in lb/sq.ft. It should be emphasized that these relationships are purely empirical and that large deviations may be possible for any given door.

EXHIBIT C-4. DEPENDENCE OF SOUND TRANSMISSION LOSS FOR DOORS ON WEIGHT



Approximate STC for wood door, STC = 12 + 32 log W, approximate STC for steel door, STC = 15 + 27 log W; where W = weight of the door in lb/sq.ft.

GLOSSARY AND ABBREVIATIONS

GLOSSARY AND ABBREVIATIONS

A-Weighted Sound Pressure Level (dBA) - A quantity, in decibels, read from a standard sound-level meter switched to the weighting network designated "A" with a slow response mode. The A-weighting network approximates the response of the human ear.

Air Carrier (Airline) - Aircraft operated by an airline that holds a certificate of public convenience and necessity issues by the CAB authorizing performance of scheduled air transportation over specified routes and a limited amount of non-scheduled service using large aircraft. Large aircraft means aircraft with more than 30 seats and a maximum payload capacity of more than 7,500 pounds.

Aircraft Mix - An arbitrary classification system which identifies and groups aircraft having similar operational characteristics for the purpose of computing runway capacity.

Air Navigational Facility (NAVAID) - Any facility used for guiding or controlling flight in the air or during the landing or takeoff of aircraft.

Air Route Surveillance Radar (ARSR) - Long-range radar which increases the capability of air traffic control for handling heavy enroute traffic. An ARSR site is usually located at some distance from the ARTCC it serves. Its range is approximately 200 nautical miles. Also called ATC Center Radar.

Air Taxi - Aircraft operated by a company or individual that performs air transportation on a scheduled or non-scheduled basis over either designated or unspecified routes, usually with light aircraft. Commuter flights are a special category of air taxi operations.

Airport Surveillance Radar (ASR) - Radar providing position of aircraft by azimuth and range data without elevation data. It is designed for a range of approximately 50 miles. Also called ATC Terminal Radar.

Airport Traffic Area - Unless otherwise specifically designated, that airspace with a horizontal radius of five statute miles from the geographical center of any airport at which a control tower is operating, extending from the surface up to but not including 3,000 feet above the surface.

Air Route Traffic Control Center (ARTCC) - A facility established to provide air traffic control service to aircraft operating on an IRF flight plan within controlled airspace and principally during the enroute phase of flight.

Airspace - The space lying above the earth or above a certain area of land or water which is necessary to conduct aerodynamic operations.

AGL - Above Ground Level.

ALS - Approach Light System.

Approach Control Service - Air Traffic control service provided by a terminal area traffic control facility for arriving and departing IFR aircraft and, on occasion, VFR aircraft.

ATC - Air Traffic Control.

ALP - Airport Layout Plan.

Based Aircraft - An aircraft permanently stationed at an airport, usually by some form of agreement between the aircraft owner and airport management.

CAB - Civil Aeronautics Board.

CY - Calendar Year.

Center's Area - The specified airspace within which an air route traffic control center provides air traffic control and advisory service.

Circling Approach - A descent in an approved procedure to an airport for a circle-to-land maneuver.

Commuter Airline - Aircraft operated by an airline that performs scheduled air transportation over specified routes using light aircraft in accordance with CAB Economic Regulation Part 298. Light aircraft means an aircraft having 30 seats or less and a maximum payload capacity of 7,500 pounds or less.

Constrained Operational Activity - Present or forecast aircraft activity which is limited due to economic, environmental, operational or physical factors.

Control Areas - These consist of the airspace designated as VOR Federal Airways, additional Control Areas, and Control Area Extensions but do not include the Continental Control Area. Control zones that do not underlie the continental control area have no upper limit. A control zone may include one or more airports and is normally a circular area with a radius of five statute miles and any extensions necessary to include instrument departure and arrival paths.

Control Tower - A central operations facility in the terminal air traffic control system consisting of a tower cab structure (including an associated IFR room if radar equipped) using air/ground communications and/or radar, visual signaling, and other devices to provide safe and expeditious movement of terminal air traffic.

Control Zones - These are areas of controlled airspace which extend upward from the surface and terminate at the base of the continental control area. Control zones that do not underlie the continental control area have no upper limit. A control zone may include one or more airports and is normally a circular area with a radius of five statute miles and any extensions necessary to include instrument departure and arrival paths.

Controlled Airspace - Airspace designated as continental control area, control area, control zone, or transition area within which some or all aircraft may be subject to air traffic control.

Clear Zone - Inner portion of runway approach zone.

Decibel (dB) - An increment on a logarithmic scale for the measure of sound pressure or sound power. Zero on the decibel scale corresponds to a standard reference pressure (20uPa) or power (10^{-12} watt).

dBA - Reference to A-Weighted Sound Pressure Level.

Enroute - The route of flight from point of departure to point of destination, including intermediate stops (excludes local operations).

Enroute Airspace - Controlled airspace above and/or adjacent to terminal airspace.

FAA - Federal Aviation Administration.

FAR - Federal Aviation Regulation.

Final Approach IFR - The flight path of an aircraft which is inbound to the airport on an approved final instrument approach course, beginning at the point of interception of that course (Final Approach Fix) and extending to the airport or the point where circling for landing or missed approach is executed.

Flight Service Station (FSS) - A facility operated by the FAA to provide flight assistance service.

FY - Fiscal Year.

FBO - Fixed Base Operator.

Fleet Mix - The proportion of aircraft types or models expected to operate at an airport.

Full-Stop Landing - Descriptive of a landing aircraft which completes an approach by exiting a runway (see touch-and-go operations.)

GA - General Aviation - Refers to all civil aircraft and operations which are not classified as air carrier.

Glide Slope (GS) - The vertical guidance component of an ILS.

HGRS. - Hangars

Instrument Approach - An approach conducted while the final approach fix is below VFR minimums.

IFR - Instrument Flight Rules that govern flight procedures under IFR conditions (limited visibility or other operational constraints).

Instrument Operation - The arrival or departure from an airport of an aircraft operating in accordance with an IFR Flight Plan or the provision of IFR separation from other aircraft by a terminal traffic control facility.

Instrument Landing System (ILS) - A precision landing aid consisting of localizer, (azimuth guidance), glide slope (vertical guidance), outer marker (final approach fix), and approach light system.

Inverse Square Law - Describes the reduction in sound pressure where the mean square sound pressure changes in inverse proportion to the square of the distance from the source. Under this ideal condition, the sound pressure level decreases 6dB with each doubling of distance from the source.

Itinerant Operation - All aircraft arrivals and departures other than local operations.

LOC - Localizer (part of an ILS).

LOM - Compass locator at an outer marker (part of an ILS). Also called COMLO.

Local Operation - Operations performed by aircraft which: (a) operate in the local traffic pattern or within sight of the tower; (b) are known to be departing for, or arriving from, flight in local practice areas located within a 20 mile radius of the control tower, or (c) execute simulated instrument approaches or low passes at the airport.

Low Altitude Airways - Air routes below 18,000 feet MSL. They are referred to as Victor Airways.

Low Level Airspace - The airspace in the immediate vicinity of an airport within which aircraft maneuver to approach or depart a facility.

LRR - Long-range Radar.

LDNG. AIDS - Landing Aids.

Leq - Equivalent Sound Level - The equivalent A-weighted sound level for a specified period of time.

Ldn - Day-Night Average Sound Level - The 24 hour equivalent sound level (Leq) with a 10-decibel penalty applied to nighttime (10 PM-7 AM) levels.

LTO Cycle - Landing Takeoff Cycle.

Marker Beacon - A VFR navigational aid which transmits a narrow directional beam. It is associated with an airway or an instrument approach.

Minimum Descent Altitude (MDA) - The lowest altitude, expressed in feet above mean sea level, to which descent is authorized on final approach or during circling-to-land maneuvering in execution of a standard instrument approach procedure where no electronic glide slope is provided.

Military Operation - An operation by military aircraft.

MM - Middle Marker (part of an ILS).

Movement - Synonymous with the term operation; i.e., a takeoff or a landing.

MSL - Mean Sea Level.

Master Plan - Long-range plan of airport development requirements.

Missed Approach - A prescribed procedure to be followed by aircraft that cannot complete an attempted landing at an airport.

NAS - National Airspace System - The common system of air navigation and air traffic control encompassing communications facilities, air navigation facilities, airways, controlled airspace, special use airspace and flight procedures authorized by FAA Regulations for domestic and international aviation.

NASP - National Airport System Plan.

NAVAID - See Air Navigation Facility.

NDB - Non-Directional Beacon - An electronic ground station transmitting in all directions in the L/MF frequency spectrum; provides azimuth guidance to aircraft equipped with direction finder receivers. These facilities are often established with ILS outer markers to provide transition guidance to the ILS system.

Noise - Noise is any undesired signal or, in acoustics, any undesired sound.

Noise Abatement - A procedure for the operation of aircraft at an airport which minimizes the impact of noise on the environs of the airport.

NA - Not Applicable.

NM - Nautical Mile.

OM - Outer Marker (part of an ILS).

Operation - An aircraft arrival at or departure from an airport.

PANCAP - Practical Annual Capacity.

PAR - Precision Approach Radar.

Positive Control Areas - Airspace wherein aircraft are required to be operative under Instrument Flight Rules.

Precision Approach - An instrument approach utilizing both vertical and horizontal guidance.

Radar Separation - Radar spacing of aircraft in accordance with established minima.

RAIL - Runway Alighment Indicator Light.

RNAV - See Area Navigation.

Registrations - Referring to ownership.

RCAG - Remote Center Air/Ground Communications.

REIL - Runway End Identification Lights.

Rotor - Referring to helicopters.

RVR - Runway Visual Range.

RW & R/W - Runway.

Separation Minima - The minimum longitudinal, lateral, or vertical distances by which aircraft are spaced through the application of air traffic control procedures.

Socio-Economic - Data pertaining to the population and economic characteristics of a region.

Sound - Sound is a pressure disturbance in an elastic medium and is associated with the auditory sensation evoked in living organisms.

Sound Level Meter - An instrument incorporating a microphone, an amplifier, an indicating meter and frequency weighting networks. This instrument is used to measure sound pressure levels.

Sound Pressure Level (SPL) - The SPL is defined as 20 times the logarithm of the ratio of a sound pressure to the reference pressure. The reference pressure is 2.0×10^{-4} dyne/cm2 or 20uPA.

Straight-In Approach - A descent in an approved procedure in which the final approach course alignment and descent gradient permits authorization of straight-in landing minimums.

SMSA - Standard Metropolitan Statistical Area.

Terminal Control Area (TCA) - This consists of controlled airspace extending upward from the surface or higher to specified altitudes within which all aircraft are subject to positive air traffic control procedures.

T-Hangar - A T-shaped aircraft hangar which provides shelter for a single airplane.

Terminal Airspace - The controlled airspace normally associated with aircraft departure and arrival patterns to/from airports within a terminal system and between adjacent terminal systems in which tower enroute air traffic control service is provided.

Traffic Pattern - The traffic flow that is prescribed for aircraft landing at, taxiing on, and taking off from an airport. The usual components of a traffic pattern are upwind leg, crosswind leg, downwind leg, and final approach.

TW & T/W - Taxiway.

Third Level - Used to refer to commuter service (see Commuter Airlines).

Threshold - The physical end of runway pavement.

TWR - Control Tower.

Transient Operations - That portion of itinerant operations performed by aircraft other than those based at the airport in question.

Transitional Airspace (Transition Area) - Areas designated to contain IFR operations in controlled airspace during portions of the terminal operation and while transitioning between the terminal and enroute environment.

Touch-and-Go Operation - An operation in which the aircraft lands and begins takeoff roll without stopping.

TVOR - Terminal Very High Frequency Omnirange Station.

TERPS - Terminal Instrument Procedures.

UHF - Ultra High Frequency

Uncontrolled Airspace - That portion of the airspace that has not been designated as continental control area, control area, control zone, terminal control area, or transition area and within which ATC has neither the authority nor the responsibility for exercising control over air traffic.

UNICOM - Radio communications station which provides pilots with pertinent airport information (winds, weather, etc.) at specific airports.

UA - Unavailable.

VASI - Visual Approach Slope Indicator providing visual glide path.

Vector - A heading issued to an aircraft to provide navigational guidance by radar.

VFR - Visual Flight Rules that govern flight procedures in good weather.

VFR Aircraft - An aircraft conducting flight in accordance with Visual Flight Rules.

VHF - Very High Frequency.

Victor Airways - See Low Altitude Airways.

VOR - Very High Frequency Omnirange Station - A ground-based radio (electronic) navigation air transmitting radials in all directions in the VHR frequency spectrum; provides azimuth guidance to pilots by reception of electronic signals.

VORTAC - Co-located VOR and TACAN.

VTOL - Vertical Takeoff and Landing (includes, but is not limited to, helicopters).