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# ECONOMIC IMPACT OF PROPOSED AIRPORT NOISE REGULATIONS, R77-4
## VOLUME II: ECONOMIC ANALYSIS OF PUBLIC AIRPORTS OUTSIDE CHICAGO

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# ECONOMIC IMPACT OF PROPOSED AIRPORT NOISE REGULATIONS, R77-4

# VOLUME II: ECONOMIC ANALYSIS OF PUBLIC AIRPORTS OUTSIDE CHICAGO

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<u>NOTE</u>

This report has been reviewed by the Institute of Natural Resources and approved for publication. With the exception of the Opinion of the Institute's Economic Technical Advisory Committee, views expressed are those of the contractor and do not necessarily reflect the position of the IINR.

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Opinion of the Economic Technical Advisory
Committee of the Illinois Institute of Natural Resources

The Economic Technical Advisory Committee (ETAC) has reviewed Volume II of the four-part study entitled ECONOMIC IMPACT STUDY OF PROPOSED AIRPORT NOISE REGULATIONS, R77-4. The Committee finds this section of the report to be in full compliance with Public Act 80-1218 (formerly Section 6 of the Environmental Protection Act). The Committee notes that Volume II submitted herewith contains the economic analysis of the proposed airport noise regulatory scheme on the 25 public airports outside Chicago. Part III of the analysis will be the engineering and technical study of O'Hare and Midway airports. Part IV (the last section) will focus on the economic impacts of the proposed regulations on O'Hare and Midway airports exclusively.

PREFACE

The Illinois Attorney General has proposed to the Illinois Pollution Control Board noise control regulations applicable to all publicly owned airports in the state. The regulations would establish limits on cumulative aircraft noise received at residential and other noise-sensitive properties near the airports. An airport producing noise in excess of the limits would require a variance to continue operations. To get a variance the airport proprietor would have to prepare and implement a noise control plan.

Under Illinois law, before the Pollution Control Board can act on the proposed regulations, it must receive from the Illinois Institute of Natural Resources an economic impact analysis of the proposal. The present study, being done under contract with the Institute, is intended to satisfy that requirement. The report, when complete, will consist of four major parts:

I. A technical study of public airports outside Chicago. This part became available in January 1981. It contains a detailed analysis of aircraft operations, land uses, and resulting noise impacts in the vicinity of each of twenty-one airports outside Chicago.

II. An economic analysis of noise abatement measures at the non-Chicago airports. This part is contained in the present volume. It examines the economic costs and benefits of implementing various noise abatement measures at the 12 airports that currently violate the proposed 1985 noise limit of 65 $L_{dn}$. As the data show, such benefits and costs can vary substantially according to the individual circumstances of an airport, including the development of nearby land.

III. A technical study of Chicago's O'Hare and Midway airports. The format of this part is similar to that of part I, except that the numbers and types of aircraft operations and the intensity of nearby land development make analysis more complex than for downstate airports.

IV. An economic analysis of noise abatement measures at O'Hare and Midway airports. The format is similar to that of part II. But the analysis differs from the earlier volume in many of its basic features, as well as in its details. Of course, the variety and dollar values of the benefits and costs, particularly those related to actions at O'Hare, will be much greater than in cases of airports outside Chicago.

Professors Roger W. Findley (law), Marvin Frankel (economics) and Paul D. Schomer (engineering), all of the University of Illinois at Urbana-Champaign, have cooperated in the overall design of the study. Particular individuals are responsible for the preparation of the separate reports: Dr. Schomer for volumes I and III, and Dr. Frankel for volumes II and IV.

Volume II, contained herein, has benefitted from the advise and suggestions of many individuals and groups. Messrs. Findley and Schomer have offered helpful counsel on a large number of issues. Members of the Illinois Public Airports Association, the Air Transport Association and the Institute's Economic and Technical Advisory Committee have contributed many constructive suggestions. Mr. Niels Herlevsen, the Project Officer, has provided continuing advise and support. Ms. Lise

Zwisler has given able and extensive assistance throughout, including the preparation of initial drafts for the sections on curfews, operations cutbacks, and the health and related effects of noise. The listed authors bear final responsibility for the contents of the volume, including any errors, omissions or other deficiencies that it may contain.

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## EXECUTIVE SUMMARY

The Illinois Attorney General has proposed that aircraft-generated noise at Illinois' public airports be limited to progressively lower levels over time - 80 $L_{dn}$ in 1979, 75 $L_{dn}$ in 1980 and 65 $L_{dn}$ in 1985. This study, building upon an earlier Technical Study, examines the effects of the Attorney General's proposal for public airports outside Chicago. Of the large number of such airports, only 12 are in current violation of the recommended limits. Several alternative abatement strategies are considered for these airports and, so far as possible, their costs are estimated. The benefits from abatement are also reviewed and estimates made of their magnitude.

The 12 airports are diversely situated with regard to the number of nearby dwellings above 65 $L_{dn}$. About 61% of all such dwellings are located at the Moline-Quad Cities Airport, and another 24% are at Peoria. Of the remaining 10 airports, 3 have from 34 to 54 affected dwellings and 6 have 25 or fewer such dwellings. Of all dwellings involved, 94.4% are located within 65-70 $L_{dn}$ and 5.4% are within 70-75 $L_{dn}$. Only 0.2% - 4 dwellings - are above 75$L_{dn}$.

The first of the abatement strategies considered, termed Level 1 methods, consists of (1) small changes in flight direction by jet aircraft after takeoff, so as to reduce travel over populated areas, (2) construction of noise-absorbing earth berms near runways, and (3) the use of preferential runways for jet takeoffs. Level 1 methods are applicable at only 4 of the 12 airports - Decatur, Moline-Quad City, Peoria and Springfield-Capital, with preferential runways suitable only at Decatur and Peoria. There is limited opportunity for the use of berms, and this approach is considered only for Peoria. Level 1 methods would serve to reduce the number of dwellings statewide (outside Chicago) subject to noise levels of 65 $L_{dn}$ or more by 75%, from 2575 to 607. Their aggregate cost would be approximately $311,000. However, the elimination of the berm at Peoria would reduce its cost to zero, while the number of dwellings remaining above 65 $L_{dn}$ would rise only modestly, from 607 to 717.

The insulation of homes represents a second approach to abatement, and it is assumed to be applied to the 607 homes remaining after the use of relatively low cost Level 1 methods. Some homes require insulation for up to 5 dB of quieting to bring their interior noise levels below 65 $L_{dn}$, while others require insulation for up to 10 or 15 dB of quieting. Insulation costs are estimated to average about $3300 per dwelling, for an aggregate cost of approximately $2.0 million, much of which should be recovered within perhaps ten years through reduced heating and air conditioning costs.

The acquisition of noise emission rights, or easements, rather than the actual reduction of noise, constitutes a third approach to the problem. Limited data suggest that the purchase of easements might cost 2.5% of property value for dwellings at 65-70 $L_{dn}$, with the cost rising to 17% of property value for dwellings at 75-80 $L_{dn}$. The (1978) cost for an average downstate Illinois dwelling would be about $1500, and the aggregate cost of easements for all dwellings remaining above 65 $L_{dn}$ after the application of Level 1 methods would be around $825,000. Thus, this approach, though it would not provide physical relief from noise, appears to be less costly than an insulation approach.

A fourth approach to the problem of aircraft noise is to clear the impacted land of dwellings by purchasing and demolishing them. This strategy is expensive, since it involves the payment of full market value for properties and possibly an added sum to cover relocation expenses for the occupants. Its aggregate cost, again following the use of Level 1 methods, would be about $29 million. The size of this figure suggests that a property acquisition program, if undertaken, should be limited to those dwellings with relatively high noise exposures.

An alternative to property acquisition would be a purchase-guarantee arrangement under which the airport authority would guarantee the market value of noise-exposed property. Should the owner elect to sell the property on the open market and be unable to obtain its fair market value, the airport authority would either purchase it from him for subsequent resale or else pay the difference between fair market value and the best market offer. Such a program would be far less expensive than one of property acquisition, and it could turn out to be a comparatively low cost strategy. However, this approach, like the insulation approach, would not satisfy the requirements of the proposed regulation.

Two additional noise-reducing strategies, night curfews and operations cutbacks of jet aircraft, are examined. Because of the complex set of repercussions generated by each of these strategies, estimates of their costs are not made. Both, but particularly operations cutbacks, represent comparatively severe methods for reducing noise. Their consequences might take the forms of passenger inconvenience and passenger diversion to other modes of travel; decreased profits for air carriers and other air service providers; a lessening of competitive advantage to Illinois firms using air transportation; and decreased ability of Illinois communities to attract new industry.

The costs of enforcing the proposed regulation would, in the first instance, fall upon three groups: the individual airport authorities, the Illinois Environmental Protection Agency, and the Illinois Pollution Control Board. The largest share of these costs would be borne by the airport authorities in responding to the reporting requirements of the regulation and the conditions for obtaining variances. Annual aggregate enforcement costs are tentatively estimated at $71,000. In light of the uncertainties as to the manner in which enforcement procedures would be carried out, the figure is subject to a significant margin of error.

The benefits from aircraft noise abatement can be evaluated in different but complementary ways. Noise is capable of producing a variety of adverse physical and related effects, including health effects. At downstate airports, these effects are essentially limited to varying degrees of speech interferences, sleep interference and annoyance. A reduction of noise to the 65 $L_{dn}$ level would bring significant relief from these effects to nearby residents.

## INTRODUCTION

Under Illinois law, the Attorney General's proposal to limit aircraft noise emissions at the state's public airports must be subjected to an economic impact analysis. The Technical Study of downstate airports constitutes the first part of this analysis. Utilizing preliminary data provided by the Illinois E.P.A., the study reviews the noise status of Illinois airports and identifies 24 of them as being in possible violation of the proposed noise standards. Two of these airports - O'Hare and Midway - are reserved for later, special study, and Chicago-Hammond is given only limited consideration because it has no jet operations. The Technical Study subjects the remaining 21 airports to further review, providing for each a detailed analysis of aircraft operations, land uses, and resulting noise impacts. Ultimately, 12 of the airports are found to be in current or prospective violation of the proposed noise standards. Three noise abatement methods are considered for these airports, and the effects of each method on the airports' noise contours and on the number of impacted dwellings are evaluated and presented.

This Economic Study, representing the second part of the required economic impact analysis, complements and builds upon the Technical Study. It considers the several alternative abatement methods which, individually or in combination, would serve to bring noise levels at the non-complying airports down to the proposed noise standards. The costs of these alternatives are examined both for the individual airports and for the downstate airports as a group. The Economic Study also reviews the benefits to be realized from the various abatement methods. Benefits are considered in terms of (a) the number of residential dwellings enjoying reduced noise levels; (b) the effects of lower noise levels on property values and personal injury claims; and (c) the health related effects of quieter surroundings. To the extent possible, benefits and costs are compared, permitting some judgements to be made about the relative efficiency of different abatement strategies.

## II. THE COSTS OF NOISE REDUCTION

The methods available to moderate the severity of airport noise vary in the extent of their effects on different groups - airport proprietors, aircraft owners, travelers, homeowners, and the general citizenry - and in the burdens they would place on them. The Technical Study identifies and develops the operational and acoustical consequences of three approaches to quieting. Level 1 methods entail the use of small heading changes for aircraft on departure; the use of preferential runways for departure; and the construction of berms to serve as noise shields during ground operations. Level 2 methods involve the implementation of night curfews, with night flights on one or more runways (during the hours of 10 p.m. to 7 a.m.) converted to day flights. Level 3 methods call for a reduction in the number of operations - takeoffs and landings - conducted at certain airports. The burden that would be imposed by each of these approaches varies in the order of their listing, with that of Level 1 methods being small by any appropriate test.

The cost implications of each of these approaches is considered below. Other approaches also are considered. One is the insulation or soundproofing of impacted dwellings to the degree needed to achieve noise levels consistent with the proposed standards. Another is the purchase from owners of easements on the impacted properties. A third, which is substantially more costly than the other two, involves the purchase of impacted dwellings, with imposition of zoning or contractual restrictions to prevent future incompatible land uses.

A. The Noise Status of Downstate Airports

The Attorney General's proposed regulation specifies maximum permissible noise levels at nearby residential properties. It calls for progressively tighter standards over time - 80 dB in 1979, 75 dB in 1980 and 65 dB in 1985. The Technical Study found that 12 of Illinois' downstate public airports currently or prospectively violated these standards. At two of these airports, noise levels at nearby residences presently exceed the 75 or 80 dB standard, while at others the levels would violate the later 65 dB standard. The noise status of the 12 airports is summarized in Table II-1.[1] The data on dwellings relate only to existing dwellings. The Technical Study recognized the possibility that in the absence of a preventive policy, additional residences would be built within the noise impact zones in future years. Were this to occur, it would increase the severity of the impaction problem at the airports listed in the table, and it could cause additional airports to violate the standards. The Technical Study did not attempt to develop data based on this contingency. However, its implications are briefly considered below in Section III.

Each of the 12 airports listed shows dwellings with noise levels of 65 $L_{dn}$ or greater. Six of the 12 have dwellings with levels of 70 $L_{dn}$ or greater, and two have dwellings subjected to noise of 75 $L_{dn}$ or more. As would be expected, the great bulk of these noise-exposed

[1]East Alton-Civic Memorial Airport, which has 60 dwellings within the 65-70 $L_{dn}$ zone, is excluded from the table and from the analysis because it is dominated by noise from military jet aircraft. Although the Technical Study showed Kankakee's airport to be a prospective violator, information obtained subsequently indicates that no residences receive noise impact as great as 65 $L_{dn}$.

TABLE II-1

Status of Residential Dwellings Around Downstate Illinois Airports

| Airport | No. of Dwellings in Noise Zone |
|---|---|
| Champaign-Willard | |
| 70-75 | 5 |
| 65-70 | 12 |
| Danville-Vermilion Co. | |
| 70-75 | 0 |
| 65-70 | 10 |
| Decatur Municipal | |
| 70-75 | 6 |
| 65-70 | 142 |
| Galesburg | |
| 70-75 | 0 |
| 65-70 | 3 |
| Moline-Quad City | |
| 75 & over | 2 |
| 70-75 | 66 |
| 65-70 | 1530* |
| Mt. Vernon | |
| 70-75 | 0 |
| 65-70 | 40 |
| Peoria | |
| 70-75 | 40 |
| 65-70 | 581 |
| Quincy | |
| 70-75 | 0 |
| 65-70 | 1 |
| Rockford | |
| 75 & over | 2 |
| 70-75 | 14 |
| 65-70 | 9 |

TABLE II-1 (continued)

| Airport | No. of Dwellings in Noise Zone |
|---|---|
| Springfield-Capital | |
| 70-75 | 2 |
| 65-70 | 34 |
| Waukegan | |
| 70-75 | 0 |
| 65-70 | 54 |
| West Chicago-Dupage County | |
| 70-75 | 9 |
| 65-70 | 15 |
| All Airports | |
| 75 & over | 4 |
| 70-75 | 140 |
| 65-70 | 2431 |

Source: Derived from data in Chapter 8 of the Technical Study.

* Of these dwellings, 1045 are mobile homes

dwellings - 94.4% of them - are located within the 65-70 $L_{dn}$ range. Another 5.4% fall within the 70-75 $L_{dn}$ zone, and fewer than 0.2% are above this zone. Thus, the downstate airport problem is essentially one of reducing noise levels by relatively modest amounts for the great bulk of the affected properties.

The 12 airports are diversely situated with respect to numbers of impacted dwellings. About 62% of all such dwellings are located at Moline-Quad Cities, and another 24% are at Peoria. Thus, 86% of all downstate impaction is accounted for by two airports. Of the remaining 10 airports, 3 have from 34 to 54 affected dwellings and 6 have 25 or fewer such dwellings.

B. The Costs of Level 1 Abatement Methods

1. Changes in Departure Headings and the Construction of Berms

Level 1 mitigation methods are applicable to only 4 of the 12 airports - Decatur, Moline-Quad City, Peoria, and Springfield-Capital. Yet as shown below, these methods serve to reduce the number of dwellings statewide subjected to noise levels of 65 $L_{dn}$ or more by about 75%. One of these methods, namely deviations in departure headings of $5^\circ$ to $10^\circ$ from the runway heading, can be used at Decatur, Moline and Springfield. At Moline, for example, a small deviation to the right on runway 9 moves the 65 dB contour to the south, thereby avoiding most of the trailer park and housing area lying to the north of the runway alignment path. In similar fashion, deviations to the left on runways 27 and 30 serve to lessen the impact on nearby housing.[1] Because such heading changes are small and need by maintained for but a brief time interval, they do not add significantly to trip length. Hence they are treated in this analysis as entailing zero (i.e., essentially negligible) costs.[2]

The construction of berms or barriers that attenuate noise transmission during the ground operation of aircraft represents a second type of Level 1 mitigation. The Technical Study indicates berms can be helpful at two airports. At Peoria, a 2,000 foot berm at the departure end of runway 22 would give protection to 22 homes, and a second berm of 2,800 feet along the southeast sideline of the same

[1] Technical Study, pp. 60, 94.

[2] To illustrate, a course deviation of $10^\circ$ held for five miles at the beginning of a 100 mile trip will add less than 0.01 miles to the length of the trip.

runway would reduce noise levels for 110 homes. At Decatur, a 2,000 foot berm at the departure end of runway 22 would protect 11 homes. The costs of these berms are estimated in the Technical Study,[1] at about $112 per foot. Because only the 2,800 foot berm at Peoria (at a cost of $313,600) would protect enough homes to be within the possible realm of feasibility, it will be treated as part of Level 1 methods, and the other two berms will not be considered further.

2. The Use of Preferential Runways

The use of preferential runways represents the third type of Level 1 mitigation. Under this approach, to the extent feasible, those runways are favored which have the least noise impact on surrounding housing. Among the downstate airports, this quieting technique, like berms, seems to be useful only at Decatur and Peoria.[2] Its limited applicability results from the joint influence of three factors - airport design or layout, the configuration of nearby housing, and wind conditions.

In evaluating the use of preferential runways, two main cost elements must be assessed: There are costs associated with possible taxi delays; and there are costs arising from air delays, or increased flying time. Each of these elements in turn contains two distinguishable components, namely, aircraft operating and maintenance costs, and passenger delay costs (reflecting the fact that passenger time is valuable). Moreover, in estimating these costs, two categories of aircraft - commercial airline jets and the relatively small business

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[1] P. 126.

[2] This technique already is employed at Rockford and Decatur airports. Further use can be made of it at Decatur.

jets - must be considered.

The layout of Decatur airport is shown in Figure II-1. The Technical Study, on the basis of computerized noise contour evaluation and with due regard for average wind conditions, indicates that with a preferential runway system, daily takeoffs on runway 24 would be reduced from 39% of the total to 21%. The reduction of 18 percentage points would be accommodated by increases of 16 points on runway 12 and 2 points on runway 6. In terms of daily operations, the effect is to shift an average of 1.2 general aviation flights per day and 1.5 commercial flights per day from runway 24 to the other runways.[1]

Consider first the possible ground time or taxi delays and the associated costs resulting from this shift for general aviation jets. Because of the location of the ramp at Decatur in relation to the departure ends of runways 24, 12, and 6, the shift results in a reduction in taxi time of roughly 7 minutes per operation. The number of operations gaining this reduction annually is 438 (i.e., 1.2 x 365). The cost per minute of ground operation of the average business jet may be put, again roughly, at $4.10.[2] Aircraft ground operation costs,

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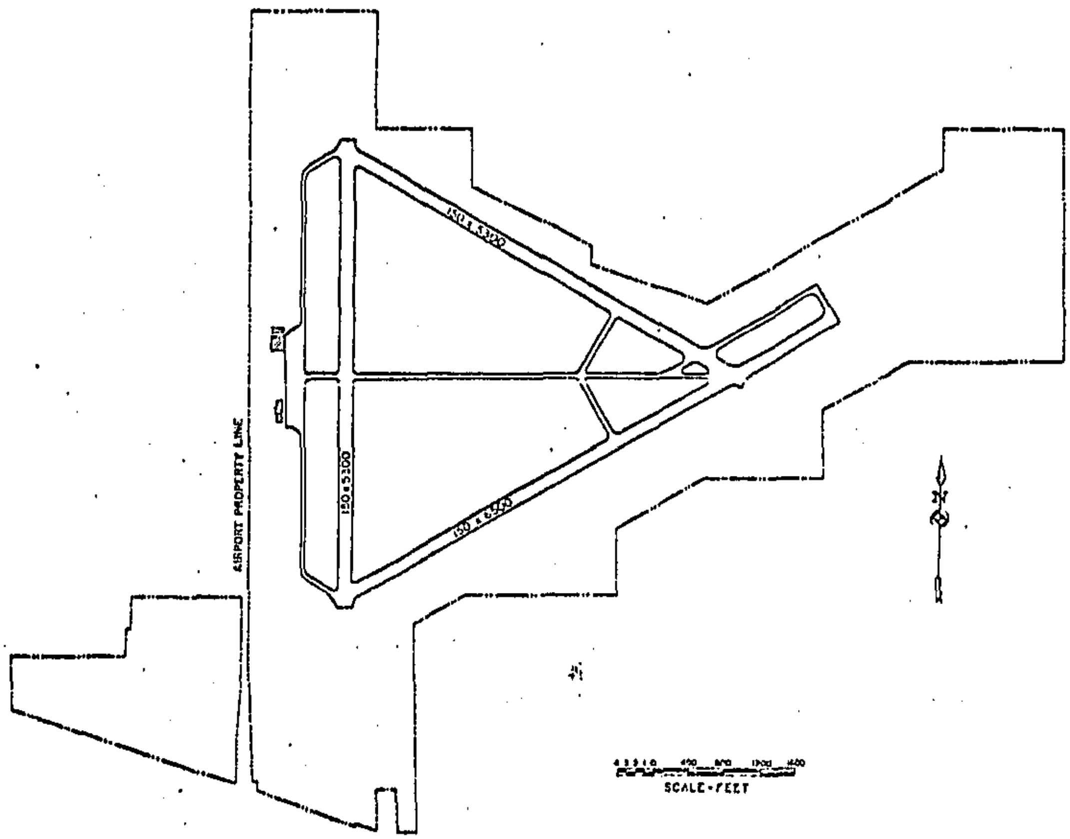
[1] See the Technical Study, Table 8-6, p. 101 and Table 9-2, p. 128.

[2] The figure includes fuel and maintenance costs only on direct operating costs, and is a weighted average covering a sample of four types of aircraft: the Citation I, the Learjet 25D, the Sabreliner 60, and the Gulfstream II. The weights, reflecting the relative importance of each aircraft type in business jet fleets, are taken from Table 3-4, p. 30 of the Technical Study. The maintenance component of operating costs is derived from data given in Professional Pilot, November 1978, p. 27, while fuel consumption data during ground operations are derived from the Jet Range Formats for the respective aircraft of the National Business Aircraft Association. Fuel cost per gallon is taken at $0.73 (for 1978).




DECATUR MUNICIPAL AIRPORT GENERALIZED SITE PLAN

Figure II-1

in this case annual savings, arising from the use of preferential runways may therefore be calculated as:

$$\$4.10/\text{minute} \times 7 \text{ minutes/operation} \times 438 \text{ operations/year}$$
$$= \$12{,}571 \text{ (saving)}$$

Consider next the passenger delay costs, or in this case savings, arising from the change in taxi time. Passengers on business jets are predominantly executive, managerial, and professional personnel. To the extent that their time is consumed in travel it is at least partially, and often wholly, lost to productive effort on behalf of the companies for which they work. Presumably a company would be willing to pay to avoid this loss, with the maximum willingness to pay set by the size of the loss. Accordingly, this willingness to pay, were it known, might be used as a measure of the value of personnel time. Alternatively, we might seek to approximate the desired figure by reference to the average salary, or hourly compensation, of the business jet travelers, with due allowance for the fact that some useful work often can be accomplished during air travel. With this idea in mind, though without any claim to precision,[1] a figure of $25 per hour, or $0.417 per minute is used as the value of the business jet traveler's time.

The number of passengers carried on a business jet flight varies considerably, being determined by the purpose of the flight and the size of the aircraft. A 1975 survey for the National Business Aircraft Association indicated an average of 4.24 passengers per flight.[2]

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[1] As will be seen below, for the purpose at hand ballpark estimates are sufficient.

[2] The figure was cited in a telephone conversation with NBAA. The survey was performed by Price Waterhouse Co.

Annual passenger delay costs, or in this case savings, may therefore be calculated as:

$0.417/minute x 7 minutes/passenger
x 4.24 passengers/operation x 438 operations/year
= $5,421 (savings)

The costs arising from air delays contain the same components as those from taxi delays, but the delay time differs. As a first approximation, let us assume that an aircraft is presently assigned the departure runway most closely aligned with its direction of flight.[1] Then reassignment to a preferential runway will necessitate turns after takeoff, and extra time for the aircraft to reach its desired flight track. In Decatur, as previously described, those flights reassigned from runway 24 to runway 12 (88.8% of the reassignments) will have to make a turn to the right of 120° (plus a course correction factor). A rough assessment suggests that, allowing for both the time required to turn and then to travel the distance added by the brief off-course heading, about two minutes of flying time might be added to a trip. With direct operating costs now at $5.20 per minute,[2] the annual cost of this component can be estimated as follows:

---

[1]The Technical Study, in its generalized analysis of the use of preferential runways (pp. 124-26) indicates that two main assumptions are possible with regard to current practice: (1) Runway assignments are arbitrary with respect to the desired direction of flight, and (2) such assignments are consistent with the desired flight direction. Both assumptions are restrictive, and neither accurately reflects actual airport practice. The use of the second assumption results in higher estimated costs for a preferential runway system than would be the case with the alternate assumption.

[2]The figure is derived from the same sources as previously cited for operating costs during ground taxi.

$5.20/minute x 2 minutes/operation x .888 x 438 operations/year
= $4045

The calculation of passenger delay costs during airborne operations resembles that used to calculate the corresponding figure during ground taxi, with only the delay time changed. For flights shifted from runway 24 to 12 we have:

$0.417/minute x 2 minutes/passenger
x 4.24 passengers/operation x .888
x 438 operations/year = $1375 .

Those flights reassigned from runway 24 to runway 6 will have to make a turn of 180° (plus a course correction factor) to regain the desired flight track, adding an estimated air time of roughly 3.5 minutes. The additions to cost will therefore be, for direct operating cost,

$5.20/minute x 3.5 minutes/operation x .112 x 438 operations/year
= $893

and for passenger delay costs

$0.417/minute x 3.5 minutes/passenger x 4.24 passengers/operation
x .112 x 438 operations/year = $304

Adding up the annual costs and savings for a preferential runway system at Decatur, for general aviation jets, gives

| | |
|---|---|
| Costs during taxi: | - $17,992 |
| Costs during flight: | 6,617 |
| Total | - $11,375 |

Thus, a net saving results.

The analysis for commercial passenger jets, almost wholly the DC9's of Ozark Airlines, follows the same procedures as those above, though with changes in a few of the parameter values. First, direct operating costs during ground taxi are estimated at $394 per hour or $6.57 per minute. Comparable costs during flight are put at $574 per hour or $9.57 per minute.[1] Second, passenger delay costs are estimated at $0.15 per minute, or $8.74 per hour. This figure simply reflects the average passenger's opportunity cost, as measured by forgone earnings.[2] It is here used as a proxy for (unavailable) information on willingness to pay. Third, the average number of passengers carried per flight is estimated at 61.04. This figure reflects a 1978 load factor of .56.[3]

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[1]The figures are derived from the Civil Aeronautics Board, Aircraft Operating Cost and Performance Report, July, 1978, p. 72. Data for the DC-9-30, which makes up the bulk of Ozark's jet fleet, have been used. Hourly fuel consumption during taxi is taken to be one-half of fuel consumption per block hour. The figures given in this source are for 1976 and have been updated to 1978 using an estimated cost increase factor of 20%.

[2]The figure is based on total compensation per man hour for 1976, as adjusted by the author to 1978. The 1976 figure is taken from the Statistical Abstract of the United States, 1978, p. 498 to 694. DeVany, using non-wage data for 1968, has estimated an implicit value for air traveler's time at $7.28. He notes that his findings "suggest that air travelers value their time at their wage." See "The Revealed Value of Time in Air Travel," Review of Economics and Statistics, v. 56, Feb. 1974.

[3]The load factor is as reported by Ozark Airlines. It has been applied to an aircraft capacity figure of 109, which represents a weighted average for Ozark of the capacities of the DC-9-10 and the DC-9-30.

Finally, the number of annual flights affected by a preferential runway system is estimated in the Technical Study at 548.[1]

Using these revised data, the following estimates result for each of the several cost components:

- Aircraft ground delay operating costs, or in this case, savings:
  $6.57/minute x 7 minutes/operation x 548 operations/year
  = $25,202 (savings)

- Passenger ground delay costs (savings):
  $0.15/minute x 7 minutes/passenger x 61.04 passengers/operation
  x 548 operations/year = $35,122 (savings)

- Aircraft air delay operating costs, runway 12 (120° turn):
  $9.57/minute x 2 minutes/operation x 0.888
  x 548 operations/year = $9,314

- Passenger air delay costs, runway 12:
  $0.15/minute x 2 minutes/passenger x 61.04 passengers/operation
  x 0.888 x 548 operations/year = $8,911.

- Aircraft air delay operating costs, runway 6 (180° turn):
  $9.57/minute x 3.5 minutes/operation x 0.112 x 548 operations/year
  = $2,056

- Passenger air delay costs, runway 6:
  $0.15/minute x 3.5 minutes/passenger x 61.04 passengers/operation
  x 0.112 x 548 operations/year = $1,967

Adding up the annual costs and savings for a preferential runway system at Decatur for commercial airline jets gives

---

[1] Table 9-2, p. 128.

| | |
|---|---|
| Costs during taxi: | - $60,324 |
| Costs during flight: | 22,248 |
| Total | - $38,076 |

and the combined total - in this case, savings - for general aviation and commercial airline jets is $49,451.

The costs of initiating a preferential runway system at Greater Peoria Airport can be analyzed in a similar fashion. The layout of this airport is shown in Figure II-2. The Technical Study[1] indicates that 38% of all jet take-offs presently originate on runway 12. It suggests that this figure be reduced to 14%. Of the reduction of 24 percentage points, 14 percentage points would be transferred to runway 22, 5 points to runway 30 and 5 points to runway 4.

Each of these transfers entails a reduction in taxi time. The reduction is small for runway 22 but considerable for 4 and 30, the departure points for both being close to the ramp. The average amount of time saved per affected operation is problematic. A rough estimate would be 2 minutes. The number of general aviation jet operations benefitting from this saving is estimated at 1679 per year, and the corresponding number for commercial operations is 3322 per year.[2]

Let us assume as before that the original runway assignments give aircraft a departure heading that is approximately aligned with the desired direction of flight. Then it follows that 79.2% of the

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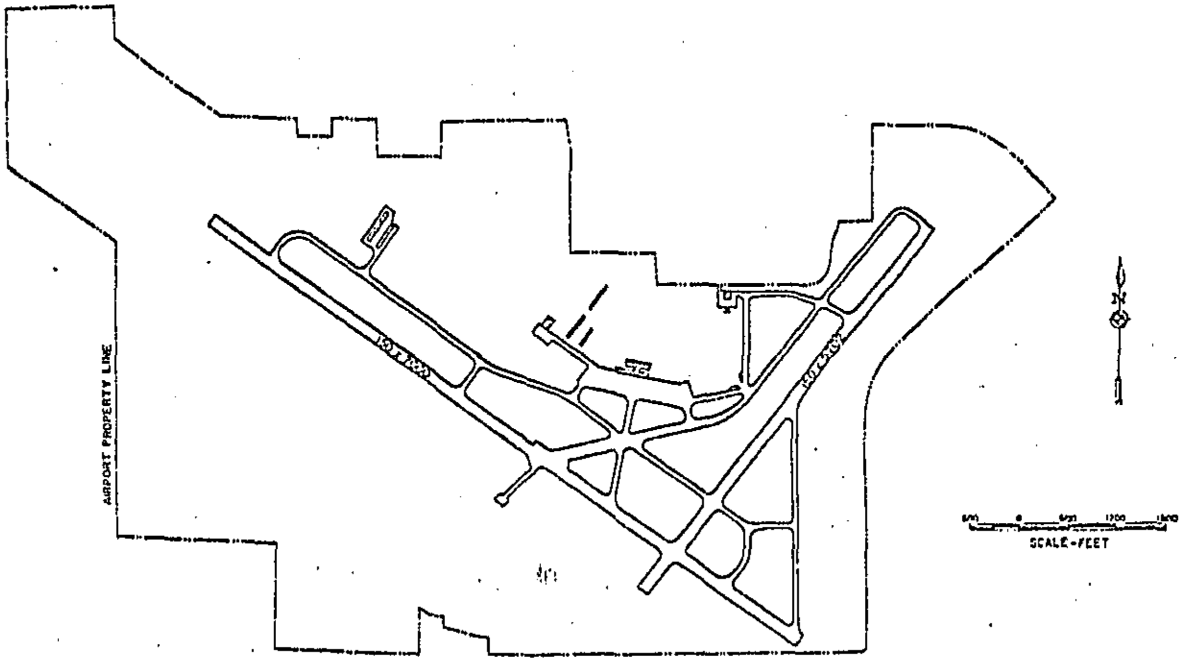
[1]Table 8-8, p. 106.

[2]Based on Table 9-2, p. 128 in the Technical Study.




GREATER PEORIA AIRPORT GENERALIZED SITE PLAN

Figure II-2

reassigned flights (those using runways 4 and 22) will have to make a 90° turn after takeoff, and 20.8% will need to make a 180° turn. The delay time, or added flight time, is estimated, as before, at 2 minutes for the 90° cases and 3.5 minutes for the 180° case.

Using these parameters, but otherwise following the same calculation procedures as for Decatur, yields estimates for the several cost elements as follows:

1. General Aviation Jets

Aircraft ground delay operating costs = $13,768 (savings)

Passenger ground delay costs = $5,937 (savings)

Aircraft air delay operating costs, runways 4 and 22 (90° turns) = $13,830

Passenger air delay costs, runways 4 and 22 = $4,702

Aircraft air delay operating costs, runway 30 (180° turns) = $6,356

Passenger air delay costs, runway 30 = $2,161

Total, general aviation jets

| | |
|---|---|
| Costs during taxi: | − $19,705 |
| Costs during flight: | 27,049 |
| Total | $ 7,344 |

2. Commercial Jets

Aircraft ground delay operating costs = $43,651 (savings)

Passenger ground delay costs = $60,832 (savings)

Aircraft air delay operating costs, runways 4 and 22 (90° turns) = $50,358

Passenger air delay costs, runways 4 and 22 = $48,179

Aircraft air delay operating costs, runway 30 ($180^{o}$ turns) = $23,144

Passenger air delay costs, runway 30 = $22,143

Total, commercial jets

| | |
|---|---|
| Costs during taxi: | - $104,483 |
| Costs during flight: | 143,824 |
| Total | $ 39,341 |

Adding the totals for general aviation and commercial jets, for Peoria, gives a combined total cost of $46,685.

In summary, the use of a preferential runway system at Decatur results overall in dollar savings of a moderate amount, while the use of such a system at Peoria generates a moderate level of costs. In both cases, the savings result from reduced ground taxi time, and these are sufficiently large for Decatur to more than offset the costs of air delays.

Table II-2 summarizes by airport and cost element the costs of each of the Level 1 mitigation methods. Two of these elements - heading changes and preferential runways - are essentially costless, leaving the whole of the aggregate cost of $313,600 attributable to the use of a 2,800 foot berm, or earth barrier, at Peoria. Table II-3 shows, again by airport, the effectiveness of each element, or quieting method, in terms of the number of dwellings that benefit from it. Together, the methods remove from violation status 1968 dwellings. This represents a reduction for the four airports of 82% and a reduction for all downstate airports - that is, the 12 in violation and here under review - of 76%. For individual airports, the effects are especially noticeable at Moline-Quad City and Peoria.

TABLE II-2

Summary of Costs for Level 1 Mitigation Methods

| Method | Cost |
|---|---|
| 1. Heading changes, Decatur, Moline-Quad City, Springfield | ---- |
| 2. Berm, Peoria (2800 ft., 110 homes) | $313,600 |
| 3. Preferential runways | |
| Decatur, G.A. | -11,375 |
| Commercial | -38,076 |
| Peoria, G.A. | 7,344 |
| Commercial | 39,341 |
| TOTAL, preferential runways | $-2,766 |
| GRAND TOTAL, Level 1 methods | $310,834 |

TABLE II-3

Contributions of Level 1 Methods to Noise Reduction

| Airport | No. Dwellings Gaining a 5 dB Reduction[1] | No. Dwellings Brought Below 65 dB |
|---|---|---|
| Decatur | | |
| Headings | 55[2] | 58 |
| Preferential runways | 49 | 46 |
| Peoria | | |
| Berm | 110 | 110 |
| Preferential runways | 387 | 367 |
| Moline-Quad City | | |
| Headings | 1387[3] | 1370 |
| Springfield | | |
| Headings | 17 | 17 |
| Total, 4 airports | 2005[3] | 1968 |

[1]Strictly speaking, the definition is "Dwelling unit equivalents" gaining -5 dB." A full 5 dB is credited to dwellings displaced to the next lower noise zone. That is, all of the quieting benefits are assigned to those dwellings that shift noise zones.

[2]In this case, 58 dwellings experience a 5 dB reduction and 3 undergo a 5 dB increase.

[3]Of these dwellings, 1007 are mobile homes.

Though the berm at Peoria generates the entire cost of Level 1 methods, it is responsible for only about 5.6% of the dwellings removed from violation status. The cost per dwelling benefitted is $2851. The question whether the berm is cost-beneficial, or whether for the dwellings involved some alternative approach would be preferable, is considered further below.

C. The Cost of Insulating Dwellings to Reduce Noise

Although the application of Level 1 methods drastically reduces the number of dwellings in violation status, it does not wholly eliminate the noise problem at any of the four airports where those methods are applied. The location of dwellings by noise zone for these airports, following Level 1 reductions, is shown in Table II-4. Similar information for the remaining eight airports, for which Level 1 methods are unsuited, will be found in Table II-1. A total of 607 dwellings remain in violation status. The largest number is at Moline-Quad City and the next largest at Peoria. At several airports, the number of dwellings affected is comparatively small. This is the case for Champaign, Danville, Galesburg, Quincy, Rockford, Springfield, and West Chicago. In each instance, 25 or fewer dwellings are affected. Fewer than 15% of the dwellings, located at 5 of the 12 airports, are subject to $L_{dn}$ levels of 70 or above.

An important way of reducing noise exposure for these remaining dwellings is through the use of acoustical insulation. This procedure cannot, of course, affect the outdoor noise level, to which the proposed 65 $L_{dn}$ standard refers. But it can reduce interior levels substantially. Even during the summer months, most individuals do not, on the great majority of days, spend more than an hour or two on their properties, out of doors. Hence a reduction in interior levels, insofar as those levels are presently excessive, would be expected to contribute significantly to an improvement in the noise environment of a dwelling's occupants.

There is an appreciable transmission loss when noise penetrates a dwelling from without. The loss or reduction varies with the

TABLE II-4

Noise Status of Dwellings at Four Airports after Level 1 Reductions

| Airport | No. of Dwellings in Violation of 65 dB |
|---|---|
| Decatur | |
| 65-70 | 44 |
| Peoria | |
| 70-75 | 2 |
| 65-70 | 142 |
| Moline-Quad City | |
| 75 & over | 2 |
| 70-75 | 49 |
| 65-70 | 177 |
| Springfield | |
| 65-70 | 17 |

characteristics of the noise and of the dwelling's structure, but averages around 20 dB. Thus outdoor $L_{dn}$ levels of 75 and 70 would produce indoor levels, respectively, of 55 and 50. Both of the latter figures are above the 45 $L_{dn}$ level estimated by the federal E. P. A. as a threshold for indoor activity interference and annoyance.[1] Through insulation of exposed dwellings, the gap between actual indoor levels and the 45 $L_{dn}$ threshold could be reduced or eliminated.

The data available on insulation costs, while not definitive, appear sufficient to permit rough estimates of the cost of quieting dwellings around Illinois airports. For our purposes, the most useful study of such costs is one based on experience at Los Angeles International Airport and prepared by Wyle Laboratories. The study utilized data from a 1969 pilot program for the soundproofing of 20 homes.[2] The results of this study were subsequently updated to 1975, adjusted for regional differences in construction costs, and extended to three other cities - Atlanta, Minneapolis and Seattle. Cost figures intended to represent a U. S. national average also were developed.[3]

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[1] U.S.E.P.A., Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, 550/9-74-004 (Washington, D. C.: Government Printing Office, March 1974), pp. 3, 29 and C-18.

[2] Wyle Laboratories, Home Soundproofing Pilot Project for the Los Angeles Department of Airports, Report No. WCR 70-1, March 1970.

[3] H. G. Meindl et al., Costs and National Noise Impact of Feasible Solution Sets for Reduction of Airport Noise, Wyle Research Report WR 75-9, prepared for the U.S.E.P.A., February 1976, pp. 3-7 to 3-10 and Appendix B.

The U. S. national average figures, further updated to 1978 by the present authors, are shown in Table II-5. The figures indicate the per square foot costs for four levels of interior noise reduction - 5 dB (A), 10 dB (A), 15 dB (A), and 20 db (A). These cost data are plotted in Figure II-3 and the points joined by a smooth curve. Use of the curve permits rough estimates of insulation costs for quieting in 1 dB increments; these estimated costs are listed in Table II-6. The Wyle study further reports that a house of 1500 square feet is typical for a household size of 3.2 persons.[1] Since the latter figure is very close to the Illinois average of 3.3 persons per house[2] the 1500 square foot figure will be taken as applicable for Illinois homes.

Dwellings affected by aircraft noise at Moline include a number of mobile homes. (Of the 228 dwellings with noise levels above 65 $L_{dn}$ after application of Level 1 methods, 38 are estimated to be mobile homes.) This type of dwelling is, of course, a good deal smaller than the typical house. Direct inquiry of mobile home dealers and park operators suggests an approximate size for such homes of 14 feet by 66 feet, or an area of 924 square feet. Accordingly, this figure is used, along with the per square foot cost figures of Table II-5, Figure II-3 and Table II-6, to estimate insulation costs for mobile homes. The calculation assumes that the figures shown in the tables and figure are applicable for mobile homes as well as other residences, though evidence on this point is lacking.

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[1]H. G. Meindl et al., Costs and National Noise Impact of Feasible Solution Sets for Reduction of Airport Noise, Wyle Research Report WR 75-9, prepared for the U.S.E.P.A., February 1976, pp. 3-7 to 3-10 and Appendix B.

[2]U. S. Department of Commerce, 1970 Census of Housing: General Housing Characteristics, Illinois (1971), Table 2.

TABLE II-5

Noise Reducing Insulation Costs for Residential Dwellings (1978)[1]

| Amount of Noise Reduction | Cost Per Square Foot |
|---|---|
| 5 dB (A) | $ 3.33 |
| 10 dB (A) | 9.55 |
| 15 dB (A) | 17.36 |
| 20 dB (A) | 25.46 |

Source: See text.

[1]The figures provided in the Wyle Laboratories study for 1975 have been updated to 1978 through use of the Bureau of Labor Statistics Home Ownership Cost Index.

Figure II-3

Cost of Insulating Residential Dwellings
for Noise Reduction

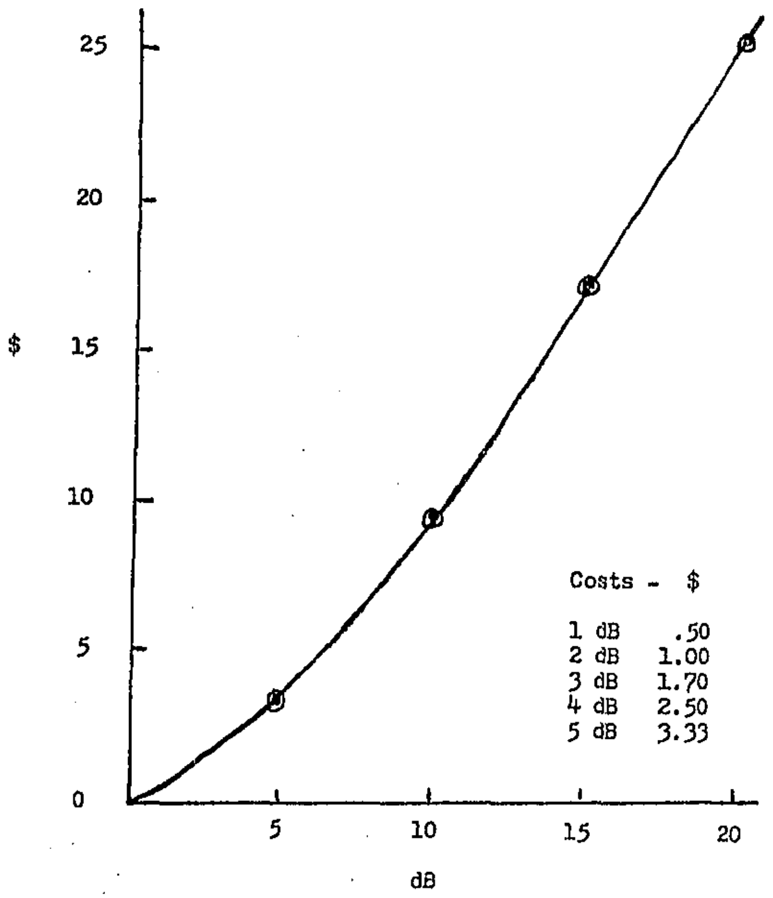

TABLE II-6

Noise-Reducing Insulation Costs
in 1 dB Increments[1]

| Amount of Reduction (dB) | Cost per Sq. Foot ($) |
|---|---|
| 1 | .50 |
| 2 | 1.00 |
| 3 | 1.70 |
| 4 | 2.50 |
| 5 | 3.33 |
| 6 | 4.40 |
| 7 | 5.50 |
| 8 | 6.70 |
| 9 | 8.00 |
| 10 | 9.55 |
| 11 | 11.10 |
| 12 | 12.50 |
| 13 | 14.10 |
| 14 | 15.70 |
| 15 | 17.36 |
| 16 | 19.00 |
| 17 | 20.70 |
| 18 | 22.30 |
| 19 | 23.80 |
| 20 | 25.46 |

[1]From Figure II-3

The information given in the preceding two paragraphs is used to estimate the cost of insulating the dwellings remaining in violation of the 65 $L_{dn}$ limit after Level 1 reductions. It is assumed that dwellings are distributed with uniform density across each noise zone. (However, since noise contours represent power functions, each decibel interval represents a specified percentage of area. Table 8-9 of the Technical Study shows that a 1 dB increase in sound corresponds to about an 18% reduction in land area. Table II-7 below gives the percentage of land area - and, pursuant to our assumption of uniform denisty, the percentage of total houses - per decibel in any 5 dB contour zone.) It is also assumed that dwellings are insulated in 1 dB increments, according to need at the cost shown in Figure II-3 and Table II-6. Dwellings in the 65-66 $L_{dn}$ range would receive 1 dB of insulation, dwellings in the 66-67 $L_{dn}$ range would receive 2 dB of insulation, etc. Thus, each dwelling would be insulated so as to achieve an interior noise level equal to what would be attained if the exterior level were in compliance with the regulation. The results are presented for the 12 airports in Table II-8.

TABLE II-7

Land Area Per Decibel as
a Function of the Total Land in a 5 dB Zone

| dB | % of Zone |
|---|---|
| X to X + 1 | 29 |
| X + 1 to X + 2 | 23 |
| X + 2 to X + 3 | 19 |
| X + 3 to X + 4 | 16 |
| X + 4 to X + 5 | 13 |
| | 100 |

TABLE II-8

Cost of Insulating Dwellings at 12 Airports
(after Level 1 Reductions)

| Airport | Amount of Noise Reduction[1] | | | |
|---|---|---|---|---|
| | 1-5 dB | 6-10 dB | 11-15 dB | Total |
| Champaign-Willard | $ 27,500 (12) | $ 47,600 (5) | - | $ 75,100 |
| Danville-Vermilion | $ 23,000 (10) | - | - | $ 23,900 |
| Decatur Municipal | $101,000 (44) | - | - | $101,000 |
| Galesburg | $ 6,900 (3) | - | - | $ 6,900 |
| Moline-Quad City | $372,700 (139+38*) | $466,000 (49) | $40,600 (2) | $879,300 |
| Mt. Vernon | $ 91,800 (40) | - | - | $ 91,800 |
| Peoria | $325,900 (142) | $ 19,000 (2) | - | $344,900 |
| Quincy | $ 2,300 (1) | - | - | $ 2,300 |
| Rockford | $ 20,700 (9) | $133,100 (14) | $40,600 (2) | $194,400 |
| Springfield-Capital | $ 39,000 (17) | - | - | $ 39,000 |
| Waukegan | $123,900 (54) | - | - | $123,900 |
| West Chicago-DuPage Co. | $ 34,400 (15) | $ 85,600 (9) | - | $120,000 |
| Totals | $1,169,100 (486+38*) | $751,300 (79) | $81,200 (4) | $2,001,600 |

Source: See text

[1]Figures in parentheses give number of dwellings. Figures with * denote mobile homes.

Several features of the table are noteworthy. First, over half of the total downstate insulation costs are incurred by dwellings requiring 5 dB or less of quieting, with most of the remaining cost incurred by dwellings requiring between 5 and 10 dB of quieting. Second, one airport - Moline-Quad City - accounts for about 44% of total downstate costs, and three airports - Moline-Quad City, Peoria, and Rockford - account for over 70% of total costs. Third, for eight of the remaining airports, the cost for each would be under $100,000, and for three of them it would be under $25,000. Fourth, for the 607 dwellings involved, the average cost per dwelling is about $3,300.

It is possible that the insulation of dwellings in 1 dB increments, as this analysis assumes, will not prove fully consistent with the practical or operational conditions of an insulation program. One potential difficulty concerns the fact that any insulation effort would, at the larger airports, be carried out as a large scale, standardized program. It may be both impractical and costly to attempt to apply insulation in so tailored a way to a housing stock whose units vary in their designs, structures, and materials. A second difficulty arises from the circumstance that insulation to achieve but one, two, or even three dB of quieting would not, for many households, bring an improvement above their thresholds of perception. Such considerations might lead to a program in which the minimum insulation requirement was, say, an average per dwelling of 5 dB. With such a requirement, the insulation costs for dwellings in the 65-70 $L_{dn}$ range would be about double those shown in Table II-8.

The types of insulation employed to reduce the levels of internal noise from external sources are, to a significant extent, the same as those needed to protect dwellings from outdoor cold and heat: attic and wall insulation, storm doors and windows (or double-glazed windows), caulking and weatherstripping.[1] Accordingly, a substantial fraction of insulation costs is likely to be recovered within a period of five to fifteen years through energy savings. The cost figures cited above for sound insulation should therefore be regarded as gross figures. We surmise that the net or true economic costs would be perhaps one-half or less of these figures.

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[1]Pacific Gas & Electric Company's Application No. 5937 before the California Public Utilities Commission, dated March 25, 1980, proposes to implement a systemwide weatherization plan for energy conservation, using these techniques. PG&E would loan each homeowner all funds necessary to pay for the weatherization improvements; the loan would be repayable, without any interest, only when the residence was sold.

D. The Purchase of Noise Easements

An alternative to the reduction of excessive noise emissions or their impacts is the direct compensation of the receivers of noise for the disadvantage they suffer. Consider an individual who is subjected to noise at a level that he regards as undesirable. Suppose he has a choice between reduction of the noise to an acceptable level and, alternatively, compensation for the discomfort he bears. Typically there will exist some minimum dollar payment that he will just prefer to noise abatement. By implication, such a payment, freely chosen, would leave him better off than would the noise reduction. It follows that, for the receiver, compensation offers a valid solution to the problem of excessive noise.

Imagine a situation in which those who generate excessive noise freely negotiate with the receivers of that noise for compensatory payment (with the alternative of noise abatement available to the receivers). Agreements would be reached and payments made, with the receivers fairly compensated and generators of noise thereby acquiring easements relieving them of further obligation so long as the noise is not increased. In practice, however, easements are not ordinarily transacted through open and unfettered exchange. Rather they are negotiated under constraints or agreed upon through court proceedings. Consequently, the sums paid for them may at times under- or overcompensate the receivers of noise.

How much might Illinois airport operators actually have to pay for easements that would permit a continuation of the noise emissions remaining after the reductions prescribed by Level 1 methods? The evidence available is limited and uneven. In a 1969 study, McClure reviewed the experience with aviation easements in five cities - Columbus (Ohio), Denver, DesMoines, Seattle and Jacksonville (Florida).[1] In some instances, easements were obtained through negotiation of the airport authority with property owners. In other instances, litigation was involved. In certain cases, properties were purchased at fair market values, easements attached, and the properties resold. In these cases, the difference between the purchase and resale prices represented the cost or worth of the easement. The mean easement cost varied from a low of 6.6% of the property value to a high of 19.8%, with an overall mean of 14.3%. The author suggests that the typical dwelling in the study might be exposed to a noise level of 100 PNdB, but supporting data are not given.

A report on experience at Tampa International Airport, covering 39 properties,[2] indicates easement costs ranging between 20% and 26% of property values. These figures are gross of appraisal and legal fees and court costs. Net of such costs, the range would be more like 12% to 15%.

A 1974 Arthur Little report on airport noise contains a brief discussion of easements.[3] The report notes, on the basis of selected

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[1]McClure, Paul T., "Indicators of the Effect of Jet Noise on the Value of Real Estate," RAND Paper p. 4117, July, 1969, pp. 24-29 and p. 34.

[2]Doyle, Robert H. and Orman, J. C., "A Comparison of Costs Associated with Local Actions to Reduce Aircraft Noise Impacts," prepared for the March 2, 1978 AOCI Economic/Environmental Specialty Conference, pp. 26-28.

[3]Arthur D. Little Inc., Analysis of the Methodology for the Economic Impact of Airport Noise Pollution Control Regulations, Report to the Environmental Protection Agency, No. 76874, April 1974, pp. II 10-11.

sources, that easements often are expensive to purchase, frequently amounting to 20% or more of the value of the property.

Experience relating to Los Angeles International Airport provides a fifth source of pertinent information. In inverse condemnation actions for damages to residential properties, where the properties were subject to noise levels of 75-80 CNEL,[1] judges and juries have found the damages to be 16% to 18% of property values; out of court settlements have run in a similar range. For properties somewhat more remote from the airport, in the 70-75 CNEL range, recoveries have run from 8% to 10% of property value. The situation for noise zones of 65-70 CNEL is more problematic. Only about one-fourth of plaintiffs have been successful in winning judgements or settlements, with the recoveries running up to 10% of property values. A standard by-product of all such judgements and settlements is provision to the airport proprietor of a noise easement in the plaintiff's land, allowing the land to be subjected permanently to aircraft noise at least up to the level prevailing at the time the easement is created.[2]

Any attempt on the basis of the above information to relate variations in easement costs to variations in the noise levels of properties is necessarily somewhat speculative. Moreover, outcomes for like properties, in like circumstances, might vary from one legal

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[1]The CNEL measure resembles the $L_{dn}$ measure in that it incorporates a 10 dB penalty for noise generated during the hours of 10 p.m. to 7 a.m. It differs from the $L_{dn}$ measure in that it also includes a 5 dB penalty for noise generated during the hours of 7 p.m. to 10 p.m.

[2]The data cited are based on discussions in June of 1978 with airport personnel and attorneys in Los Angeles, and on July 1980 follow-up conversations with these individuals.

jurisdiction to another. Bearing in mind these qualifications, use of the Los Angeles data, which are roughly consistent with the more limited data for other areas, as a reference suggests the following possible pattern of easement costs:

| Noise Level | Cost (percent of property value) |
|---|---|
| 75-80 $L_{dn}$ | 17% |
| 70-75 $L_{dn}$ | 9% |
| 65-70 $L_{dn}$ | 2.5% |

These figures, which should be viewed as quite tentative, have been used, along with the noise contour data and estimates of the average value of Illinois dwellings ($40,800 for single-family homes and $12,000 for mobile homes in 1978),[1] to prepare the estimates in Table II-9. The cost total for all twelve downstate airports is about $825,000, as compared to a total cost of $2.0 million for the insulation of homes approach. Were it to happen that easement purchases were required only for properties with 70 $L_{dn}$ or greater, the cost would be appreciably less, totaling only about $318,000. The Moline-Quad City airport again accounts for a significant fraction of the total, and this airport jointly with that of Peoria generates over half of the total. The average cost of $1,360 per dwelling for easements is about 40% of the corresponding figure of $3,300 for insulation (before energy

[1]The $40,800 figure represents the median price of one-family homes sold in 1977, adjusted to 1978 by means of the Bureau of Labor Statistics Homeownership Index. The data are from U.S. Department of Commerce, Statistical Abstract of the United States, 1978, Table 1391, and U.S. Department of Labor, Monthly Labor Review, April, 1978, Table 23. The figure for mobile homes is an average of estimates given to the authors by mobile home dealers and operators of mobile home parks.

TABLE II-9

Cost of Easements at 12 Airports (after Level 1 Reductions)

| Airport | Easement Cost[1] | | | |
|---|---|---|---|---|
| | Dwellings at 65-70 $L_{dn}$ | Dwellings at 70-75 $L_{dn}$ | Dwellings at 75-80 $L_{dn}$ | Total Cost |
| Champaign-Willard | $ 12,240 (12) | $ 18,360 (5) | ---- | $ 30,600 |
| Danville-Vermilion | $ 10,200 (10) | ---- | ---- | $ 10,200 |
| Decatur Municipal | $ 44,880 (44) | ---- | ---- | $ 44,880 |
| Galesburg | $ 3,060 (3) | ---- | ---- | $ 3,060 |
| Moline-Quad City | $153,180 (139+38*) | $179,930 (49) | $ 13,870 (2) | $346,980 |
| Mt. Vernon | $ 40,800 (40) | ---- | ---- | $ 40,800 |
| Peoria | $144,840 (142) | $ 7,340 (2) | ---- | $152,180 |
| Quincy | $ 1,020 (1) | ---- | ---- | $ 1,020 |
| Rockford | $ 9,180 (9) | $ 51,410 (14) | $ 13,870 (2) | $ 74,460 |
| Springfield-Capital | $ 17,340 (17) | ---- | ---- | $ 17,340 |
| Waukegan | $ 55,080 (54) | ---- | ---- | $ 55,080 |
| West Chicago-DuPage Co. | $ 15,300 (15) | $ 33,050 (9) | ---- | $ 48,350 |
| Totals | $507,120 (486+38*) | $290,090 (79) | $ 27,740 (4) | $824,950 |

Source: See text.

[1]Figures in parentheses give number of dwellings. Figures with * denote mobile homes.

savings).

The addition of easement costs to the costs of Level 1 reductions gives a combined cost of $1.14 million, or only about 50% of the combined cost of insulation and Level 1 reductions.

E. Property Acquisition as a Remedy

The acquisition of residential (or other) property by an airport authority represents a further strategy for alleviating the problem of excessive noise. Under this approach dwellings would be purchased and demolished and the land reserved to noise-compatible uses. Depending on circumstances, such uses might entail commercial or industrial activity, or the land might be dedicated to parks and open space. The acquisition approach can also be used in conjunction with other approaches. For example, a dwelling might be purchased, insulated, and resold with a noise easement attached. Or, more simply, the insulation step might be skipped.

The acquisition approach tends to be expensive, because it is to be expected, out of equity or legal considerations, that the prices paid for dwellings would approximate their full market value, undiminished by any effects of aircraft noise. Moreover, the cost is likely to be augmented by a need to pay relocation benefits to occupants and by administrative costs. A source of useful data is the experience of the Port of Seattle with Sea-Tac International Airport. From 1975 through 1978 POS purchased 340 residential properties for removal. The salvage value of the dwellings, amounting to about 8.6% of the value of house and lot, served to reduce the net cost of acquisition, but this was more than offset by the cost elements just noted - relocation benefits amounting to 22.9% of property value and administrative costs at 4.2% of property value. Allowing for these elements, total costs per property amounted to 118.6% of the property's value.[1]

[1]The data are cited in Doyle, R. H. and Orman, J. C., op. cit., pp. 22-24.

The costs of an acquisition program can be offset to the extent that acquired property can be reallocated to noise-compatible uses. The opportunities for such reallocation are dependent upon the presence of industrial-use and commercial-use needs for the sites in question, and these needs are in turn dependent on the intensity and spatial characteristics of prevailing economic activity. A characteristic of the airports under consideration is that much of the land surrounding them is vacant, and its potential availability for economic uses limits the market for additional, airport-acquired land. The judgement offered in one airport land-use study, though offered with regard to major metropolitan airports, seems especially apposite to downstate Illinois airports:[1]

> Redevelopment was found to be an effective and permanent but generally very expensive solution, because of high land acquisition costs and low demand for reuses. Redevelopment can be justified only in selected, small, heavily impacted areas."

At Sea-Tac International, consideration was given to rezoning acquired properties for manufacturing and commercial uses, but it was concluded that the land was not well suited to these purposes.[2]

Accordingly, the procedures for estimating acquisition costs for downstate airports make no allowance for possible reuses of the purchased land. Table II-10 shows by noise zone the estimated costs of an acquisition program, using the 118.6% adjustment factor cited above and an estimated mean dwelling cost for 1978 of $40,800 ($12,000 for mobile homes). In these calculations, dwellings subject to acquisition

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[1]Urban Systems Research and Engineering, Inc., Land Use Control Strategies for Airport Impacted Areas, October 1972. (Prepared for the FAA Document no. FAA-EQ-72-1). The airports studied were Los Angeles International, Miami International, Long Island-MacArthur and Dallas-Fort Worth.

[2]Interview by the authors with Port of Seattle personnel, June 1979.

TABLE II-10

Costs of Property Acquisition at 12 Airports (after Level 1 Reductions)

| Airport | Acquisition Cost[1] | | | |
|---|---|---|---|---|
| | Dwellings at 65-70 $L_{dn}$ | Dwellings at 70-75 $L_{dn}$ | Dwellings at 75 $L_{dn}$ & over | Total Cost |
| Champaign-Willard | $580,519 (12) | $241,883 (5) | ---- | $822,402 |
| Danville-Vermilion | 483,765 (10) | ---- | ---- | 483,765 |
| Decatur Municipal | 2,128,568 (44) | ---- | ---- | 2,128,568 |
| Galesburg | 145,130 (3) | ---- | ---- | 145,130 |
| Moline-Quad City | 7,279,248 (139 + 38*) | 2,370,451 (49) | 96,753 (2) | 9,191,544 |
| Mt. Vernon | 1,935,062 (40) | ---- | ---- | 1,935,062 |
| Peoria | 8,128,873 (142) | 96,753 (2) | ---- | 8,225,626 |
| Quincy | 48,377 (1) | ---- | ---- | 48,377 |
| Rockford | 435,389 (9) | 677,272 (14) | 96,753 (2) | 1,209,414 |
| Springfield-Capital | 822,401 (17) | ---- | ---- | 822,401 |
| Waukegan | 2,612,334 (54) | ---- | ---- | 2,612,334 |
| West Chicago-DuPage Co. | 725,648 (15) | 435,389 (9) | ---- | 1,161,037 |
| Totals | $25,325,314 (486 + 38*) | $3,821,747 (79) | $193,506 (4) | $29,340,567 |

Source: See text.

[1]Figures in parentheses give number of dwellings. Figures with * denote mobile homes.

are those remaining at 65 $L_{dn}$ or above after the application of Level 1 methods. As expected, the costs of this program are many times the costs of insulation or easements, both in the aggregate and on an airport by airport basis. At Decatur Municipal Airport, for example, the estimated cost of insulating the 44 affected homes is about $101,000, and the cost of easements is around $45,000. By contrast, the estimated costs of an acquisition-demolition program are about $2.13 million. For the 12 downstate airports with dwellings exposed to noise levels of over 65 $L_{dn}$, total insulation costs of $2.0 million compare with acquisition-demolition costs of $29.3 million.

These cost disparities suggest the desirability of limiting an acquisition program to properties subject to relatively high noise levels, and to employ other methods for less seriously disturbed properties. Thus, the four properties subject to an $L_{dn}$ of more than 75 (two each at Moline-Quad City and Rockford) might be purchased and the remaining dwellings insulated. This procedure would raise the cost of an insulation-only approach by only about 6%. Were acquisition extended to all dwellings over 70 $L_{dn}$, with those in the 65-70 $L_{dn}$ range insulated, the aggregate cost for the 12 airports would rise substantially to $5.2 million. This figure, while considerably more than the cost of an insulation-only approach, is but a fraction of the cost of an acquisition-only program

F. A Purchase-Guarantee Program

An alternative to a program of outright acquisition, and one likely to be far less expensive over time, is a purchase-guarantee arrangement under which the airport authority guarantees the fair market value of noise-exposed properties. Under this type of program, if an owner elects to sell his property on the open market, and if he cannot obtain fair value for it - that is, a value undiminished by any noise damages[1] - the airport authority would either purchase it from him at fair value for subsequent resale or else pay him the difference between fair value and the best market offer.

Two features of this approach contribute to keeping costs relatively low. First, the airport authority pays only for such damage to a property as the market may determine to exist. These costs would be augmented in some degree by the costs of negotiation and occasional litigation. But a well designed program could help to minimize these costs. Second, not all owners are equally desirous of selling their properties. Moreover, the guarantee itself, by removing a source of uncertainty and concern for owners, may reduce the number of potential sellers in any period. Hence expenditures under the program will tend to be distributed over an extended period and, thereby, their financing more easily managed.

A purchase-guarantee program constitutes one element in the Port of Seattle's long-term noise abatement plan for Sea-Tac International Airport. The program would apply to properties with noise levels of

[1]Such a value might be determined by real estate appraisals of the usual kind.

70-75 $L_{dn}$. There has not yet been any activity under this program, but it is slated for implementation within the next four to five years.[1]

Any diminution in value experienced by a property subject to aircraft noise presumably reflects property damage associated with noise's adverse effects. This same loss in value may also be taken as a measure of the property-value benefits to be gained from eliminating the excess noise or its effects.[2] But properties that are reduced in value because of aircraft noise typically are far from worthless; they may retain 80% or 90% of their original value. It follows that the acquisition and demolition of these properties, with associated costs at least as great as the property's (noise-reduced) value, must exceed the benefits to be gained from such action. In other words, when judged in terms of market values as determined by homeowners' preferences, property acquisition as a remedy is typically not cost beneficial. This suggests that it should be regarded as an exceptional measure to be reserved for unusual cases.

[1]Interview with Joseph Sims, Assistant Director of Planning, Port of Seattle, June 15, 1979.

[2]This point is discussed further in Section III-C below.

## G. The Use of Night Curfews to Reduce Noise

### 1. Introduction

The objective of a curfew on jet aircraft operations is to provide nighttime quiet and noise relief between 10 p.m. and 7 a.m. to residents living near Illinois airports. The curfew might be utilized following the use of Level 1 noise reduction measures for all dwellings remaining above 65 $L_{dn}$. Or it might be used selectively, in combination with other mitigation techniques like insulation and property acquisitions.

The opportunity for noise reduction by curfews increases as the volume of nighttime aircraft activity rises. Most downstate airports have occasional nighttime operations. The airports at Champaign, Decatur, Peoria, and West Chicago have a maximum average of between 1 and 3 nightly jet takeoffs while the Quad Cities and Greater Rockford Airports average 4 to 5 takeoffs nightly.[1] Jet operations occurring between 10 p.m. and 7 a.m. generally fall into two groups. The first group consists of commercial operations, usually arrivals, occurring between 10 p.m. and 11 p.m. The other group is the early morning general aviation business flights that usually depart between 6 a.m. and 7 a.m. to take passengers to morning meetings or to morning flights leaving from larger airports. There are few operations between 11 p.m. and 6 a.m.[2] The only regular exceptions are infrequent air ambulance operations at Rockford and nighttime air freight operations. Apart

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[1] The data are contained in Appendix B of the Technical Study.

[2] See the accompanying Technical Study, p. 117.

from somewhat irregular operations at Springfield, the only Illinois cities presently served by jet air freight are Peoria, Moline and Chicago. World Jet would add regular freight service to Springfield and a pending application (as of early 1978) would add 3 or 4 more Illinois cities. Lighter aircraft would go to other airports from these main centers. Another carrier, Flying Tiger, is considering the development of a major air freight terminal at Decatur.

2. The Effects of a Curfew

In the Technical Study, curfews are utilized following the implementation of all Level 1 mitigation measures. It is assumed that the nighttime jet flights that are eliminated would be converted to daytime operations. As a result, the total number of jet operations is assumed to remain constant, while the 10 dB penalty attached to night flights in the $L_{dn}$ contour calculations is removed. Table II-11 below shows the combined effects of Level 1 mitigation techniques and curfews. Column 1 is the number of dwelling units impacted by more than 65 $L_{dn}$ of noise after all Level 1 techniques have been used. Column 2 shows the number of dwellings remaining above 65 $L_{dn}$ after Level 1 and the curfew. Column 3 is the net change in the number of impacted dwellings as a result of the curfew. Column 4 is the percentage of nighttime operations eliminated in order to achieve the desired reduction - in some instances even 100 percent will not suffice - and Column 5 shows the decibel reduction possible with the curfew.

While the major benefit from curfews is clear - no planes, no noise - the implementation of a curfew could partially reverse development of the local economy and eliminate such advantages as night

TABLE II-11

The Effects of Curfews at 12 Airports

| Airport | Dwellings above 65 $L_{dn}$ after Level 1 | Dwellings above 65 $L_{dn}$ after Level 1 and Curfews | Net Change in Dwellings with Curfew | Percent of Night Flights Affected by Curfew | $L_{dn}$ Reduction with Curfew[1] |
|---|---|---|---|---|---|
| Champaign-Willard | 17 | 9 | -8 | 100 | 4 |
| Danville-Vermilion County[2] | 10 | 0 | -10 | 87 | 5 |
| Decatur Municipal | 44 | 0 | -44 | 74 | 3 |
| Galesburg | 3 | 0 | -3 | 27 | 1 |
| Moline-Quad City | 228 | 117 | -111 | 100 | 3 |
| Mt. Vernon[3] | 40 | 10 | -30 | 100 | 3 |
| Peoria | 144 | 24 | -120 | 100 | 3 |
| Quincy | 1 | 0 | -1 | 42 | 1 |
| Rockford | 25 | 16 | -9 | 100 | 5 |
| Springfield Capital | 17 | 4 | -13 | 100 | 3 |
| Waukegan | 39 | 1 | -38 | 100 | 3 |
| West Chicago-DuPage County | 24 | 9 | -15 | 100 | 5 |

Source: This table is adapted from Tables 8-13, 8-15, and 8-16 in the Technical Study.

[1] Values are rounded to the nearest decibel

[2] These figures are upper bounds since the data indicate the $L_{dn}$ contours may be 5 dB too large.

flights may have brought. Accordingly, the costs of a curfew should be measured by the loss of these advantages. Unfortunately, there is no simple way of measuring these costs and attaching to them a dollar figure which could later be added to the other costs of noise abatement. However, we can identify and describe the effects of a curfew upon both passengers and air carriers. The following several paragraphs serve this purpose. The identified effects clearly have greater significance for airports with substantial numbers of night flights. For those downstate Illinois airports with few night flights, their importance may be comparatively small.

Aircraft flights will occur during the nighttime to the extent that they are mutually advantageous for the public and the airlines. Since they benefit both the users and the carriers, they must be presumed to represent a net social gain exclusive of any environmental disadvantages.

Passenger schedules, charter flights and economy-minded "midnight specials" are developed according to work, leisure and other daily activities of people. Cargo customers, too, may benefit from night flights, since more rapid cargo delivery can be a competitive edge.

As noted earlier, most operations at downstate airports between 10 p.m. and 11 p.m. are arrivals of commercial flights, while those between 6 a.m. and 7 a.m. are typically business jet departures. With the prohibition of arrivals after 10 p.m., the passenger schedule is pushed back. Departures from other places must be earlier and may be inopportune for passengers. Similarly, prohibiting business jet departures before 7 a.m. (thus requiring later departure or use of non-jet aircraft) may shorten the total time at a destination and mean that a full day's work cannot be done. Curfews can create inconvenience for passengers and businessmen by making it difficult to get connecting flights. As a result of changes in arrival and departure times, the traveler may be faced with time delays and congestion. Some passengers who would have flown at night would, with inconvenience, shift to other flights. Others would cancel trips. Yet others would shift, also with inconvenience, to different modes of travel.[1]

Another possible effect of a curfew could be to weaken the competitive position of local businesses. As noted before, overnight cargo delivery can sometimes be an important competitive edge. A nighttime curfew would cause changes in existing freight schedules so that overnight delivery may no longer be feasible.

In addition to imposing costs on passengers, businessmen and air freight customers, a curfew also directly affects both those corporations owning business jets and the commercial air carriers. For the former, the opportunities for flexible, effective aircraft use in response to business needs are diminished. Air carriers may experience an increase in operating costs and a decrease in revenues. Flight schedules will be the most important variable affected by a

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[1]A survey to determine the effects of limiting night flights at Logan Airport in Boston indicates that the typical night passenger at the airport is a businessman or a professional in his thirties, earning $20,000 or more a year. Most night travelers are on business trips or going to visit friends. Businessmen and people making emergency trips seemed to feel the most strongly about the availability of night flights. Vacationers and people visiting friends were the least concerned. The study concludes as many as 66 percent, or 2 out of 3 passengers questioned, were flexible and would fly at other times of the day. Another 25 percent would cancel their trip plans and another 9 percent were unsure what they would do. See Massachusetts Port Authority, The Effect of Limiting Night Flights at Logan Airport, 1979, pp. 108-113.

curfew. Changing the schedules can change such things as airline staffing, aircraft activity, and passenger and cargo flows. Costs may increase if additional personnel and equipment must be purchased. Rescheduling nighttime operations to the daytime could increase the costs associated with re-optimizing aircraft routings as aircraft and crews are repositioned.

The cost impact of a curfew at airports with few night flights, such as Champaign and Decatur, may not seem to be of notable consequence. Where jet activity is low, its elimination would not appear to cause significant inconveniences or dislocations. At Champaign, for example, the elimination of about 2 nightly takeoffs, or 4 nightly operations, would seem to bring 8 dwellings below the proposed 65 $L_{dn}$ limit. At Decatur, the elimination of 3 nightly takeoffs, or 6 operations, would bring 44 dwellings below the limit. Yet it should be borne in mind that activity rates can change over time. A curfew would eliminate not only current flights but potential future flights whose number might be appreciably greater. (Of course, the number of affected dwellings could increase too, with new construction.) Thus, the future costs of a nighttime restriction (as well as the benefits) could be greater than at present. An illustrative case in point is the consideration being given by a large air freight company to establishing a major air freight terminal and distribution center at one of four downstate airports. The company has indicated that the outcome of the proposed airport noise regulations will be a factor in its decision on whether to move forward with its plans in Illinois. The outlays for establishing such a terminal would, by one estimate, be about $50 million. Additional outlays would follow to support the continuing activities of the terminal.[1]

Even though a curfew carries potential costs of many kinds, it also creates some offsets. Passengers shifting from curfew hour flights will help to increase noncurfew hour load factors, reducing the per passenger-mile costs and, in some measure, cushioning the overall decrease in revenue. In addition, operating costs may be reduced as a result of a decrease in the payroll for night shift workers.

3. Conclusion

A curfew would bring nine hours of relief from nighttime jet noise to households close to airports. At the same time, it might create significant current or future costs for some local downstate economies if the jet operations were not replaced with propeller aircraft that provided essentially equivalent service. It could create passenger and business inconvenience, and for air carriers and airports bring increased operating costs. In the long run, curfews could cause local communities to lose some of their attractiveness for industry.

[1]Testimony of Eric P. Canada in hearings before the Pollution Control Board. Hearings transcrpt on R77-4, April 9, 1980, p. 4807.

## H. Cutbacks in Jet Operations as a Means of Reducing Noise

### 1. Introduction

The Technical Study indicates that 8 airports may remain in violation of the proposed 65 $L_{dn}$ noise level after application of Level 1 methods and curfews. Table II-12 lists these airports and the number of impacted dwellings remaining after the use of Level 1 controls and curfews. It also lists the percentage of daytime jet operations to be eliminated, and the required decibel reduction necessary at each airport to comply with the 65 $L_{dn}$ guidelines.

Operations cutbacks represent a straightforward and effective, if somewhat severe, means of noise reduction. As Table II-12 shows, substantial cutbacks at some airports would be needed. This is not surprising in view of the energy-level noise level relationships. For example, at the Champaign Willard Airport, 60 percent of the daytime jet operations must be eliminated in order to gain 4 dB of noise reduction. At the Moline-Quad City and Rockford airports jet operations must be cut by 80 percent to reduce noise 7 dB. Such a large decrease in air service, unless replaced by propeller aircraft capable of providing approximately equivalent service, could significantly affect air carriers, businesses, passengers, and the local community. Moreover, operations cuts would not appear to be well suited to an environment of changing travel needs. For a decision to eliminate, say, 40% of existing jet operations is equally a decision to freeze jet operations at 60% of the current level. It should be noted that at some downstate airports jet service recently has decreased as a result of airline deregulation by the C. A. B., and that there has

TABLE II-12

Operations Cutbacks Needed at Eight Airports to Achieve 65 $L_{dn}$

| Airport | Dwellings Above 65 $L_{dn}$ After Level 1 and Curfews | Percent of Jet Operations to Eliminate | Required Decibel Reduction[1] |
|---|---|---|---|
| Champaign-Willard | 2 | 50 | 3 |
| Moline-Quad City | 117 | 80 | 7 |
| Mt. Vernon[2] | 10 | 37 | 2 |
| Peoria | 24 | 37 | 2 |
| Rockford | 16 | 80 | 7 |
| Springfield Capital | 4 | 37 | 2 |
| Waukegan | 1 | 20 | 1 |
| West Chicago-DuPage County | 9 | 37 | 2 |

Source: This table is adapted from Table 8-16, p. 121 in the Technical Study.

[1]Values are rounded to the nearest decibel.

[2]These numbers are upper bounds. Data in the Technical Study indicate that the contours may be 5 dB too large.

been an increase in the number of commuter airline flights by propeller aircraft.)

2. The Effects of Eliminating Flights

Aircraft flights occur when they are mutually beneficial to the public and the airlines. The Director of Schedule Planning and Analysis for United Airlines in Chicago testified before the Illinois Pollution Control Board that

> . . . to a large degree every airline schedule represents the satisfaction of a public transportation need that is unique in terms of point-to-point service, time of day, and other factors and that need will not be satisfied by other airline schedules if it is cancelled.[1]

The prevailing degree of service can be taken to be warranted by market conditions and to represent a net social gain exclusive of any environmental externalities.

Airport development and the availability of air transportation bring a variety of primary and secondary benefits to the community. They increase economic activity, and with it the economic well-being, of the area. As an airport expands, its revenues increase: landing fees, gasoline sales, handling fees, parking and concession fees all rise. Air facilities can also attract new businesses, creating new investment, jobs, and an increased demand for local goods and services. With these changes, the tax base grows and local revenues increase. Travelers also benefit since the availability of air transportation can represent a substantial savings in travel time. Cargo customers, too, may benefit as rapid air freight delivery may offer a

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[1] Illinois Pollution Control Board, Public Hearing in the Matter of Airport Noise Regulations R77-4, December 5, 1979, p. 4004.

competitive edge.

While the major benefit of cutting jet flights is obvious - reduced noise - taking such a step without compensating increases in non-jet flights could weaken the economic vitality of an area and eliminate some of the benefits that air transportation has brought. The costs of cutting flights, then, should be measured by the loss of these benefits. Unfortunately, there is no simple way of attaching a dollar figure to these costs which, if available, could later be added to the other costs of noise abatement. However, it is helpful to describe the effects of reducing total (jet and non-jet) flights upon businesses, the local community, passengers, and the air carriers.

One of the greatest economic values of an airport obviously lies in the transportation services it provides. Air transportation facilitates business and personal travel and can lead to significant time and cost savings. The availability of air travel, whether corporate or commercial, is a productive addition to the corporate community. It allows businesses to utilize time and manpower more efficiently. The growth of corporate flying, in particular, has led to sizeable savings for business. Some statistics may help reveal the growing importance of corporate aviation. In 1979, approximately 27 percent of the total general aviation fleet in the United States, or about 50,000 aircraft, were business aircraft. Nearly 10 percent of these were turbine powered. In addition, a recent study shows that 514 of the top 1,000 American industrial firms listed by FORTUNE Magazine operate their own business aircraft - a total of 1,773 planes.[1]

[1]McCarthy, Michael J., "The Impact of General Aviation on a Local Ecomony," Conference on General Aviation Airport Noise and Land Use Planning, Georgia Inst. of Tech., Atlanta, GA, October 3, 1979, p. 86.

Corporate aircraft increase efficiency because they are convenient, flexible, and highly mobile. They are useful not only for transporting executives from smaller airports, like many downstate Illinois airports, to major airports such as St. Louis or Chicago so that they can make connections to distant cities, but also for shorter-haul trips. The plane can be scheduled to go where the firm wants it to go, and to arrive at a specified time. Greater mobility and flexibility allow the firm to decentralize and to maximize the potential of plant locations. It can diversify its operations and compete in previously unpenetrated markets. In addition, executives lose no time waiting for scheduled aircraft and need not break off their activities in order to "catch a plane". They frequently hold conferences, empty their briefcases of work, or plan the day's meetings on board.

A net reduction of total flights not only may eliminate some of the above-mentioned benefits for businesses but also could produce detrimental effects for the local economy by reducing the community's attractiveness to new industry that brings with it new investment and new jobs.[1]

The availability of air services benefits the local traveler too. For private citizens, the benefits of time saved by adequate air transportation can be sizeable. Vacationers try to maximize the time spent at vacation spots, and persons flying for family reasons desire

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[1]A U. S. Department of Commerce survey of 3000 manufacturing firms found that for 11% of them, the availability of air service was critical to their location decision; for 17% more, air service was significant. Ibid., p. 92.

to spend maximum time with relatives and friends. Cancellation of jet flights, if they are not replaced by non-jet operations, could eliminate many of the benefits of time saved. For example, Ozark Airlines presently provides single plane jet service from various downstate Illinois airports to a large number of cities in other states including Atlanta, Denver, Dallas, Miami, Minneapolis, Sioux City, Detroit, New York, New Orleans, Nashville and Omaha.[1] If such flights were cut, it is unlikely that they would be replaced with service by propeller aircraft. Moreover, such replacement, were it to occur, would typically entail a degradation in service quality.

A notable effect of cancelling flights to and from downstate Illinois airports would be to make it more difficult for passengers to get connecting flights. Since this is one of the main functions served by business planes, the effectiveness of these aircraft would thereby be compromised. Because of the way airline routings are put together, service cuts have a multiplicative effect. The loss of service is not confined to the city that cancels the flight. It can also extend to other downline cities which are not directly affected by service to and from the city which cancelled the flight. To illustrate, suppose a commuter-type flight originates in City A and lands in several downstate Illinois cities before traveling to City B where a large bank of connecting flights is available. If the City A origin were cancelled, it could lead not only to the loss of connecting opportunities for that city's passengers, but to a similar loss for other cities.

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[1] Illinois Pollution Control Board, op. cit., Exhibit No. 180.

In general, carriers would tend to cancel those flights which were the least advantageous economically. These often involve the shorter-haul markets that use smaller aircraft and have higher costs and lower profits for each arrival and departure than the long-haul flights.[1] Eliminating those flights can change such things as airline staffing, aircraft activity, and passenger and cargo flows. Costs may increase if additional personnel must be hired to handle any peaking and passenger congestion on the remaining flights, while at the same time general passenger inconvenience may lead to an overall loss of demand as passengers seek new forms of transportation.

Despite the potential costs which cancelling daytime services poses for the air carriers, it also may create certain offsets that, in some measure, can cushion the increase in costs caused by a disruption of the status quo. Passengers shifting to the remaining flights will increase load factors, reducing the per passenger-mile costs. In addition, overall operating costs could be expected to fall as the total number of flights provided decreases.

3. Conclusion

Despite the fact that eliminating flights offers a straightforward and effective means of reducing noise, it constitutes a relatively severe form of remedy. The potential costs of reducing daytime jet services at downstate Illinois airports could be substantial. If the jet flights were not replaced or could not be replaced, by propeller flights offering equivalent service, business productivity and effeciency

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[1] Illinois Pollution Control Board, Op. Cit., p. 4055.

could be reduced. Unit costs could go up as firms were forced to use time and manpower less efficiently. Local communities could become less attractive to new industry. For passengers, losses could take the form of reductions in the choice of departure times and in the ability to make connecting flights, and some individuals could incur losses also through diversion to less direct and more time consuming forms of transportation.

The extent of these effects necessarily would vary among airports, depending upon the role air service plays in the surrounding communities, upon the scale of any cutbacks, and upon the adequacy of alternative forms of transportation. At Moline, the requisite 80% cut would eliminate 36 of 48 daily jet takeoffs, and an equal number of landings (to bring 117 dwellings below 65 $L_{dn}$). At Springfield, a 37% cut would eliminate 6 of 15 takeoffs, and an equal number of landings (to bring 4 dwellings below 65 $L_{dn}$). The curtailment of jet service need not, in all cases, entail an equivalent reduction in air service. For some downstate airports, some of the deficiency would be made up through the use of quieter piston and turboprop aircraft.

I. Enforcement Costs

Three entities, or groups, will incur costs in the administration and enforcement of the proposed regulation: the individual airport authorities, the Illinois EPA and the Illinois PCB. The largest share of these costs will be borne by the airport authorities in responding to the reporting requirements of the regulation and the conditions for obtaining variances. More modest costs will be carried by the IEPA in reviewing and evaluating airport data, in making some on-site noise measurements, and in participating at variance proceedings. Comparatively nominal costs will be faced by the PCB in conducting hearings for variances and rendering decisions. Unfortunately, considerable error ranges attach to the specific estimates of these several cost elements, particularly those to be carried by airport proprietors, because of uncertainties as to how the regulation may be interpreted and applied.

Under Rule 504 of the regulation, each airport proprietor must maintain a record of daytime arrivals and departures and nighttime arrivals and departures, of all jet aircraft, classified by type (e.g. DC9, Learjet 20,etc.). The record must indicate the runway used, and for each departure, the length of flight (in 500 mile increments). The record must further be submitted to the IEPA on a monthly basis.

There are approximately 42 public airports in the state with some jet traffic, and hence they would be subject to this requirement.[1] At none of these airports, at the present time, does there exist a reporting system that would routinely provide all information sought under Rule 504.

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[1]See the Technical Study, Appendix A, which reproduces the I.E.P.A's summary of airports, noise levels, and type of traffic.

At FAA towers operating in Stage III Terminal Control Areas, such as Champaign Willard, the relevant data are available on an unconsolidated, individual flight basis and are retained for 15 days. Presumably, these data could be made available to airport managers for summarization in the required way. For other categories of FAA towers, all of which have limited hours of operation, the data compiled are less complete. Moreover, the majority of the 42 airports do not have towers, and operating and service personnel are present only during a normal or extended working day.

In these circumstances, it is not clear just what arrangements airports might employ to collect the requisite information or what compromises, as through the use of sampling and estimates, might be found acceptable by the PCB. Perhaps routine pilot reporting could be arranged. In any event, let us assume, somewhat arbitrarily, that the airports with minimal jet traffic, of which there are 14, will each incur reporting costs of $600 per year ($50 per month) and that the remaining 28 airports will experience costs of $1200 per year. Thus, annual aggregate costs for each of the two groups are respectively $8400 and $33,600.

The 12 airports with noise levels above 65 $L_{dn}$ would presumably require and seek variances for limited or extended periods. Rule 505 specifies the kinds of information and analysis that an application for a variance must contain. Broadly, the application must provide: (1) a map of the land area impacted by aircraft noise in excess of the prescribed limits, an indication of existing land uses and zoning classifications, and estimates of the number of persons presently occupying Class A land and the number who would occupy presently vacant land if it were developed for Class A uses; and (2) a plan to control the noise impact of the airport, including an analysis of some 16 specific abatement methods. Consideration of each of the 16 options must include estimates of the effects on the presently impacted populations and land areas, and of the option's cost or its effects on the airport's services. (This economic impact study provides some, but by no means all, of the needed information for each of the airports.) Unfortunately, it is not clear how stringently these provisions would be adhered to or what level of analysis of each of the several options would be deemed sufficient by the PCB.

Variances, when granted, may be for no more than three years, and renewals can be sought. Hence 12 airports would be seeking variances every three years, until such time as they might bring themselves into compliance. For convenience, let us suppose that, on the average, four airports per year file for variances. A plausible surmise, given the uncertainties, is that compilation of the necessary data (including the generation of noise contours), evaluation of alternative abatement options, and preparation of a variance request might require two professional man-weeks at the smaller or less active airports - Danville-Vermilion, Galesburg, Mt. Vernon, Waukegan, Quincy, and West Chicago-DuPage - and eight professional man-weeks at the busier airports - Champaign-Willard, Decatur, Moline-Quad City, Peoria, Rockford, and Springfield-Capital. Valuing a professional man-year at $20,000, the cost for a less active airport would be $800 and for a more active one $3,200. Applying these figures on a weighted average basis to the four airports per year needing variances gives a total annual cost of $8,000.

Adding together the costs to airports for reporting and for variance requests gives a total annual cost of $50,000.

The costs to be borne by the IEPA like those to airport proprietors, also are somewhat problematic. They depend upon the Agency's efforts in reviewing and evaluating the monthly reports filed by airports, the extent to which it might consult with airport proprietors on their noise problems and undertake noise monitoring at selected airports, and the degree to which it might feel it necessary to prepare materials in response to variance requests. The equivalent of perhaps one-half of a professional person per year might be needed for these tasks. The annual cost would thus be $10,000.

The costs to the Pollution Control Board might involve roughly a day of hearings for each variance request, with three of the Board's staff in attendance, an additional one to two days for a staff member to summarize and assess the hearings testimony and submissions, and some further amount of time for each Board member to review the case and reach a decision. In addition, participation in a hearing would involve perhaps two or three persons each for the airport and the EPA. In all, a dozen man-days might be required at, say $150 per day. Allowing for travel and related expenses, the cost per hearing would be around $2,500, and the annual cost (for 4.3 hearings) would be $10,750. Costly litigation beyond the variance stage is possible in some cases. These contingent costs are here ignored.

Total annual enforcement costs may therefore be summarized as follows:

| | |
|---|---|
| Airport reporting costs | $42,000 |
| Airport preparation of variance requests (excluding hearings participation) | 8,000 |
| IEPA costs (excluding hearings participation) | 10,000 |
| PCB and hearings costs | 10,750 |
| Total annual cost | $70,750 |

To the extent that, over time, airports in violation of the regulation succeeded in bringing themselves into compliance, the last three categories of costs, and the total could be expected to decline.

The foregoing enforcement cost estimates, as stated, are on an annual basis, whereas most other cost (and benefit) estimates in this study represent capitalized sums. In lieu of formally capitalizing these costs at some specified discount rate, over some specified number of years, we might simply note their 5-year and 10-year totals. The respective sums are $353,750 and $707,500.

J. Secondary and Indirect Effects of the Proposed Regulation

Many types of regulatory actions, including the one considered here, not only may generate costs for the parties subjected to them, but may give rise to indirect impacts or burdens. Prices and employment may be affected, and there may be costs to agriculture and to state and local governments. In certain instances, there may be impacts on energy supplies and costs. The Environmental Protection Act calls for a review of these possible effects.

In the case of the proposed noise regulation, the scale of such indirect effects, like the more direct impacts, can be expected to vary, depending on the abatement method employed. Level 1 methods, except berms, carry essentially zero direct costs and would entail zero indirect effects. By contrast, property acquisition was found to be relatively costly and, if used on a large scale, would doubtless cause perceptible secondary repercussions.

For illustration, consider an abatement option of comparatively moderate cost, such as insulation. If undertaken by the 12 airport authorities, its aggregate cost of $2.0 million (before energy savings) might, as one possibility, be recovered through charges in the form of jet aircraft landing fees. Suppose recovery took place over a 5 year period, with a flat charge on each jet (air carrier or other) landed. Given the volume of operations at these airports, such a charge would be about $5 per landing. This charge is by no means negligible when seen as an increment to the landing fee for air carriers of $24-$30 charged by many airports, or to the parking fee of $7 - $10 charged to business jets. However, the $5 fee diminishes in importance when put on a per passenger basis. Rough calculations indicate that this fee amounts to about $0.25 per passenger landed.[1] This sum is substantially less than 1% of the typical passenger charge for an Ozark flight, or of the implicit passenger charge, or cost of a business jet flight. The $5 landing charge is also seen to be small, though not negligible, when compared to the direct operating costs (1978) of jet aircraft - about $9.50 per minute for a DC-9 and $5.20 per minute for a business jet.

If prospective energy savings are allowed for, as discussed earlier, the foregoing landing fee and passenger charge figures would be reduced by perhaps 50%. Thus, the landing fee would be about $2.50, a comparatively modest figure.

It is appropriate to add to the charge figures 5 years worth of the enforcement costs borne by airports. This adjustment would add perhaps 20% to the charge estimates of $5 per landing and $0.25 per passenger. The resulting cost on a per passenger basis would remain quite small. Taken on a per landing basis, it would represent one minute or less of aircraft operating costs.

The foregoing observations treat costs as an aggregate for the affected airports. But it should be noted that the insulation burden is not evenly distributed among these airports. The Quad Cities airport in particular has a relatively large share of the dwellings eligible for insulation, but its share of air traffic is not commensurately as large. As a result, insulation costs, if recouped in landing fees, would require charges of around 2.5 times as great as those indicated above. The per passenger cost would be a little less than twice the earlier figure.

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[1]The estimate assumes loads of 45 passengers for Ozark and 3 passengers for business jets.

A property acquisition program, as described in Section II-E, was estimated to cost about $29 million, or 14.5 times as much as the insulation approach. One would expect the indirect impacts to be, at the least, correspondingly greater. By contrast, the selective use of property acquisition, say for dwellings with noise levels of 75 $L_{dn}$ or more, would have negligible indirect, as well as direct, effects.

The potential indirect and direct effects of curfews were discussed in Sections G and H. The Technical Study[1] indicates that, following the use of Level 1 methods and curfews, which together would bring four airports to 65 $L_{dn}$, cuts in jet operations averaging 50% would be needed at the remaining eight airports to achieve compliance. These cuts would entail the elimination of about 63,000 jet operations per year (takeoffs and landings). So large a reduction, if not offset by additional non-jet operations, could be expected to result in significant declines in revenues and employment for the parties immediately affected - suppliers of air service, shippers, and passengers - and in yet further declines in supporting and related activities.[2]

The extent to which the regulation may impose costs on state and local governments, like certain of its other costs and effects, depends

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[1]Table 8-15, p. 119.

[2]Estimates of these secondary impacts vary. One study suggests, for example, that every "basic" job in the airport industry induces another 1.5 local jobs in non-basic services, wholesale and retail trade, finance and local government. See The Economic Impact of Los Angeles International Airport on Its Market Area, Waldo & Edwards, Inc., August 1976, pp. 59-64. Another study, not entirely comparable in its definitions and treatment, suggests that for every job provided in activities immediately associated with airport operations - airlines, freight forwarders, concessionaires - an added 0.875 jobs will be generated in related and supporting activities. See Massachusetts Port Authority, op. cit., pp. 121-126.

on the type of quieting methods adopted. A relatively severe remedy like operations cuts could weaken the property tax base of local governments and, through reduced business and personal incomes, lower sales and income tax flows to the state. Property acquisition would reduce property tax flows to local government. More moderate abatement methods, however, would not appear to impose significant costs for government, apart from the direct costs that may, in the first instance, be borne by airport authorities.

Three of the noise abatement methods we have considered carry potential consequences for fuel consumption or energy use. With respect to Level 1 methods, we found for the two airports involved (Decatur and Peoria) that savings in operating costs, including fuel costs, during the ground phase of operations, approximately offset the increase in operating costs during the flight phase, resulting in no overall or net change. Even with a different outcome, the effect from a statewide perspective would be small, since only a few airports benefit from Level 1 methods. Operations cuts would, of course, save fuel, and the larger the cuts, the greater such savings would be. Even with a switch by many would-be passengers to alternate forms of transportation, savings would remain since jet air travel, while highly time-efficient as compared to other forms of transportation, entails higher fuel consumption per passenger mile.[1] Insulation could, for

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[1]A business jet might realize perhaps 6 to 10 passenger miles per gallon of fuel consumed. For a DC-9-30 the figures might be in the range of 16 to 20 passenger miles per gallon. (Data in the Civil Aeronautics Board volume, Aircraft Cost and Performance Report, July 1978, p. 72, indicate a figure for Ozark Airlines' DC-9-30 of 16 passenger miles per gallon.) The outcomes depend heavily on assumed trip lengths and load factors. Automobile travel might, on the average, yield 40 passenger miles per gallon, and the figure for bus travel would be a good deal higher than this.

the affected dwellings, achieve a significant reduction in energy use for space heating and air conditioning. When viewed on a statewide basis, however, the savings would be small.

No perceptible effects on Illinois agriculture are to be expected from the proposed regulation of the airports covered in this study.

# III. THE BENEFITS FROM REDUCING AIRCRAFT NOISE

## A. Ways of Evaluating Benefits

There are two basic methods by which to assess damages caused by noise or, alternatively, benefits that would accrue from its abatement. One approach describes only the physical and related effects of the noise, such as interference with speech and sleep, annoyance, and hearing loss. The second assigns dollar values to noise damages (abatement benefits) by estimating property value losses (or personal injury damages)attributable to the noise. Both approaches are pursued below.

## B. The Physical and Related Effects of Noise

### 1. Introduction

As communities surrounding public airports in Illinois grow, and as airport operations expand, the number of people exposed to aircraft noise increases and, as a result, so do the adverse effects of noise on man's health. Hearing loss is the health effect most often associated with noise. In addition, high levels of noise cause sleep and speech interference, annoyance, stress, changes in the cardiovascular system, blurred vision, colitis, and migraine headaches, and can aggravate existing physical and mental health problems.[1]

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[1]Papers from the Workshop in Medical Effects of Environmental Noise, Gothenburg, Sweden, 1977, published in Journal of Sound and Vibration, Academic Press, New York, v. 59, #1, p. 59-143; Miller, James D., "Effects of Noise on People," Journal of the Acoustical Society of America, v. 56, #3, September, 1974, p. 729 ff; U.S.E.P.A.

(Continued on next page)

The type of noise emanating from the downstate Illinois airports is typically intermittent and time-varying rather than steady and continuous. To illustrate, at the Decatur airport there are an average of 24 business or commercial jet operations per day.[1] As an aircraft passes overhead, the peak noise on some properties adjacent to the airport might average 90-95 dBA outdoors, or 70-75 indoors. The noise rises to this peak as the aircraft approaches and diminishes as it moves away. With each operation, this noise pattern is repeated.

When measuring intermittent or time-varying noises either the equivalent level ($L_{eq}$) or the day-night average sound level ($L_{dn}$) technique is used. $L_{eq}$ is defined as "the A-weighted sound pressure level of a steady noise having the same energy as the intermittent sound being measured for the same period of time. $L_{dn}$ is an average of twenty-four hourly $L_{eq}$ values with a ten decibel weighting penalty for the nighttime hours."[2] In the example above, the average $L_{dn}$ at the Decatur airport is between 65 and 75 dBA.[3]

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Public Health and Welfare Criteria for Noise, Washington, D. C., July 1978; K. E. Nelson and T. D. Wolsko, Transportation Noise: Impacts and Analysis Techniques, Argonne National Laboratory, Energy and Environmental Studies Division, prepared for Illinois Institute for Environmental Quality, October, 1973, p. 13, 17. Considerable uncertainty remains as to various of the medical or physiological effects of noise. See Miller, James D., ibid., p. 761, who states that the only conclusively established effect of noise on health is that of noise-induced hearing loss. See also R. Rylander, "Medical Effects of Noise Exposure: Basic Considerations," Journal of Sound and Vibration, 1978, 59-1, p. 61. The literature dealing specifically with the medical effects of aircraft noise is very limited.

[1]See page 19 of the accompanying Technical Study.

[2]Anderson, G. S., Miller, L. N., and Shadley, J. R., Fundamentals and Abatement of Highway Traffic Noise, Cambridge, Mass., 1973, p. 1-4; Potter, Richard C., The Acoustic Impact of Motor Racing in the State of Illinois, Cambridge, Mass., January, 1976, p. 2.

[3]See page 142 of the accompanying Technical Study.

2. Hearing Loss

As stated above, hearing loss is the health effect most often associated with high levels of noise. Excessive exposure to sound damages the auditory mechanism of the inner ear. The degree of non-regenerative hearing loss depends upon the amount of damage. The injuries can range from mild distortion to complete deafness.

The effects of noise on hearing may be temporary in nature, or they may be permanent. The ear is capable of recovering from temporary but not permanent changes in hearing sensitivity. Permanent threshold shifts occur after many years of repeated, near-daily exposures to excessive noise. As daily exposure continues year after year, the ear loses its ability to recover from temporary threshold shifts and the temporary shift becomes permanent.

Much research has been done to measure the hearing changes brought about by noise exposure. The results of this work are not uniformly conclusive and, as a result, there remain some uncertainty and controversy over the precise noise thresholds and exposure times necessary to induce a change in hearing sensitivity. Representative of some of the work that has gone on is a study done by James S. Miller. He concludes the average person may experience a temporary hearing threshold shift if he is exposed to noise levels in excess of 70-80 dBA for extended periods of time. Most people can tolerate many brief exposures to 70 to 80 dBA of noise if the exposures are adequately separated in time.[1]

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[1]Miller, James D., "Effects of Noise on People," Journal of the Acoustical Society of America, V. 56, No. 3, Sept., 1974, p. 733. A review of data on industrial noise exposure concludes that permanent hearing damage may occur at levels as low as 75 dB(A) if exposure continues for 10 or more years. U.S. E.P.A., Public Health and Welfare Criteria for Noise, Washington, D.C., July 27, 1973, p. 5-27.

Appendix F in the Technical Study shows the $L_{dn}$ contours of the airports included in this study. All the airports have $L_{dn}$ contours which fall between 60 and 80 dBA and $L_{eq}$ values that are a bit lower. Indeed, the $L_{dn}$ contours of most of the airports lie between 60 and 70 dBA. Only two downstate airports currently have impacted dwellings lying within the 75 and 80 dBA contours: Rockford airport and Moline-Quad City airport each have two impacted single family dwellings.[1] This information and the fact that aircraft noise is time-varying and intermittent, suggest that the incidence of hearing loss in the vicinity of downstate airports will be low and that to the extent it does occur, it will be both mild and temporary.

3. Cardiovascular Effects

The human body reacts defensively to sudden noises or to high levels of steady-state noises. The physiological changes that take place are part of a generalized stress reaction by the body. The typical cardiovascular effects of this reaction include contraction of the abdominal blood vessels, increases in blood pressure, heart (pulse) and respiration rates, increased adrenaline flow, vasoconstriction (constriction of peripheral blood vessels) and paleness of the skin.[2] In addition to the generalized stress reaction to high levels of noise, it is interesting to note a difference between

[1] See Table 8-12a in the accompanying Technical Study.

[2] Miller, James D., op. cit. Also, "Workshop on Medical Effects of Environmental Noise," Journal of Sound and Vibration, V. 59, No. 1, 1977, pp. 80-81, 107-110.

the effects of steady-state noise and intermittent noise. Continuous noise may cause arterial tension, reduced venous pressure, reduced peripheral resistance, and bradycardia (abnormally slow heartbeat). Intermittent noises, for example aircraft flyovers, tend to cause hypertension, rising arterial pressure, and frequent capillary spasms.[1]

There is evidence that noise levels below 120 dBA cause no permanent cardiovascular effects. Up to 120 dBA it has been shown that people can at least partially adapt to noise.[2] For example, once a noise is anticipated, or is discovered to pose no threat, it may no longer startle a person or induce a defensive reaction. The noise levels emanating from downstate aircraft flyovers, even at their peak, are well below 120 dBA.

Even if the noise does not cause a defensive reaction, persistence or frequent repetition may produce a stress reaction; and to the extent that stress is harmful to health, such noise may affect the human cardiovascular system.[3]

4. Effects on Vision

There is evidence[4] that noise levels above 90 dB can affect vision through vasoconstriction. Noise reduces the blood supply to the

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[1]Nelson and Walsko, op. cit., p. 13.

[2]Sataloff, M. D., Joseph, Industrial Deafness, McGraw-Hill, New York, 1957, p. 50.

[3]Illinois Institute for Environmental Quality, Economic Analysis of Environmental Regulation in the Racing Industry, p. 104.

[4]Berland, Theodore, The Flight for Quiet, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1970, p. 100; Still, Henry, In Quest of Quiet, Fred Herner Publishing Projects, Stackpole Books, Harrisburg, PA, 1970, p. 192.

conjunctiva (white of the eye) by causing the small peripheral blood vessels to constrict. It can also cause the pupils and the blood vessels in the retina to dilate, making it more difficult to focus.

In addition to these physical effects on the eye, studies have shown that noise above 90-100 dB adversely affects performance of tasks that require a great deal of visual attention. Above 120 dB, noise affects the muscles which control the lens of the eye and reduces both the speed at which the eye focuses and its ability to move through certain angles.[1] In general, these effects are temporary and performance returns to pre-noise levels shortly after noise cessation.

5. Sleep Interference

Noise from passing aircraft can disturb sleeping people, causing them to either awaken or experience a change in sleep level, and thereby affecting both the quantity and the quality of sleep. Insufficient sleep has been found to increase susceptibility to disease, intensify depressive conditions, and to aggravate existing physical and mental health problems.[2]

The probability of sleep disturbance and the severity of disturbance increase as aircraft passbys increase in frequency and noise level. The ability to adapt sleep to repeated noise exposures is only partial. Awakening may be reduced by as much as 50% in three weeks while there is no adaptation to sleep level disturbances.[3]

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[1] Still, Henry, op. cit., p. 200-201.

[2] Berland, op. cit., p. 68.

[3] Thessen, G. J., "Effects of Noise During Sleep," Psychological Effects of Noise, Welch, B. L. and Welch, A. S., eds., Plenum Press, New York, 1970, pp. 271-275.

In general, outdoor noise levels of 45 dB(A) with the windows open and 55 dB(A) with windows closed are considered sufficiently quiet for sleep.[1] The occasional night operations at some downstate Illinois airports generate peak sound levels inside nearby dwellings that are well above these levels.

6. Speech Interference

The presence of fluctuating noise levels caused by aircraft flyovers interferes with speech and other types of auditory communication. However, intermittent sound levels have been found to mask speech less than an equivalent steady-state noise level.[2] The extent to which noise disrupts communication varies depending upon the circumstances surrounding the conversation. The location of the speakers, whether they are indoors or outdoors, the distance between them, the noise characteristics and levels, and the available amount of insulation from unwanted sound are all important factors in determining the level of speech interference.

Speech interference is defined as less than 100 percent intelligibility.[3] Indoor speech interference begins when the level of

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[1]Dietrich, C. W., Development of Regulations for Noise at Property Lines, Illinois Institute for Environmental Quality, July 22, 1971, p. 5.

[2]Shepherd, William, "Speech Interference Assessment - An Overview and Some Suggestions for the Future," Noise and Speech Interference - Proceedings of a Mini Symposium, Shepherd, William, ed., NASA Langley Research Center, Hampton, VA, September, 1975, p. 7.

[3]U. S. E. P. A., Public Health and Welfare Criteria for Noise, Washington, D. C., July, 1973, Section 6.

unwanted sound rises above 45 dBA,[1] and at indoor noise levels above 65 dBA speech intelligibility deteriorates rapidly.[2]

Outdoors, in face-to-face personal conversations where the speaker and the listener are within 5 feet of each other, practical communication can occur at noise levels as high as 66 dBA. In outdoor group conversations, where distances between people range from 5 to 12 feet, communication is practical when background noise is between 50 and 60 dBA, while at distances between 12 and 30 feet, background noises above 45 or 50 dBA create speech interference.[3]

To continue our previous illustration, a typical jet aircraft flyover at the Decatur airport may have a peak noise level of 90-95 dBA outdoors and 70-75 dBA indoors. At such noise levels, for 10 to 20 seconds, speech may be all but impossible outdoors, and for 5 to 10 seconds it may be difficult to talk indoors.

Because of its interference in auditory communication, aircraft noise can be especially disruptive at school. Noise can disrupt normal classroom activities and reduce the spontaneity of the educational process by making student-teacher communication difficult. It can affect student recall and increase the time needed to process information, thus effectively reducing a student's accuracy. Several studies point to an inverse relationship between the noisiness of a child's surroundings and the development of his auditory and verbal

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[1]U.S. E.P.A., Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, Washington, D.C., March, 1974.

[2]Shepherd, op. cit., p. 14.

[3]U.S. E.P.A., July, 1973, op. cit.

skills. Excessive noise may retard a child's linguistic development. The effects of noise interruptions from aircraft flyovers at school are cumulative. A recent study done in Seattle suggests that the bottom thirty-three percent of the student body suffers from the cumulative effects of such noise interference.[1] However, our review of land use patterns at downstate airports does not show any schools in the 65 $L_{dn}$ or higher contours.

In addition to interfering in the educational process, noise also may interfere with such things as church services, public gatherings, and recreational activities.

7. Annoyance

Annoyance is a psychological response to a given noise exposure. It is caused by the unpleasantness of the noise, "by the disruption of ongoing activities, by physiological or psychological reactions to noise, and by the meaning carried by a given noise."[2] For example, in studies done with jet noise, one of the factors which added most to people's annoyance was their implicit fear of a plane crash.[3]

The existence of an annoyance can be experimentally tested, but it is difficult experimentally to find the annoyance value of noise

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[1]Maser, L. A., Summary Paper on the Settlement Between the Highline School District and the Port of Seattle, Highline School District 401, 1978.

[2]Illinois Task Force on Noise, Economic Impact Study of the Proposed Motor Vehicle (In-Use) Noise Regulations, Illinois Institute for Environmental Quality, Chicago, Document #76/10, May, 1976, p. 109.

[3]U.S. E.P.A., Summary of Public Health and Welfare Criteria for Noise, Washington, 1974, p. 1.

because the degree of annoyance depends upon the characteristics of the situation in which the noise is heard. Some of the factors influencing the degree of annoyance are:[1]

(1) The intensity and spectral characteristics of the noise.

(2) The frequency and duration of the noise.

(3) The informational content of the noise and the degree of interference it causes with other activities.

(4) The time of day during which the intruding noise occurs.

(5) The attitude of people toward the noisemaker.

(6) The background noise against which a particular noise event occurs.

The results of a study reported by the United States Environmental Protection Agency[2] shown in Table III-1 below suggest that complaints about noise sources represent only a fraction of those annoyed. According to the study, with a day-night average sound level of 65 dB, about 33 percent of the population could be annoyed while only 5 percent would register complaints.

8. The Extent of Noise-Induced Health Effects at Downstate Airports

Which of the several adverse health effects described above are significant for downstate airports? To answer this question, one must refer to the actual noise levels experienced. For all but 5 downstate

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[1]Illinois Institute for Environmental Quality, Control of Noise from Motor Vehicles, Report of the Task Force on Noise, No. 74-42, 1974, p. V-36.

[2]U.S. E.P.A., The Effects of Noise on People, Washington D.C., NTID 300.7, December 31, 1971.

TABLE III-1

Relations Between $L_{dn}$, Annoyance, and Noise Complaints

| $L_{dn}$ | Percentage of highly annoyed Population | Percentage of annoyed population complaining |
|---|---|---|
| 50 | 13 | Less than 1 |
| 55 | 17 | 1 |
| 60 | 23 | 2 |
| 65 | 33 | 5 |
| 70 | 44 | 10 |
| 75 | 54 | 15 |
| 80 | 62 | Over 20 |

Source: See text.

airports, the most exposed dwellings lie within the 65-70 $L_{dn}$ range, and at only two airports are there dwellings exposed to more than 75 $L_{dn}$. Recall also that aircraft noise is typically time-varying and intermittent. As an aircraft passes overhead, the noise level on properties adjacent to the airport may rise to a peak of 90-95 dBA outdoors and 70-75 dBA indoors.

Appendix B in the Technical Study provides data on the average daily number of daytime (7 a.m. to 10 p.m.) and nighttime (10 p.m. to 7 a.m.) jet operations at downstate Illinois airports. Many of the airports have fewer than 5 daytime jet takeoffs daily, with fewer than 2 daily on any one runway. The airports at Decatur, Mt. Vernon, Quincy, and West Chicago average between 5 and 10 daytime jet takeoffs and, except for Runway 23 at Mt. Vernon, which has approximately 7 daily takeoffs, all runways average fewer than 5 such operations each day. The Champaign, Rockford, and Springfield airports have between 10 and 20 daytime jet takeoffs, while those at Moline and Peoria average more than 20 each day.

Nighttime operations generally fall into two classes: commercial operations between 10 p.m. and 11 p.m., and general aviation operations between 6 a.m. and 7 a.m. There are almost no operations between 11 p.m. and 6 a.m. As Appendix B in the Technical Study shows, most downstate airports have an average of less than one jet takeoff nightly on any one runway. Champaign Willard Airport, Decatur Municipal Airport, Greater Peoria Airport, Quad Cities Airport, and DuPage County Airports have an average of 1 or fewer nightly jet takeoffs per runway, while Greater Rockford Airport averages 4.7 takeoffs nightly on Runway 18.

Except for the larger downstate airports, the noise interruptions created by jet aircraft passbys are irregular and relatively infrequent. This suggests that the possible health-related effects, if they occur at all, are minimal and temporary. However, at larger airports such as Peoria, Rockford, and Quad-Cities, there is the possibility of some incidence of noise-induced health effects. Apart from this qualification, it can generally though tentatively be concluded that the noise levels emanating from downstate airports are neither severe enough nor frequent enough to permanently damage the health of nearby residents. But at some of these airports, varying degrees of speech and sleep interference and annoyance must be reckoned with.

C. Benefit Measures Based on Property Values

1. The Regression Method as a Source of Property Value Benefit Data

Although we are not able to express our preference for quiet, or reduced noise, by the direct, specific purchase of it in the market-place, we do engage in certain transactions in which, implicitly, we place a value on it. An important type of such transaction is the purchase of a house. One's assessment of a particular dwelling depends on the many characteristics of that dwelling, including various features of the neighborhood in which it is located, and on the flow of benefits which those characteristics are perceived to bring. Among the characteristics in question are the style of house, its age, its size, number of bedrooms, whether it has air conditioning, proximity to schools, accessibility to downtown, noisiness of the neighborhood, whether the neighborhood is affected by air pollution, etc. Accordingly, we may think of these characteristics as the variables that determine the value of a house. To the extent that they are favorable, a dwelling will sell for more; to the extent that they are unfavorable, a house will sell for less. The relationship involved here may be written

$$V = f(Z_1, Z_2, Z_3, \ldots, Z_n)$$

where $Z_1$, $Z_2$, etc. = the characteristics that determine the dwelling's value, and V = dwelling value. Once decisions have been made as to the independent variables to include and the specific form of the relationship, and given a sufficient set of observations on each of the variables, regression procedures will yield numerical estimates of the coefficients associated with each of the independent variables. The coefficients provide a measure of the influence of each variable on the dwelling price. The partial derivative of V with respect to an independent variable, e.g.,

$$\frac{\partial V}{\partial Z_1} = \frac{\partial f}{\partial Z_1} \quad ,$$

in turn expresses the change in dwelling value arising from a small change in the independent variable. Thus if $Z_1$ is the average neighborhood noise level measured in dB(A), the derivative will tell us by how much a 1 dB(A) change in that level will affect the dwelling price. Differently, it will tell us the worth that a homebuyer attaches, on the average, to a 1 dB(A) reduction (or increase) in residential noise. The worth in this case represents a capitalized sum or present value of the expected flow of benefits to the buyer from a 1 dB(A) reduction that continues over an indefinitely long succession of future years.[1]

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[1]The benefits to property owners from a noise reduction represent bona fide economic gains. But it does not follow from this that all existing owners previously suffered a loss from the earlier, higher noise level. Those who purchased their properties after the onset of that higher noise level would have obtained them at a discount because of noise damage. (Their predecessors in title, who were owners at the onset of the higher noise level would have suffered a loss.) The discount may be understood as a (capitalized) compensation to such buyers for the noise damage they will suffer. Looked at from a different vantage point, those who generate the noise that impacts others, in this case the air carriers and air travellers, may be thought of as benefiting from the free use of a common property resource, namely, quiet surroundings.

A 1980 federal law, P.L. 96-193, 94 Stat. 51, 49 U.S. Code 2101-2108, encourages airport operators to submit to the Secretary of Transportation "noise exposure maps" which identify "noncompatible uses" in each area of the map. Section 107 provides that no person who subsequently acquires property in an area shown on such a map may recover damages with respect to noise attributable to the airport if he had "actual or constructive knowledge" of the map, unless there has been a significant change in airport operations. The constitutionality of

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A number of investigators have employed an econometric approach of this kind in order to estimate how individuals evaluate the effects of various kinds of pollution, including noise pollution. With regard to the latter, the inquiries have been directed primarily toward the more pervasive noise sources, namely motor vehicle and aircraft noise.[1] A mathematical relationship of semi-logarithmic form is often used in this type of study. Specifically, we might have

$$\ln V = aN + bZ_1 + cZ_2 \ldots$$

where

V = the market value of a particular dwelling;

N = the value of an index that measures the noise level at this property;

$Z_1$, $Z_2$, . . . = measures of other characteristics of the property which, with $N_o$ determine its value;

a, b, c, = numerical coefficients resulting from regression analysis.

The semi-log form, as explained below, has the effect of making damages from noise, or benefits from its reduction, dependent not only on the noise level, but also on the value of the affected property. This is the kind of outcome one would expect. That is, one would expect

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this provision is likely to be challenged if and when it is asserted by an airport operator. Section 107 does not seek to limit damage recoveries by persons who acquired their land prior to submission of relevant noise exposure maps.

[1]For a brief review of some of the literature, see Jon P. Nelson, Economic Analysis of Transportation Noise Abatement, Ballinger Publishing Co., 1978, Ch. 6.

that the dollar damages from a given noise level would be greater for properties of greater value. With the semi-log form, damages turn out to be a constant percentage of property value. In a given noise environment, if a $40,000 dwelling suffered damages of $1200, a $60,000 dwelling would experience damages of $1800. The semi-log form also has the characteristic of being consistent with sound measurement methods. In the relationship above, dwelling value is expressed in log form, but the noise variable is not because the noise measure is itself based on a logarithmic scale. The appropriateness of the semi-log form is further suggested by data indicating this type of relationship between subjective ratings of annoyance and noise expressed in decibels.[1]

While the semi-log form may be preferred on these grounds, its use in seeking to measure noise damages is technically not essential, and relationships of other forms are used in some of the studies referred to below.

Several studies of the effects of aircraft noise or property values have been completed within the past thirteen or fourteen years, and the most recent of them within the past two years. Collectively, they cover some 16 cities and 17 airports. Most of them employ a cross section of property value data along with information on characteristics of housing and some measure of aircraft noise exposure. While all of them are econometric in form, they vary in certain of

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[1]Bishop, D. E., "Judgements of the Relative and Absolute Acceptability of Aircraft Noise," Journal of the Acoustical Society of America, v. 40, July 1966, pp. 108-122.

their methodological aspects. There are variations in sample size, in criteria for sample coverage, in sources of data on dwelling values, and in methods of determining noise levels. There are differences also in both the functional forms used to relate the dependent to the independent variables and in the numbers and kinds of independent variables, besides the noise variable, that are recognized. The methodological adequacy of the studies varies, some of them being stronger than others. At the same time, taken as a group, they do provide a body of data and findings, and a measure of concensus, concerning the possible extent or worth of noise damage to property values.[1]

The results of these studies - twelve in number[2] - are summarized in a recent paper by Nelson.[3] For purposes of comparability, each set of findings is expressed in terms of a Noise Depreciation Sensitivity Index (NDSI) which indicates, for a typical property, the percentage reduction in property value per unit of added noise. For the semi-log

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[1]The estimation of pollution damages by reference to differential property values involves certain conceptual and procedural problems, and the results from this type of study must, at this stage, be regarded somewhat tentatively. For a discussion of some of the issues see, for example Polinsky, A. M. and Shavell, Stephen, "The Air Pollution and Property Value Debate," Review of Economics and Statistics, Vol. LVII, 1975; also Freeman, A. M., "Air Pollution and Property Values: A Methodological Comment," Review of Economics and Statistics, Vol. LIII, p. 415, (1971); and Freeman, A. M., "On Estimating Air Pollution Control Benefits from Land Value," Journal of Environmental Economics and Management, Vol. 1, p. 74 (1974). See also Nelson, op cit., Chs. 4 and 5.

[2]Two studies consist in effect, of distinct sub-studies and cover more than one city and airport.

[3]Nelson, Jon P., "Airports and Property Values: A Survey of Recent Evidence," Journal of Transportation Economics and Policy, January, 1980.

form referred to above, derivation of the NDSI is straightforward. Restating a previous expression, we have

$$\ln V = aN + bZ_1 + cZ_2 \ldots$$

Taking the derivative of both sides gives

$$\frac{1}{V}\,dV = a \cdot dN + b \cdot dZ_1 + c \cdot dZ_2 \ldots$$

Since we are considering changes only in the noise variable, with all else constant, terms on the right other than the first have zero value. Setting dN = 1 to reflect a unit change in the noise variable we may write

$$\frac{dV}{V} \cdot 100 = a \cdot 100 = \text{NDSI}$$

The twelve studies yield a total of 18 NDSI's. They are summarized in Table III-2. The indexes range from 0.29% to 1.10%, though a majority of them are concentrated in the 0.50%-0.60% interval. The median of the 18 values is 0.535% and the mean is 0.58%. For the purpose of the estimates that follow, the mean value will be used. To illustrate the application of this NDSI, consider an Illinois property (house and lot) which, in the absence of aircraft noise, has the average (1978) value for such properties in the state of $40,800. If now, with other things unchanged, the introduction of aircraft noise, or its increase, were to raise the $L_{dn}$ by 5 dB, say from 65 to 70, we would estimate a decline in the property's value of $1183 (5 x .0058 x $40,800 = $1,183). Alternatively, abatement measures that reduced the noise level from 70 $L_{dn}$ to 65 $L_{dn}$ would bring an increment in property value, and a benefit, of the same amount.[1]

[1]Strictly speaking, the NDSI should be applied to the value of the property subjected to the mean noise level of the properties in the regression sample, rather than to the value of a property undamaged by noise. In the present situation, however, differences in estimates from the two procedures would be small.

TABLE III-2

The Effect of Noise on Property Values: Summary of NDSI Measures

| Study Area | NDSI[1] |
|---|---|
| Cleveland | 0.29% |
| New Orleans | 0.40 |
| Sydney-Marrickville | 0.40 |
| Sydney-Rockdale | 0.50 |
| Edmonton | 0.50 |
| Toronto-Etobicoke | 0.50 |
| San Francisco | 0.50 |
| St. Louis | 0.51 |
| Buffalo | 0.52 |
| Rochester | 0.55 |
| San Francisco | 0.58 |
| Minneapolis | 0.58 |
| Dallas | 0.58 |
| London | 0.68 |
| San Jose | 0.70 |
| San Diego | 0.74 |
| Boston | 0.83 |
| Washington, D. C. | 1.10 |

Source: Nelson, Jon P., "Airports and Property Values: A Survey of Recent Evidence," Journal of Transportation Economics and Policy, January, 1980.

[1]The Noise Depreciation Sensitivity Index measures the percentage depreciation (appreciation) in property value per decibel increase (decrease) in the noise level.

2. Inverse Condemnation Recoveries as a Measure of Property Value Benefits

In Section II-D, which developed the costs of easement, there was discussion of judgements and settlements for noise damages to properties near Los Angeles International Airport. An important component of evidence in these judgements and settlements was testimony by real estate appraisers of the degree to which the value of noise-impacted properties had been impaired. This testimony was often conflicting, in that appraisers for property owners typically claimed higher damages than the damages represented by appraisers for the airport authority. Moreover, the outcomes of the litigation have not been systematically collected and summarized. In consequence, the data base available to us from the Los Angeles experience is limited and uneven. Nonetheless, the results, as best we have been able to distill them, are somewhat at variance with the regression studies described above. In the lower noise range of 65-70 $L_{dn}$, they indicate damage values, or benefits from abatement, that are sometimes lower and sometimes higher than those obtained with the regression method, depending on the abatement method being considered. In the higher noise zones of 70-75 and 75-80 $L_{dn}$, they consistently indicate higher damage values. In terms of the Noise Depreciation Sensitivity Indexes summarized in Table III-2 above, the implied coefficients for all noise zones would lie toward or above the upper end of the range of values.

The two sets of coefficients, the one based on regression studies and the other on inverse condemnation recoveries, are summarized in the table below. To interpret the table, a 7.5 dB noise reduction, from 72.5 $L_{dn}$ to 65 $L_{dn}$, would generate estimated benefits of 4.35% (of property value) using the regression data and 9.0% using the inverse condemnation data. A 4 dB reduction, from 69 dB to 65 dB, would yield estimated benefits of 2.32% (or 4 x .58%) by the regression

TABLE III-3

Summary of Noise Abatement (Damage) Coefficients

| Noise Level | Benefits from Abatement (Percent of Property Value): Regression Studies[1] | Benefits from Abatement (Percent of Property Value): Inverse Condemnation Data[2] |
|---|---|---|
| 65-70 $L_{dn}$ (1-5 dB Reduction) | 1.45% (0.58-2.90%) | 2.5% |
| 70-75 $L_{dn}$ (6-10 dB Reduction) | 4.35% (3.48-5.80%) | 9.0% |
| 75-80 $L_{dn}$ (11-15 dB Reduction) | 7.25% (6.38-8.7%) | 17.0% |

[1]The single figure entries in this column show, respectively, benefits from noise reductions of 2.5 dB, 7.5 dB and 12.5 dB. The figures in parenthesis show the range of benefits associated with the indicated range of noise reduction.

[2]The figures show benefits to a property from a reduction in noise to 65 $L_{dn}$ or below. The data provide but one figure for each noise zone.

method and 2.5% using the inverse condemnation data (since this figure applies for the entire 65-70 $L_{dn}$ zone). Note that if, as a result of implementing a particular abatement method, a group of dwellings is moved from the 65-70 $L_{dn}$ zone to the 60-65 $L_{dn}$ zone, we would credit each dwelling with a 5 dB noise reduction. In this case, the benefit per dwelling by the regression method would be 2.9%, whereas it would be the lesser amount of 2.5% using the inverse condemnation data.

What possible explanations are there for the disparities in the two sets of estimates? One partial explanation is that errors in the data bases used in the regression studies, specifically errors in the measurement of the (explanatory) noise variable, may have biased the damage or benefit coefficient downwards. Another is that the functional forms, or models, specified in the regression studies may have precluded the capture of the more intense effects (per decibel) of noise that may exist at higher noise levels. A third is that the inverse condemnation data are fragmentary. They come only from one airport jurisdiction and only in a relatively gross form that precludes systematic breakdown and evaluation. Fourth, the legal forums in which actions to recover damages for injuries caused by aircraft noise are resolved are not analogs of the market processes by which prices are typically determined. Factors extraneous to those processes may influence the decisions of judges and juries, and the resulting damage awards may not accurately reflect the underlying economic reality.

In view of the differences in results from the two approaches, as shown in the table above, the consequences of each for the estimation of benefits are indicated in Section C-3 below. Benefit estimates based on the regression studies are designated as R-based and those based on the litigation data as L-based.[1]

The benefits that are measured by reference to property values might be expected, in a well-functioning real estate market, to cover all those benefits that property owners would perceive, or be aware of, in buying or occupying a home. Examples would be the benefits that a quieter environment provides from lower levels of speech and sleep interference, from less disturbance to reading and concentration, and from less annoyance. Buyers' demand functions, or bid prices, and sellers' offer prices, would reflect such factors. On the other hand, to the extent that there might exist benefits of a more subtle kind, such as reduced hearing losses that would show themselves only over long periods of time, home owners might well not be aware of them, and they would not therefore exert an influence on dwelling demand and supply and resulting dwelling prices.

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[1]In a 1979 California case, often referred to as the Westchester case, damages from aircraft noise were awarded to plaintiffs on the basis of personal injury, rather than, as in all previous cases, inverse condemnation. See Greater Westchester Homeowners Association vs. City of Los Angeles (14 ERC 1074, 160 Cal. Rptr. 733). A total of $86,000 was awarded in this case to 15 families containing 86 persons for damages sustained during the period 1967-1975. Unfortunately, information from the case does not add usefully to data on the economic measurement of damage from aircraft noise. We do not know the noise levels to which the plaintiffs were subjected, how the aggregate sum awarded was distributed among them, or the time period intended to be covered in the individual distributions. The decision was rendered by a court, and the sums involved thus represent essentially one man's opinion. (In contrast, the inverse condemnation data covered in the text, though still offering but a rather thin data base, cover a total of 15 separate cases involving court trials, jury trials, and settlements.) We do not know what considerations affected the judge's decisions as to the particular sums awarded, and we do not know to what extent meaningful economic criteria may have played a role. Hence it is not possible to appraise the case in economic terms or attach economic significance to the results.

At this time, there is no way of knowing whether the personal injury basis for damages will be sustained in jurisdictions outside of California or whether any future awards on this basis, whether in California or elsewhere, will bear any relation in magnitude to those of the California court.

It is fundamental to the methods under discussion that they seek to measure the impact of aircraft noise on property values, not the impact of the airport on those values. The introduction or expansion of an airport tends to stimulate economic activity, encouraging the growth of commerce and industry and of employment. This in turn tends to strengthen the demand for nearby land, including land for residential purposes. Property values tend to rise as a result. Aircraft noise works in the opposite direction, exerting a negative effect on residential property values. The overall effect of the airport on property values is a consequence of these two forces. The studies referred to above are designed to measure only the (negative) noise effect. The studies tell us that if the noise were eliminated or reduced, with all else unchanged, the value of a property would rise. It is nonetheless possible, and for many situations is likely to be the case, that even with the noise, a property is worth more than it would be in the absence of the airport. Expressed differently, in such situations, the overall effect of the airport on property values, including the (negative) noise effect, may be favorable.

### 3. The Dollar Benefits of Some Alternative Abatement Methods

To estimate the benefits from Level 1 methods by the procedures described above, it is necessary to refer back to Tables II-3 and II-4, which show, for each of the four affected airports and for all together, the number of dwellings enjoying a 5 dB reduction in the noise level. The use of this information permits the construction of Table III-4 below which shows, for each of the four affected airports, the estimated dollar benefits resulting from each type of Level 1 abatement.

TABLE III-4

Estimated Benefits from the Use of Level 1 Methods

| Airport | Estimated Benefits[1] R Basis | Estimated Benefits[1] L Basis |
|---|---|---|
| Decatur | | |
| Headings | $65,100 (55) | $56,100 (55) |
| Preferential runways | 58,000 (49) | 50,000 (49) |
| Peoria | | |
| Berm | 130,200 (110) | 112,200 (110) |
| Preferential runways | 457,900 (387) | 394,700 (387) |
| Moline-Quad City | | |
| Headings | 800,100 (1387)[2] | 689,700 (1387)[2] |
| Springfield | | |
| Headings | 20,100 (17) | 17,300 (17) |
| Total, 4 Airports | $1,531,400 | $1,320,000 |

Source: See Text

[1]R Basis figures are based on regression data. L Basis figures are based on inverse condemnation data. Figures in parentheses are numbers of dwellings experiencing a 5 dB noise reduction.

[2]Of these dwellings, 1007 are mobile homes.

The benefit data are presented in somewhat different form in Table III-5 to facilitate comparisons with the cost data in Table II-2. Aggregate benefits for the four airports are $1.53 million on the R basis and $1.32 million on the L basis, with heading changes contributing somewhat over half of the totals and preferential runways about one-third of them. It is clear from a comparison of Tables III-5 and II-2 that heading changes and preferential runways are cost-beneficial by a wide margin, but the use of the berm at Peoria is not. The cost of the berm is about 2.5 times the resulting benefits.

In section II-C the costs of insulation were estimated. Corresponding benefits, according to the measurement methods explained above, are shown in Table III-6A (on the R Basis) and III-6B (on the L Basis). Total benefits for the 12 airports are $461,500 on the R Basis and $824,900 on the L Basis. These figures compare with an estimated total cost of insulation, as shown in Table II-8, of $2.0 million. About 44% of the costs, and a roughly similar percentage of the benefits, are attributable to the Quad Cities airport. Peoria is second in line, with around 18% each of the costs and benefits.

The cost figures for insulation, as discussed in section II-C, are before allowance for offsets through energy savings. The limited information available suggests that these savings, on a present value basis, might be as much as 50%, or possibly more, of insulation costs. If we allow for a 50% offset, the overall total of insulation costs would decline from $2.0 million to $1.0 million. The latter figure remains well above the R based benefit figure of $461,500, but only a little above the L based benefit estimate of $824,900. Given this outcome, and in view of the incompleteness of the information underlying

TABLE III-5

Estimated Benefits from the Use of Level 1 Methods - Alternative Presentation

| Method | Estimated Benefits[1] R Basis | Estimated Benefits[1] L Basis |
|---|---|---|
| 1. Heading Changes | | |
| Decatur | $ 65,100 | $ 56,100 |
| Moline-Quad City | 800,100 | 689,700 |
| Springfield | 20,100 | 17,300 |
| Total | $885,300 | $763,100 |
| 2. Berm | | |
| Peoria, 2800 ft. | $130,200 | $112,200 |
| 3. Preferential Runways | | |
| Decatur | $ 58,000 | $ 50,000 |
| Peoria | 457,900 | 394,700 |
| Total | $515,900 | $444,700 |
| Grand Total | $1,531,400 | $1,320,000 |

Source: See text

[1] R Basis figures use regression data. L Basis figures use inverse condemnation data.

TABLE III-6A

Estimated Benefits from Insulating Dwellings, R Basis
(after Level 1 Reductions)

| Airport | Amount of Noise Reduction[1] 1-5 dB | 6-10 dB | 11-15 dB | Total |
|---|---|---|---|---|
| Champaign-Willard | $ 7,400 (12) | $ 9,000 (5) | ---- | $ 16,400 |
| Danville-Vermilion Co. | $ 6,200 (10) | ---- | ---- | 6,200 |
| Decatur Municipal | $27,200 (44) | ---- | ---- | $ 27,200 |
| Galesburg | $ 1,900 (3) | ---- | ---- | $ 1,900 |
| Moline-Quad-City | $92,800 (139+38*) | $88,200 (49) | $6,000 (2) | $187,000 |
| Mt. Vernon | $24,700 (40) | ---- | ---- | $ 24,700 |
| Peoria | $87,700 (142) | $ 3,600 (2) | ---- | $ 91,300 |
| Quincy | $ 600 (1) | ---- | ---- | $ 600 |
| Rockford | $ 5,600 (9) | $25,200 (14) | $6,000 (2) | $ 36,800 |
| Springfield-Capital | $10,500 (17) | ---- | ---- | $ 10,500 |
| Waukegan | $33,400(54) | ---- | ---- | $ 33,400 |
| West Chicago-DuPage Co. | $ 9,300 (15) | $16,200 (9) | ---- | $ 25,500 |
| Total (R Basis) | $307,300 (486+38*) | $142,200 (79) | $12,000 (4) | $461,500 |

Source: See text.

[1]Figures in parentheses give number of dwellings. Figures with * denote mobile homes.

TABLE III-6B

Estimated Benefits from Insulating Dwellings, L Basis
(after Level 1 Reductions)

| Airport | Amount of Noise Reduction[1,2] 1-5 dB | 6-10 dB | 11-15 dB | Total |
|---|---|---|---|---|
| Champaign-Willard | $12,200 (12) | $18,400 (5) | ---- | $30,600 |
| Danville-Vermilion Co. | $10,200 (10) | ---- | ---- | $10,200 |
| Decatur Municipal | $44,900 (44) | ---- | ---- | $44,900 |
| Galesburg | $3,100 (3) | ---- | ---- | $3,100 |
| Moline-Quad City | $153,200 (139+38*) | $179,900 (49) | $13,900 (2) | $347,000 |
| Mt. Vernon | $40,800 (40) | ---- | ---- | $40,800 |
| Peoria | $144,800 (142) | $7,300 (2) | ---- | $152,100 |
| Quincy | $1,000 (1) | ---- | ---- | $1,000 |
| Rockford | $9,200 (9) | $51,400 (14) | $13,900 (2) | $74,500 |
| Springfield-Capital | $17,300 (17) | ---- | ---- | $17,300 |
| Waukegan | $55,100 (54) | ---- | ---- | $55,100 |
| West Chicago-DuPage Co. | $15,300 (15) | $33,000 (9) | ---- | $48,300 |
| Total (L Basis) | $507,100 (486+38*) | $290,000 (79) | $27,800 (4) | $824,900 |

Source: See text.

[1]Figures in parentheses give number of dwellings. Figures with * denote mobile homes.

[2]This method of calculation credits the same benefits to every dwelling in a given noise zone, regardless of the amount of insulation received. Thus, dwellings at 66 dB and receiving one dB of insulation are credited with the same benefit, namely, 2.5% of property value, as dwellings at 69 dB and receiving 4 dB of insulation.

the estimates, the insulation approach may merit further study as an abatement option.

It was earlier pointed out that the use of insulation as an abatement method, while it can reduce indoor noise to targeted levels, does not affect outdoor noise. In estimating the benefits from insulation, this qualification has been ignored. We have assumed that, say, a five or ten dB indoor noise reduction causes an equivalent reduction in the overall noise level. Accordingly, our estimates of benefits in Tables III-6 A and B are overstated.

The purchase of noise easements does not, of course, reduce the noise level, and the worth to property owners of the payments that are made is equal simply to the value of those payments. Hence no meaningful distinction can be made between the cost and benefit sides. Accordingly, for easements, no benefit estimates are given. Easements nonetheless represent a legitimate approach to the airport noise problem, and their possible use should be kept in mind in evaluating alternative strategies. Estimates of the costs of purchasing easements were presented in Table II-9.

With property acquisition, displaced homeowners presumably relocate to quieter surroundings and thereby gain real benefits. For purposes of estimating these benefits, let us assume that properties in each zone are centered at the midpoints of the zones, e.g., at 67.5 $L_{dn}$ for the 65-70 $L_{dn}$ zone; and that property owners in the 65-70 $L_{dn}$ zone enjoy a 5 dB noise reduction, those in the 70-75 $L_{dn}$ zone gain a 10 dB reduction, and those in the over-75 $L_{dn}$ zone gain a 15 dB reduction. We imply by this procedure that property owners relocate to neighborhoods with noise levels of 62.5 dBA or below.

The resulting benefit estimates for each of the 12 airports are shown in Table III-7. The estimates are shown on the R Basis, which yields somewhat lower overall benefits than estimates on the L Basis. However, totals on the latter basis are given at the end of the table. Aggregate estimated benefits approximate $789,000 on the R Basis and $825,000 on the L Basis. These figures may be compared with the aggregate estimated cost of property acquisition, shown in Table II-10, of $29 million. Thus, costs greatly exceed benefits. It is, of course, to be expected that the costs of acquisition will exceed the benefits from it, since the effect of aircraft noise is to impair the value of residential property, whereas the purchase and demolition of a dwelling, in the absence of opportunities for conversion to other uses, reduces the value of the property essentially to zero. This circumstance reinforces the view that property acquisition, when used as a remedy for noise, should be used in a selective and limited way.

Our comparisons of benefits and costs have run mainly in terms of aggregates for the 12 affected airports. Comparisons can also be made for the individual airports. While circumstances among these airports vary, giving rise to some variation in particular results, it will generally be found that the outcomes observed for the aggregates apply also to the individual airports.

In the face of potential remedies that are not cost-beneficial, is there any approach that would afford reasonable relief or compensation to property owners while restraining the costs to airport authorities? One such approach is a version of the purchase-guarantee arrangement referred to previously. Under this arrangement, the homeowner would be assured a price for his property, when he chose to sell it,

TABLE III-7

Estimated Benefits from Property Acquisition
(R Basis, after Level 1 Reductions)

| | Amount of Noise Reduction[1] | | | |
|---|---|---|---|---|
| Airport | 5 dB | 10 dB | 15 dB | Total |
| Champaign-Willard | $14,200 (12) | $11,800 (5) | ---- | $26,000 |
| Danville-Vermilion Co. | 11,800 (10) | ---- | ---- | 11,800 |
| Decatur Municipal | 52,100 (44) | ---- | ---- | 52,100 |
| Galesburg | 3,500 (3) | ---- | ---- | 3,500 |
| Moline-Quad City | 177,700 (139+38*) | 116,000 (49) | 7,100 (2) | 300,800 |
| Mt. Vernon | 47,300 (40) | ---- | ---- | 47,300 |
| Peoria | 168,000 (142) | 4,700 (2) | | 172,700 |
| Quincy | 1,200 (1) | ---- | ---- | 1,200 |
| Rockford | 10,600 (9) | 33,100 (14) | 7,100 (2) | 50,800 |
| Springfield-Capital | 20,100 (17) | ---- | ---- | 20,100 |
| Waukegan | 63,900 (54) | ---- | ---- | 63,900 |
| West Chicago-DuPage Co. | 17,700 (15) | 21,300 (9) | ---- | 39,000 |
| Total (R Basis) | $588,100 (486+38*) | $186,900 (79) | $14,200 (4) | $789,200 |
| Total (L Basis) | $507,100 | $290,000 | $27,800 | $824,900 |

Source: See text.

[1]Figures in parentheses give number of dwellings. Figures with * denote mobile homes. The 5, 10 and 15 dB reductions cover respectively dwellings in the 65-70, 70-75, and over 75 $L_{dn}$ zones.

equal to that of equivalent properties in a specified lower noise zone, with any difference being made up, or compensated by the airport authority. The resulting cost to the authority, and benefit to the property owner, might be expected to approximate the benefit figures shown in Tables III-6A and B. That is, the costs and benefits to the respective parties would reflect the loss in property values caused by aircraft noise.

4. Benefits from Curfews and Operations Cutbacks

Like insulation and property acquisition, curfews are considered for application following the use of Level 1 methods. Operations cutbacks would be applied as needed following the use of curfews. The estimated dollar values of benefits resulting from each of these abatement strategies are presented on both the regression basis (R Basis) and litigation basis (L Basis) in Table III-8. The effect of curfews is to shift specific numbers of dwellings from their pre-existing noise zone, e.g., 70-75 $L_{dn}$, to the next lower zone. No dwellings shift downwards by more than one zone. Accordingly, the affected dwellings are credited with 5 dB of quieting. With operations cutbacks, at most airports dwellings shift downward by one noise zone. However, in a few instances, downward shifts of two or three zones are observed. In these instances, all dwellings are credited approximately with quieting benefits down to a 62.5 $L_{dn}$ threshold. Dwellings which as a result of prior abatement actions had been brought below the proposed regulatory limit of 65 $L_{dn}$, are not recognized as receiving possible additional benefits from subsequent quieting actions.

The aggregate benefit from curfews is $537,000 on the R Basis and

TABLE III-8

Estimated Benefits from Curfews and Operations Cutbacks[1]
(after Level 1 Reductions)

| Airport | Benefits From[2] Curfews | Operations Cutbacks[3] |
|---|---|---|
| Champaign-Willard | $13,000/16,100 (8,3) | $13,000/14,500 (7,2) |
| Danville-Vermilion Co. | 11,800/10,200 (10) | ---- |
| Decatur Municipal | 52,100/44,900 (44) | ---- |
| Galesburg | 3,500/3,100 (3) | ---- |
| Moline-Quad City | 137,400/171,300 (73+38*,31,1) | 163,300/175,600 (97,19,1) |
| Mt. Vernon | 35,500/30,600 (30) | 11,800/10,200 (10) |
| Peoria | 146,700/127,700 (120,2) | 28,400/24,500 (24) |
| Quincy | 1,200/1,000 (1) | ---- |
| Rockford | 29,600/52,800 (9,14,2) | 21,300/21,600 (14,2) |
| Springfield-Capital | 15,400/13,300 (13) | 4,700/4,100 (4) |
| Waukegan | 62,700/54,100 (53) | 1,200/1,000 (1) |
| West Chicago-DuPage Co. | 28,400/39,200 (15,9) | 10,600/9,200 (9) |
| Total | $537,300/564,300 | $254,300/260,700 |

Source: Housing count data derived from Chapters 8 and 9 of the Technical Study. Benefit calculations are explained above in the text.

[1]Figures in parentheses indicate number of dwellings receiving benefits. A single figure indicates dwellings at 65-70 $L_{dn}$ that receive benefits, while two or three figures separated by commas indicate respectively dwellings at 65-70 $L_{dn}$, 70-75 $L_{dn}$, and 75-80 $L_{dn}$ that receive benefits.

[2]The first figure in each pair of entries gives R based benefits and the second gives L based benefits.

[3]The degree to which jet operations would be cut at each airport is given in Table II-12.

\$564,000 on the L Basis, and the aggregate benefit from operations cutbacks is about \$254,000 on the R Basis and \$261,000 on the L Basis. The incidence of these strategies, as well as the benefits from them, is uneven among airports. At four of the affected airports, a partial elimination of night jet operations suffices to bring all remaining dwellings to or below the 65 $L_{dn}$ limit, while at the remainder the total elimination of such operations is insufficient for this purpose, and operations cutbacks are called for. At Moline-Quad City and Rockford, the cutbacks would amount to about 80% of all remaining jet operations, at Champaign-Willard 50%, and at Springfield-Capital 37%.

Since it was not possible to develop estimates of the dollar costs of curfews and cutbacks, no comparison of such costs with the estimated benefits presented in Table III-8 can be made. We can, however, proceed in a more impressionistic way and ask whether the quieting actions in question are likely to cost as much or more than the benefits they would bring. For example, are the costs of partial or complete elimination of night flights, in terms of benefits foregone, at 12 downstate airports, likely to equal or exceed the R Based estimate of \$537,000? Bear in mind that the latter figure is a capitalized sum and that the curfew therefore applies not merely for a year, but for the indefinite future. Notwithstanding, let us limit our attention to a five year time horizon and treat the \$537,000 as if it were to be amortized over this period. This assumption enables us to make two helpful calculations: (1) The average daily benefit generated per airport by the curfew; and (2) the average benefit generated per operation curfewed.

For the first calculation, we get (on the R Basis)

$$\$537{,}000 \div (13 \times 365 \times 5) = \$23$$

The number of daily operations affected by the curfew, for all 12 airports, is 44.3. (An operation consists of one takeoff or one landing.) The second calculation is therefore

$$\$537{,}000 \div (44.3 \times 365 \times 5) = \$7$$

Of the first calculation we may ask, are the daily benefits foregone by adopting a curfew at an average downstate airport likely to equal or exceed $23? Alternatively we might ask, is it worth imposing a curfew at an airport in order to save or gain $23 per day? If the answer to the latter question is no, or to the former one yes, then a curfew is not cost-beneficial. The same questions can be framed in terms of the operations affected. Are the benefits foregone per operation curfewed equal to or greater than $7? Or, is it worth prohibiting a night flight in order to save $7? If the answer to the latter question is no, or the former one yes, then the curfew strategy is not cost-beneficial.

Operations cutbacks can be assessed in a similar fashion. Are the costs of permanent substantial cutbacks at eight downstate airports likely to equal or exceed, say, the R Based benefit figure of $254,000? Or, are the daily benefits foregone at the average airport likely to equal or exceed $17 [$254,000 ÷ (8 x 365 x 5)]? Or, putting the matter on a per operation basis, are the benefits foregone by eliminating an operation likely to equal or exceed $0.80 [$254,000 ÷ (174.7 x 365 x 5)]?

It should be borne in mind that operations cuts, besides their direct impact on the parties using jet service, also carry secondary impacts, transmitted through reduced payrolls and revenues, for commerce and industry.

The above estimates are quite sensitive to the criteria used to determine the population of dwellings receiving benefits and to the method, whether regression-based or litigation-based, for measuring those benefits. As previously noted, in the calculations above, possible benefits for dwellings brought below the proposed regulatory level by previous abatement actions, such as Level 1 methods, are not recognized. Data supporting the L Based estimates indicate that there would be no such benefits; that is, damages from noise levels of less than 65 $L_{dn}$ are negligible or zero. However, the R Based method does not imply such a cutoff. With this method, the lower bound for benefits might be in the 55-60 $L_{dn}$ range.

If, using the R Based method, we allow for the quieting effects of curfews not only on the dwellings above 65 $L_{dn}$ at the time the curfews are imposed, but also on the dwellings taken below 65 $L_{dn}$ by the prior application of Level 1 methods, then aggregate benefits for the 12 airports would rise substantially from the figure shown in Table III-8, to roughly $2 million. This in turn would give:

a. Daily benefits of $84 from a curfew at the average downstate airport.

b. Benefits foregone per operation curfewed of $25.

For operations cutbacks, if we allow for quieting not only to dwellings above 65 $L_{dn}$ at the time of that action, but also to dwellings taken below 65 $L_{dn}$ by the prior application of Level 1 methods and curfews, then aggregate benefits for the nine affected airports also rise substantially, to roughly $2.23 million. This in turn gives:

a. Daily benefits from operating cutbacks at the average airport of $153.

b. Benefits of $7 per operation eliminated.

The same questions may be asked of these alternate figures as were asked of the original set.

D. Summary of Costs and Benefits for Downstate Airports

Statewide costs and property value-based benefits for alternative abatement strategies are shown in Table III-9. Of the several strategies considered, benefit estimates were developed for all and cost estimates for all but curfews and operations cuts. In the cases where a direct comparison of costs and benefits is possible, only Level 1 methods prove to be cost-beneficial, and by a very wide margin. However of the three elements in this category, the berm is not cost-beneficial. The exclusion of the berm reduces the cost of Level 1 methods to zero (actually to below zero), while reducing benefits by only about 10%.

The insulation of dwellings entails costs that in total are about 140% greater than the associated, L Based property-value based benefits, and over four times as great as the corresponding R Based benefits. (See Table III-9, footnote 1.) The relative disparity between costs and benefits is greater as the noise level, and with it the amount of required insulation, rises. However, these comparisons make no allowance for the fuel savings that insulation would bring. These savings could cut the effective cost of insulation by perhaps half. Allowing for this reduction, costs would remain substantially in excess of R Based benefits, but only about 20% above L Based benefits.

Easements, which would substitute compensation for abatement, bring benefits that are equal to their costs. Estimated easement costs are, in the aggregate, less than one-half of insulation costs. Thus, following Level 1 methods, they represent a least cost approach.

Property acquisition (and demolition) is the most costly of the

TABLE III-9

Summary of Statewide Costs and Property Value-Based Benefits for Alternative Abatement Strategies

| Abatement Method | Costs | Benefits | |
|---|---|---|---|
| | | R Basis | L Basis |
| Level 1 | | | |
| Heading changes | $ - 0 - | $ 885,000 | $ 763,000 |
| Berm | 314,000 | 130,000 | 112,000 |
| Preferential runways | - 3,000 | 516,000 | 445,000 |
| Total | $311,000 | $1,531,000 | $1,320,000 |
| Insulation | | | |
| Properties at | | | |
| 65-70 $L_{dn}$ | $1,169,000 | $307,000 | $507,000 |
| 70-75 $L_{dn}$ | 751,000 | 142,000 | 290,000 |
| Over 75 $L_{dn}$ | 81,000 | 12,000 | 28,000 |
| Total | $2,001,000 | $461,000 | $825,000 |
| Easements[1] | | | |
| Properties at | | | |
| 65-70 $L_{dn}$ | $507,000 | | |
| 70-75 $L_{dn}$ | 290,000 | ----- | ----- |
| Over 75 $L_{dn}$ | 28,000 | | |
| Total | $825,000 | | |
| Property Acquisition | | | |
| Properties at | | | |
| 65-70 $L_{dn}$ | $25,325,000 | $588,000 | $507,000 |
| 70-75 $L_{dn}$ | 3,822,000 | 187,000 | 290,000 |
| Over 75 $L_{dn}$ | 194,000 | 14,000 | 28,000 |
| Total | $29,341,000 | $789,000 | $825,000 |
| Curfews[2] | ----- | $537,000/2,000,000 | $564,000 |
| Operations Cutbacks[3] | ----- | $254,000/2,230,000 | $261,000 |

| Abatement Method | Benefits per Airport per Day[4,5] | Benefits per Operation Restricted[4,5] |
|---|---|---|
| Curfews | $23/$84 | $7/$25 |
| Operations Cutbacks | $17/$153 | $0.80/$7 |

TABLE III-9 (continued)

| Enforcement Costs | | |
|---|---|---|
| Annual | 5 Year Total | 10 Year Total |
| $71,000 | $354,000 | $708,000 |

Sources: Text and previous tables.

[1]With the purchase of easements, the noise level remains unchanged. The benefits to property owners are equal simply to the easement costs, or compensation paid.

[2]The first of the two R Based benefit figures recognizes benefits only for those properties situated above 65 $L_{dn}$ at the time the curfew is imposed. The second of the figures recognizes possible benefits for other properties (down to 52.5 $L_{dn}$) previously brought to 65 $L_{dn}$ or below by Level 1 methods.

[3]The first of the two R based benefit figures recognizes benefits only for those properties situated above 65 $L_{dn}$ at the time operations cuts are imposed. The second of the figures recognizes possible benefits for other properties (down to 52.5 $L_{dn}$) previously brought to 65 $L_{dn}$ or below by Level 1 methods and curfews.

[4]To calculate these figures, a five-year time horizon is used. A longer time horizon would lower the figures and a shorter one would raise them.

[5]The first of each pair of figures credits benefits for dwellings down to 62.5 $L_{dn}$. The second credits benefits down to 52.5 $L_{dn}$, and includes benefits for dwellings previously brought to or below 65 $L_{dn}$ by Level 1 methods or (in the case of operations cuts) Level 1 methods and curfews. Both figures in each pair are R Based. With the L Based measure, there are no benefits below 65 $L_{dn}$.

several approaches, with costs far above the benefit estimates. It is reasonable to suppose this approach would be seriously considered only in special instances - where properties were subject to unusually high noise impaction, or where, in a given location, the number of affected properties was few and their removal would facilitate compatible uses of the land, or where the physical safety of the occupants was a central consideration.

Benefit estimates are shown for curfews and operation cutbacks, but no satisfactory procedure was discovered for estimating the costs of these abatement strategies. It is helpful to an understanding of the benefit figures to adjust them to an "airport per day" or "operation restricted" basis. The results of this adjustment are shown toward the end of Table III-9. One may then ask, for example, how the benefit of $7 from the elimination of a night flight compares with the probably cost, or benefit foregone from eliminating that flight. Both curfews and operations cuts represent relatively severe abatement methods as compared, say, to flight pattern changes, because they produce a series of repercussions affecting airport use, carrier scheduling and aircraft utilization, and convenience and mode of passenger travel. In the case of operations cuts, these effects may in some degree be mitigated through the substitution of propeller-driven aircraft for the jets previously used.

The foregoing findings are partially based on benefit estimates that rely on the results of differential property value studies. These results show a degree of concensus, but also of variability (see Table III-2 and III-3, and compare the several R Based and L Based benefit estimates in Table III-9), and there is certainly the possibility that the true parameters for estimating the benefits from noise abatement are somewhat higher or lower than the values used here. Interestingly, a doubling or, in some cases tripling, of these values, and in turn of the benefit estimates, would not suffice to change the cost-benefit balance.

Of the several abatement options considered, only three - Level 1 methods, curfews and operations cuts - actually reduce noise on the receiving property in the manner required by the proposed regulation. Of the other four options discussed - insulation, easements, property acquisition, and a purchase guarantee arrangement - one would reduce noise only inside the home, while the other three would have no effect on the noise level. Property acquisition would serve to change the land use classification, thereby achieving compliance with the regulation. The securing of easements also would achieve compliance. The regulation makes no mention, however, of insulation or purchase guarantee. Nonetheless, each represents a valid approach to the problem.

It is difficult to integrate the potentially adverse health and health-related effects of aircraft noise into a cost-benefit framework, since we have not been able to measure directly the dollar losses of these effects or the dollar benefits from reducing them. But some qualitative and approximate judgements are possible. First, very few of the 2598 dwellings presently subject to noise levels over 65 $L_{dn}$ are exposed to sufficiently high or prolonged impacts to make their occupants likely candidates for hearing loss. But some hearing loss is possible for the few households (four dwellings) exposed to noise levels of over 75 $L_{dn}$ if the exposure continues for 15 to 20 years or more. Second, the observed noise levels are not sufficiently high to cause adverse effects to occupants in cardiovascular functions, in vision, or in other basic physiological functions. But third, the noise levels are sufficient to cause significant degrees of annoyance to the occupants of the affected dwellings at all 13 airports. They also are sufficient to cause significant amounts of speech interference at these airports. Sleep interference, dependent on night operations, is more selective in its impact. That impact would be appreciable at Rockford and of nominal or minor importance at the remaining airports.

These adverse effects are not additive, or supplemental, to the damages measured by property value changes. Rather the property value changes reflect those effects, and in their absence, would presumably be negligible or zero.

The mitigation of existing noise impacts at downstate airports through the application of one or more of the abatement methods considered in this study will not, by itself, assure a permanent reduction or elimination of the problem. The current situation results primarily from the operation of two forces: first, the growth in both business and commercial jet traffic over the past two decades and the expansion of airports to accommodate this traffic; second, the development of land proximate to airports for noise-incompatible, residential purposes. The first of these forces is not predicted to continue over the next 20 years. Although jet operations will grow somewhat, the associated tendency toward increased noise is expected to be offset by a changing fleet mix that incorporates quieter aircraft. Moreover, the noise contours presented in the Technical Study allow for a growth of 1-2 dB at many of the airports.

However, in the absence of countervailing policy, residential development around airports, including development within moderate and even high noise zones, can be expected to continue. The result will be an intensification of present impaction or the undoing of favorable effects from any abatement measures that may have been taken.

Two ways of coping with this problem, which might be used individually or in combination, suggest themselves. One consists of measures to restrict land uses around airports to noise-compatible purposes. Such measures might be supported by legislation at state or local levels or might be achieved through cooperative efforts by airport authorities and local zoning bodies. The other approach involves steps to assure that when noise impacted property is newly purchased or transferred, full discolsure is made to buyers about its noise status. Disclosure would not reduce noise or its effects. It would protect buyers from adverse surprise and help to insure that they would not pay more for property than its noise-discounted worth.

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