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MODE AND ROUTE CHANGING ASSOCIATED WITH THE SPIT ROAD TRANSIT LANE

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ABSTRACT:

This paper analyses the mode and route changing by commuters in response to the introduction of the Spit Road Transit Lane in Sydney. The analysis is based on data collected by a questionnaire survey in December 1975. It was found that the number of carpools travelling from the peninsula served by the lane increased dramatically, mainly as a result of the formation of new carpools. As a result, fewer cars in total and, in particular, fewer low occupant cars travel from the area. Most new car-poolers were formerly car drivers, although a number were originally bus travellers. However, counter-balancing this, a number of former car drivers have now switched to bus travel leaving bus patronage virtually unaltered. Information regarding origin and destination of mode and route switchers is also given and discussed.

THE SPIT ROAD TRANSIT LANE *

INTRODUCTION

One of the major problems facing transport planners today is the difficulty of catering for an unbalanced, constantly growing demand for more road space. Experience has shown that unquestioning provision of new or wider highway facilities is not the way to cope with this demand. As a result, two relatively new concepts have increasingly been applied to transport planning.

The first concept is the idea of manipulating demand for travel rather than merely trying to supply new and bigger facilities. Staggered working hours, decentralization and carpooling programs all reduce the need to provide for an unbalanced, concentrated travel demand.

The second, albeit more fundamental concept was formalized in the 1960's in America (Cherniack, 1963) and recognizes that roads exist for the purpose of moving people rather than vehicles. This concept is based on the premise that - given a constant demand for travel - if more people travel in each vehicle on the road, fewer vehicles will be required and hence less road space and other scarce resources will be consumed.

One way of marrying these two concepts is to give high-occupancy vehicles (trains, trams, buses, carpools) priority on the road. In this way, travel demand is manipulated by promoting efficient modes, and roads are used primarily as people (not vehicle) movers. This paper analyses the effect on mode and route choice of one such priority scheme, the Spit Road Transit Lane in Sydney.

THE SPIT ROAD TRANSIT LANE

Spit Road is one of only four access routes to the Warringah Peninsula in Sydney. The population of the Warringah Peninsula has been expanding rapidly, without commensurate expansion in job opportunities. Consequently, the area acts largely as a dormitory suburb for the major employment areas of North Sydney, Sydney and South Sydney. However, although the population of the peninsula has been expanding rapidly (it was 169,000 in 1974), there is no rail service to the area and the natural barrier formed by Middle Habour has restricted the number of access routes to the area to three road routes and a ferry service (Fig. 1).

As a result, the two major car routes to and from the area (Roseville and Spit Bridges) experience considerable congestion in the peak hours. In 1973, the Public Transport Commission of New South Wales suggested that a bus lane over Spit Bridge would be a viable

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* This paper is based on research carried out at Monash University. The views expressed in the paper are wholly those of the authors.

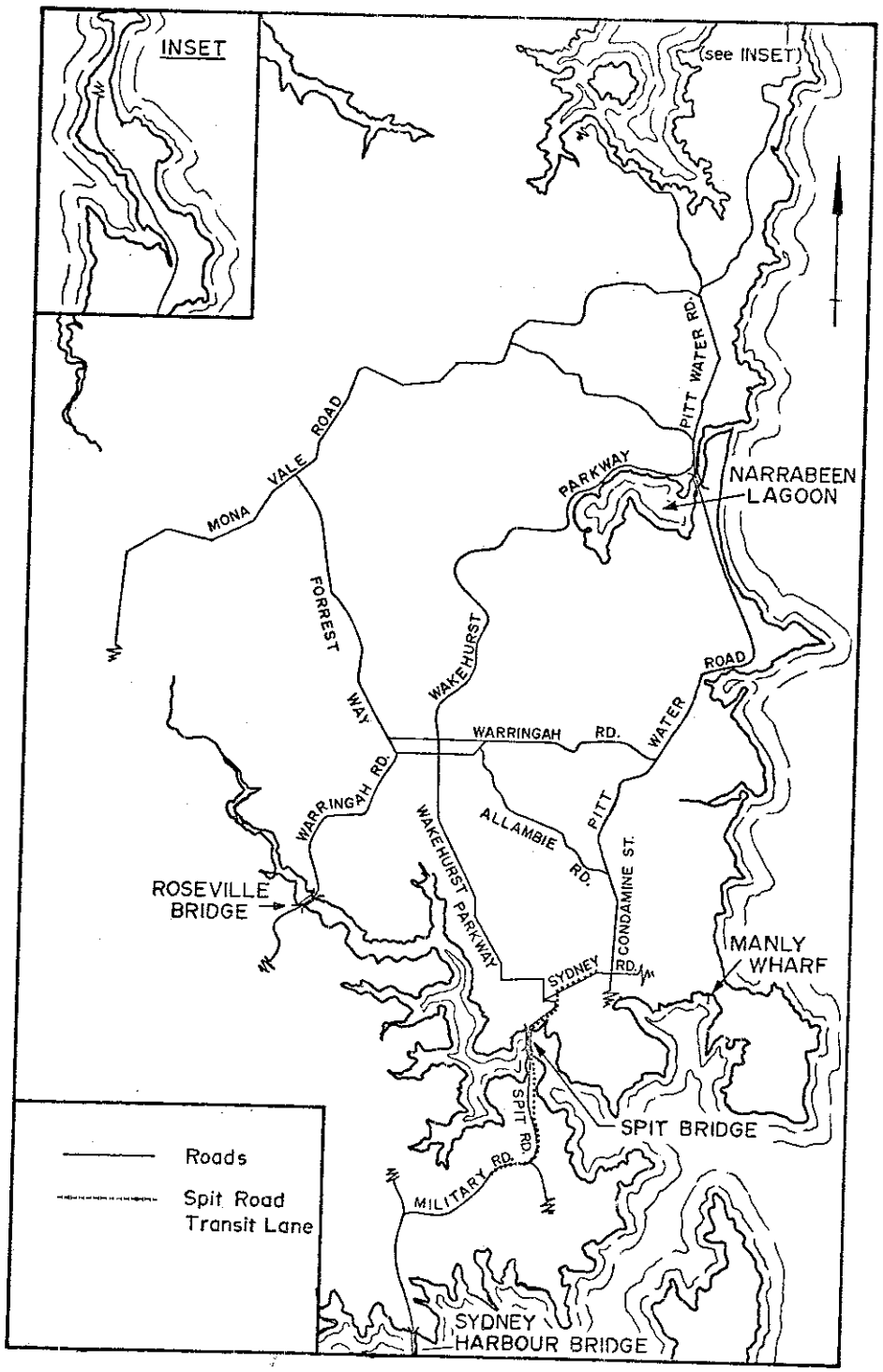

FIG 1 Roads in the Warringah Penninsula

method of reducing the delay experienced by buses travelling on this route. The New South Wales Department of Motor Transport examined the proposal and suggested that the lane also be opened to vehicles with three or more occupants.

The Spit Road transit lane was opened on November 25, 1974 (Fig. 2). When it opened it was 6.1 km in length and reserved one of three peak direction lanes for buses, carpools (defined as cars with three or more occupants), taxis, hire cars, and motorbikes. In conjunction with the opening of this lane, a number of other traffic engineering schemes (including opening residential roads as 'overflow' routes) were implemented (Hallam, 1977). Since that time a number of modifications have been made to the layout and operation of the lane.

A number of studies have been performed to test the effect of the introduction of the lane on traffic performance in general and mode choice in particular (DMT, 1976; McKenzie, 1977). The DMT obtained samples of travel times on the transit route starting at Condamine Street (i.e. before the start of the transit lane). It was found that average bus travel time dropped from 24.2 minutes in October 1974 to 13 minutes in October 1975 (DMT, 1976). At the same time, the variability of bus travel time (measured by variance) fell from 68.6 minutes^2 to 3.2 minutes^2.

The effect on buses of the change in travel time mean and variance can be seen in the table below :

TABLE 1: BUS TRAVEL TIME DISTRIBUTION

% OF BUSES WITH TRAVEL TIME VALUES STATED	BUS TRAVEL TIME (MINUTES) OCT.'74	MAR.'75	OCT.'75
75%	30	16	14
85%	33	17	15
95%	38	18	16

Source: DMT, 1976.

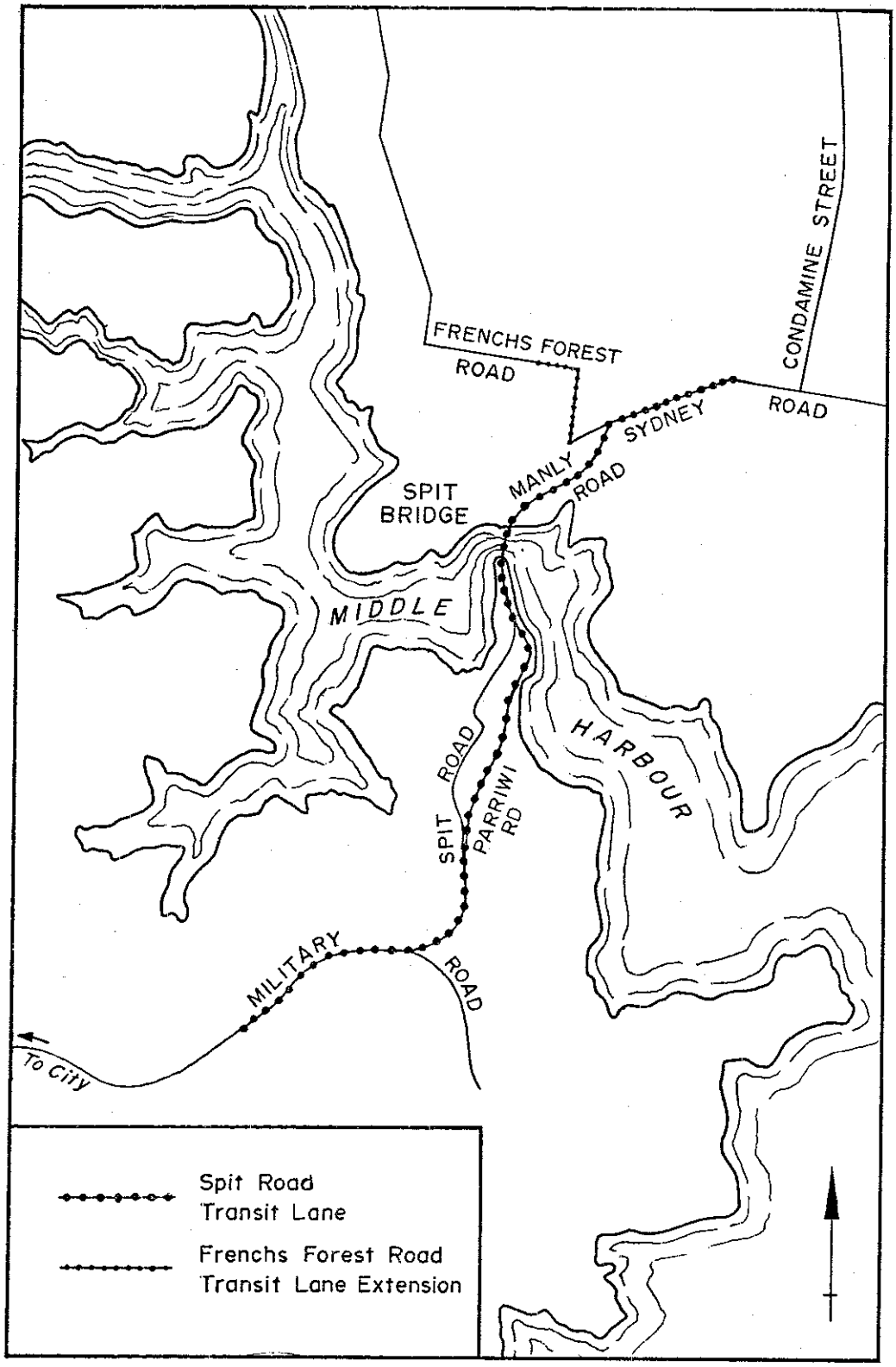

FIG. 2 The Spit Road Transit Line

QUESTIONNAIRE SURVEY

One year after the introduction of the lane, consultants were engaged to distribute a questionnaire (Fig. 3) to a sample of people travelling out of the peninsula between 6:30-9:30 a.m. The distribution points covered all possible exits from the Warringah Peninsula - Spit Bridge, Roseville Bridge, Mona Vale Road and Manly Wharf. Questionnaires were distributed to vehicles waiting in queues at traffic signals at intersections. Bus passengers (on routes using Spit Bridge) and ferry passengers received questionnaires from survey personnel who travelled on the buses and ferries.

Table 2 gives populations, sample sizes and response rates for the survey. Response rates were generally quite high and return rates from the non-public transport routes were quite consistent (between 37.7 and 41.1 percent). The distribution of the questionnaire per half-hour period was also found to be reasonably accurate (DMT, 1976).

TABLE 2: QUESTIONNAIRE DISTRIBUTION AND COLLECTION STATISTICS

ROUTE	TOTAL PASSN. POPN.	TOTAL FORMS		% RE-TURNED	FORMS RE-TURNED AS % OF PASS. POPN.
		ISSUED	RE-TURNED[a]		
Mona Vale Road	4,340	2,597	1,069	41.1	24.6
Warringah Road (Roseville Bridge)	14,470	9,000	3,497	38.9	24.2
Spit Road Transit Lane	4,450	2,206	811	40.0	18.2
Spit Road Non-Transit Lanes	10,490	6,774	2,557	37.7	24.4
Spit Road Buses	6,510	1,483	1,367	92.2	21.0
Ferries & Hydrofoil	4,310	2,124	2,025	95.3	47.0
TOTAL	44,570	24,004	11,326	47.2	25.4

Note: a) 520 forms returned late were not processed.

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This study is being undertaken by Planning Workshop Pty Ltd for the Department of Motor Transport. By answering this questionnaire carefully and completely you can provide vital information to enable policy makers to improve your trip from Manly-Warringah. Name and address is not required.

Late in November last year a special Transit lane for buses and car pools (cars carrying three or more people) was introduced along Sydney Parriwi, Spit and Military Roads. Your answers to this questionnaire will let the Department know your attitude to this Transit lane.

Questions 6, 7, 8, 9, 10 and 11 refer to the usual morning trip on weekdays during the peak traffic period
Please tick box ☑ or write answer as appropriate

FOR OFFICE USE ONLY

ID 1 2 3 4 5 6 Time 7 8 9

Route 10 11

12 13

1. What is the main purpose of this trip?
   Work ☐ Shopping ☐ School ☐ Other ☐

2. Where did you start this trip and what is your destination?
   Trip Start: Suburb _____ Postcode _____
   Trip Destination: Suburb _____ Postcode _____

14 15 16 17 18 19 20 21

3. What has been your method of travel from the Manly-Warringah area on the last five weekdays?

	Monday	Tuesday	Wednesday	Thursday	Friday
Car	☐	☐	☐	☐	☐
Car pool	☐	☐	☐	☐	☐
Bus	☐	☐	☐	☐	☐
Ferry	☐	☐	☐	☐	☐
Motorbike	☐	☐	☐	☐	☐

22 23 24 25 26 27 28 29 30 31

4. If you are travelling by car or car pool today how many people are in the car? ___

32 33

5. What is your occupation and employment situation? (Students please state age)

Occupation: Tradesman/craftsman ☐, Process worker/labourer ☐, Professional/technical ☐, Administrative/managerial ☐, Clerical ☐, Sales ☐, Student (state age) ☐, Unemployed ☐, Other ☐

Employment: Self employed ☐, Wage or salary earner ☐, Unpaid helper ☐, Student ☐, Unemployed ☐

34 35 36 37

6. Where do you live?
   During December 1975: Suburb _____ Postcode _____
   Before November 1974: Suburb _____ Postcode _____

38 39 40 41 42 43 44 45

7. If you travel by car or car pool, how many people usually travel in the car?
   During December 1975 _____ Before November 1974 _____

46 47 48 49

8. In travelling away from the Manly-Warringah area what route do you usually use?

	During December 1975	Before November 1974
Spit Bridge	☐	☐
Roseville Bridge	☐	☐
Mona Vale Road	☐	☐
Ferry	☐	☐
No consistent route	☐	☐

50 51 52 53

9. What is your usual destination?
   During December 1975: Suburb _____ Postcode _____
   Before November 1974: Suburb _____ Postcode _____

54 55 56 57 58 59 60 61

10. What is your usual mode (method) of travel from Manly-Warringah?

	During December 1975	Before November 1974
Car	☐	☐
Car pool	☐	☐
Bus	☐	☐
Ferry	☐	☐
Motorbike	☐	☐

62 63 64 65

11. What is the length of time taken in your usual journey at this time (to nearest ten minutes)?
    During December 1975: _____ Before November 1974: _____

66 67 68 69 70 71

12. What time do you usually leave home (to nearest ten minutes)?
    During December 1975: _____ During November 1974: _____

72 73 74 75 76 77

13. What is your opinion of the new "Transit" lane?
    Should be retained ☐, Should not be retained ☐, Undecided ☐

78 79

14. Please make any other comments . . . . . .

80

PLEASE RETURN IN REPLY PAID ENVELOPE OR HAND TO COLLECTORS BETWEEN 4 PM & 7 PM TONIGHT AT PLACE WHERE FORM WAS HANDED OUT

FIGURE 3:
The Questionnaire

The questionnaire was designed to determine the type and magnitude of mode changing resulting from the introduction of the transit lane. It probed morning peak period travel habits (usual origin, destination, mode, route, travel time, time leave home and occupancy) during November 1974, before the introduction of the transit lane, and during December 1975, the month of the survey. The questionnaire also asked for information concerning the trip being made at the time of the survey (origin, destination, trip purpose, mode, occupancy and route) as well as commuting habits over the previous four days and occupation and employment of the respondent. The preamble heading the questionnaire defined 'carpools' as "cars carrying three or more people" and defined 'usual' as referring to the respondent's "usual morning trip on weekdays during the peak traffic period".

When the raw data was analysed, it was found that the results of the questionnaire responses to questions asking mode of travel. seriously underestimated the number of carpoolers travelling out of the Warringah Peninsula (Table 3).

TABLE 3: COMPARISON OF ESTIMATES OF NUMBER OF CAR AND CARPOOL TRAVELLERS COMMUTING OUT OF THE WARRINGAH PENINSULA; UNEDITED DATA.

DATA SOURCE / MODE	UNEDITED QUESTIONNAIRE; QUESTIONS ASKING MODE		TRAFFIC COUNTS (persons)
	ON DAY OF SURVEY	USUAL DECEMBER 1975	OCTOBER 1975
Car	32,102	31,953	28,013
Carpool	2,409	2,444	5,535

However, upon closer analysis it was found that many respondents stated that their travel mode was car, but then stated that the number of people in the car was three or more. By definition, these people were considered to be carpoolers. The small number of people who stated that their mode was 'carpool' suggests that confusion lay in choice of mode, rather than statement of occupancy.

This confusion could have resulted from the fact that respondents had a different perceptual definition of 'carpool' than specified on the questionnaire. Members of non-formalised or irregular carpools (e.g. parents driving children to school, or commuters travelling in the same car for a reason specific to that day only) may not have considered themselves to be carpooling, because they thought a carpool was a formalised arrangement between commuters travelling to work each day.

The layout of the questions asking travel mode may also have contributed to this confusion. In these questions the mode 'car' is listed before 'carpool'. It would be possible for a carpooler to begin looking down the list of alternative modes, see 'car', and tick that box without looking further.

Therefore, as replies from carpools were clearly underrepresented in the data set, answers to questions asking travel mode were recoded according to the stated occupancy of the car or carpool (this recode did not apply to public transport modes or motorbikes). If stated route was Mona Vale Road, Spit Bridge or Roseville Bridge the following recodes were applied :

a) If stated mode was car, but stated occupancy was three or more, mode was recoded to 'carpool'.

b) If stated mode was carpool, but stated occupancy was one (an occupancy of zero might just have implied a failure to answer the occupancy question and an occupancy of two might just have implied a failure by the respondent to count himself when computing occupancy), mode was recorded to 'car'.

Table 4 details the number of times this recode was applied.

TABLE 4: NUMBER OF CASES WHERE CAR AND CARPOOL MODES WERE RECORDED ACCORDING TO OCCUPANCY.

VARIABLE	RECODED TO	NUMBER OF CASES
Usual Mode 1975	Car	170
	Carpool	755
Usual Mode 1974	Car	12
	Carpool	554
Mode on Day of Survey	Car	61
	Carpool	707

Table 5 shows the number of car and carpool travellers travelling out of the entire peninsula as estimated by both traffic counts and the edited questionnaire responses. Given daily and seasonal variations in traffic volumes, and the difficulty of attributing exact response rates to car and carpool travellers, these results are considered quite acceptable - they are certainly a significant improvement upon results of the unedited questionnaire (Table 3).

TABLE 5: COMPARISON OF ESTIMATES OF THE NUMBER OF CAR AND CARPOOL TRAVELLERS COMMUTING OUT OF THE WARRINGAH PENINSULA; EDITED DATA.

DATA SOURCE / MODE	EDITED QUESTIONNAIRE; QUESTION ASKING MODE		TRAFFIC COUNTS (persons)
	ON DAY OF SURVEY	USUAL DECEMBER 1975	OCTOBER 1975
Car	28,792	28,711	28,013
Carpool	6,109	5,892	5,535

ROUTE AND MODE CHANGING DUE TO THE TRANSIT LANE

The analysis of mode and route changing is based upon survey questions probing the usual travel habits of respondents before the introduction of the transit lane and after the introduction of the lane. No question on the survey explicitly asked whether or not changes in travel habits were due to the transit lane. To reduce the possibility of extraneous influences, on travel decisions affecting this analysis, only commuters whose stated origin and destination had not changed between 1974 and 1975 are included in the analysis. Table 6 gives the response rate of these commuters.

Table 7 shows the route choice of carpoolers who have started carpooling since the introduction of the transit lane and carpoolers who carpooled before the transit lane, but have since changed route. These two groups are compared with carpoolers who have not changed their route or mode since the introduction of the transit lane.

TABLE 6: RESPONSE RATE OF COMMUTERS WITH NO O-D CHANGE

MODE	TOTAL POPULATION[a]	NUMBER OF RESPONDENTS, USUAL 1975 MODE		ESTIMATED RESPONE RATE OF COMMUTERS WHOSE O-D IS UNCHANGED[b]
		TOTAL	O-D SAME 1974 TO 1975	
Car[c]	23,758	5,926	3,395	0.248
Carpool	5,770	1,158	818	0.201
Bus	6,510	1,176	743	0.180
Ferry	4,310	1,194	728	0.277

Note : a) Total Population based on observed populations (Table 2).

b) Response Rate $= \frac{T}{PT \times ODU}$

where : T = Total number of respondents stating this is their usual mode (1975).

PT = Population Total for mode in question.

ODU = Proportion of these respondents who have the same O-D characteristics 1974 and 1975.

c) Includes only Roseville and Spit Bridges.

TABLE 7: ROUTE CHOICE OF CARPOOLERS WHO HAVE CHANGED ROUTE OR MODE SINCE THE INTRODUCTION OF THE TRANSIT LANE

TRAVEL CHANGE / ROUTE 1975	CARPOOLERS WHO HAVE :			TOTAL
	Changed Route But Not Mode Since 1974	Not Changed Route Nor Mode Since 1974	Changed Mode Since 1974	
All Routes	114	2,273	1,467	3,854
Spit Bridge	95	1,392	1,124	2,611
Percent Using Spit Bridge	83.3%	61.2%	76.6%	67.7%

Note: a) Numbers refer to estimated total numbers of commuters.

b) Non-responses to usual route questions have been excluded from table.

c) Table based on 775 responses.

It can be seen that, overall, 67.7 percent of all carpoolers leaving the Warringah Peninsula (who have not changed origin or destination) travel via Spit Bridge. However, this tendency for carpoolers to use Spit Bridge cannot be attributed to carpool diversion as a result of the introduction of the transit lane. Carpoolers who have changed route (but not mode) since the introduction of the transit lane make up less than three percent of the total sample of carpoolers. The effect that the transit lane has had on carpool route choice appears to have been related more to the mode switch associated with the transit lane than to carpool diversion. Over seventy-six percent of commuters who have started to carpool since the introduction of the transit lane (38.1 percent of the carpool population) travel from the peninsula via Spit Bridge, while only 61.2 percent of carpoolers who have not changed route nor mode use Spit Bridge.

Table 8 presents the estimated total carpool route changing that has occurred since the introduction of the transit lane. Route changes associated with a mode change to carpool are included in the table.

TABLE 8: CARPOOL ROUTE CHANGING SINCE THE INTRODUCTION OF THE TRANSIT LANE

Route 1974 / Route 1975	Spit Bridge	Roseville Bridge	Mona Vale Road	No Consistent Route	Row Total
Spit Bridge		169	0	25	194
Roseville Bridge	50		5	0	55
Mona Vale Road	0	0		0	0
No Consistent Route	0	5	0		5

Note : a) Numbers refer to estimated total numbers of commuters.

b) Non-Responses have been excluded from table.

c) Table based upon 51 responses.

Table 8 shows that there has been an overall change in carpool route choice from Roseville Bridge to Spit Bridge. Spit Bridge has had a net gain of 144 carpoolers travelling over it, while Roseville Bridge has had a net loss of 119 carpoolers. However, only 45 percent of these route changers (i.e. 114 travellers) travelled by carpool before the transit lane was introduced.

Thus, route choice of carpools travelling away from the Warringah Peninsula favoured Spit Bridge before the transit lane was implemented. The introduction of the transit lane increased the route choice of carpoolers approximately an extra six percent in favour of Spit Bridge (Table 7), but less than half of this change was due to carpool diversion. Most of the route changing was associated with a mode change to carpool.

While the transit lane appears to have attracted some carpool travellers away from Roseville Bridge to Spit Bridge, the reverse has occurred for car travellers. Overall, forty-seven respondents who travelled by car before and after the transit lane was introduced changed route from Roseville Bridge to Spit Bridge, while 141 respondents changed route in the other direction. This leaves a net diversion to Roseville Bridge of 94 respondents representing 379 commuters.

Using the average occupancy for cars calculated from responses to the questionnaire (1.16 persons/car), this would correspond to a net diversion of about 327 cars to Roseville Bridge. Similarly, only about twenty carpool cars have been diverted to Spit Bridge. Net vehicle diversion to Roseville Bridge would therefore appear to be approximately 300 cars or about 4.7 percent of the vehicles using Roseville Bridge whose occupants have not changed origin nor destination since 1974.

It should be noted that this figure represents only the effects of route diversion. As previously mentioned, mode changing has been a much more significant effect of the transit lane and this in turn affects the number of vehicles travelling via each route.

Before examining the effect the transit lane has had on mode choice in the peninsula, it is worth noting that the lane may have resulted in some route changing of bus travellers. Four hundred and eighty-six respondents stated that they travelled by bus both before and after the introduction of the transit lane and, after introduction of the transit lane, usually travelled via Spit Bridge. Only two of these respondents stated that their route before the introduction of the transit lane was Roseville Bridge and a further three stated that they had no consistent route before the transit lane.

Thus it would seem that the transit lane has caused at most twenty-seven Roseville Bridge bus commuters to divert to Spit Bridge. However, as Roseville Bridge buses were not included in the survey, no comparative figures for route switch to Roseville Bridge are available.

Table 9 summarises the mode changing that has occurred throughout the peninsula since the introduction of the transit lane.

TABLE 9: PERCENTAGE OF COMMUTERS TRAVELLING BY MODE A IN 1975 WHO TRAVELLED BY MODE B IN 1974.

Mode 1975 \ Mode 1974	Car	Carpool	Bus	Ferry	Motorbike and Multi-Mode [a]	Total Mode 1975 No. [b]	Total Mode 1975 %
Car	95.0	2.5	1.5	0.4	0.6	4455	100
Carpool	26.2	62.3	7.5	2.8	1.6	827	100
Bus	6.9	2.1	86.5	4.2	0.3	727	100
Ferry	3.1	0.4	1.6	94.2	0.7	704	100
Motorbike and Multi-Mode [a]	8.2	2.2	5.0	4.1	80.6	319	100

Note : a) 49 respondents usually travelled by motorbike, 5 by car-bus multimode, 78 by a car-ferry multimode and 175 by some other (unspecified) multimode.

b) Numbers refer to actual number of respondents.

It can be seen from Table 9 that most 1975 carpoolers who have changed mode since 1974 have changed from car. In fact, 3.5 times as many carpoolers come from cars as come from buses. Even when the relative population sizes of car travellers using Roseville and Spit Bridges and bus travellers is taken into account (there are 3.3 times more car travellers than bus travellers), the analysis indicates that car travellers are at least as likely to adopt the carpool mode as bus travellers.

Similarly, the largest percentage of new bus travellers come from cars. Previous car travellers account for over one-half of the new bus travellers. Thus, despite the fact that a number of bus travellers have been attracted to carpools, the fact that the bus mode has itself attracted a substantial number of car travellers would indicate that mode switching since the introduction of the transit lane has been largely at the expense of car travel.

Table 10 is based upon the figures in Table 9, but the numbers have been scaled to represent the actual numbers of commuters (who travelled between the same O-D pairs in 1974 and 1975) travelling out of the Warringah Peninsula.

TABLE 10: ESTIMATED MODE CHANGING AFTER THE INTRODUCTION OF THE TRANSIT LANE

Mode 1974 / Mode 1975	Car	Carpool	Bus	Ferry	Total Changed [b] No.	Total Changed [b] %
Car	17,218	448	274	72	- 669	- 3.7[c]
Carpool	1,080	2,597	313	114	+ 959	+ 23.4
Bus	300	89	3,761	184	- 54	- 1.2) -4.2
Ferry	83	11	40	2,476	- 236	- 9.0)

Notes:
a) Numbers represent estimated actual numbers of commuters.
b) A positive total change implies that more commuters travelled by the mode in question after the introduction of the transit lane compared to before.
c) Percentage change = No. change/Row total.
d) 143 respondents who stated their mode in 1975, but not 1974, have been redistributed in accordance with Table 9.

It is clear that the transit lane has promoted a substantial increase in the amount of carpooling out of the peninsula. This increase has been at the expense of all other modes, but, in particular, from car and ferry. The number of car travellers commuting out of the peninsula by all routes has been substantially reduced. Overall, twelve times as many car travellers as bus travellers (669 and 54 respectively) and over twice as many car travellers as public transport travellers (669 and 290 respectively) have been diverted from their original modes.

However, it is also clear from Table 10 that the transit lane has seriously eroded the patronage of the ferry. As a result, the percentage of public transport travellers that have changed mode is

slightly higher than the percentage of car travellers who have changed mode. A number of comments concerning this should, however, be made.

Firstly, the Spit Road transit lane has shown that priority lanes are an effective way of promoting carpooling at the expense of car travel. Secondly, if commuters are given the same incentive to use public transport as to use carpools, then carpool formation will not be at the expense of public transport. As shown in Table 10, bus patronage has not been greatly affected by the transit lane. Indeed, more car and carpool travellers have changed to bus than bus travellers to carpool. However, 274 bus travellers changed to car during the year following the introduction of the transit lane and, as a result, bus patronage dropped slightly. Possibly these commuters were taking advantage of the improved travel time for cars on Spit Road, but it is probably more likely that these commuters did not change mode in response to the introduction of the transit lane. In this case, it is possible that the transit lane has averted an even larger swing from bus to car.

It should also be noted that transit lanes operating in the peak hours affect mainly peak hour public transport patronage. As many public transport services are overloaded at this time anyway, some loss of patronage will not always be undesirable.

Finally, the loss of ferry patronage may not be due entirely to the transit lane. At the time the transit lane was being introduced (November 1974), the ferry was plagued by industrial unrest. The strikes associated with this and the concomitant disruption of the ferry service may well have diverted commuters to other modes.

If the reduction in car travellers and the increase in carpoolers noted in Table 10 are factored by the average occupancies of cars and carpools noted earlier (1.16 and 3.37 persons per vehicle respectively), the reduction in the number of cars travelling out of the peninsula is about 300 or 1.8 percent of all private vehicles carrying commuters who had the same origin and destination in 1974 and 1975. That is, more private vehicle commuters are being carried in fewer cars.

O-D CHARACTERISTICS OF NEW CARPOOL AND NEW BUS TRAVELLERS.

In this section the origins and destinations of commuters who have changed mode since the introduction of the transit lane are examined. The origins and destinations of these commuters will be compared with the origins and destinations of other commuters travelling by the mode previously used by these commuters.

Origins

Figures 4, 5 and 6 compare the origins of new carpoolers with the origins of commuters travelling by the mode previously used by these carpoolers. One would expect that, if mode changing was uniform throughout the peninsula, the distribution of the origins of new carpoolers who have diverted from a particular mode would be the same as the distribution of the origins of commuters still travelling by that mode. For example, if twice as many commuters travel by, say, car from postcode area A as from postcode area B, one would expect twice as many postcode area A car travellers to change mode to carpool as postocde area B car travellers (all other things being equal). Thus, Figure 4 compares the origins of carpoolers who travelled by car before the implementation of the transit lane with the origins of commuters travelling by car on the day of the survey.

Figure 4 shows that, while carpooling has attracted car travellers from throughout the peninsula, it has preferentially attracted car travellers from suburbs South of Narrabeen Lagoon and East of Wakehurst Parkway (i.e. near the start of the transit lane - Refer to Fig. 1). In this area, there is only one postcode (Fairlight) from which the number of car travellers as a percentage of all car travellers is greater than the number of carpoolers who previously travelled by car as a percentage of all carpoolers who previously travelled by car. In particular, a very large percentage of the carpoolers who previously travelled by car travel from Balgowlah. On the other hand, West of Wakehurst Parkway and North of Narrabeen Lagoon, a majority of the postcodes contain more car travellers as a percentage of all car travellers than carpoolers who previously travelled by car as a percentage of all carpoolers who previously travelled by car.

However, it must be remembered that car travellers from North of Narrabeen Lagoon and, especially, West of Wakehurst Parkway are less likely to use Spit Bridge than car travellers South of Narrabeen Lagoon. The slight tendency for the transit lane to attract car travellers from areas near the start of the transit lane is probably less an effect of the transit lane than of the natural origin-destination characteristics and concomitant route choice of Warringah Peninsula commuters.

Figure 5 compares the origins of carpoolers who travelled by bus before the implementation of the transit lane with the origins of commuters travelling by bus on the day of the survey. As with the analysis of previous car travellers, there is a statistically significant

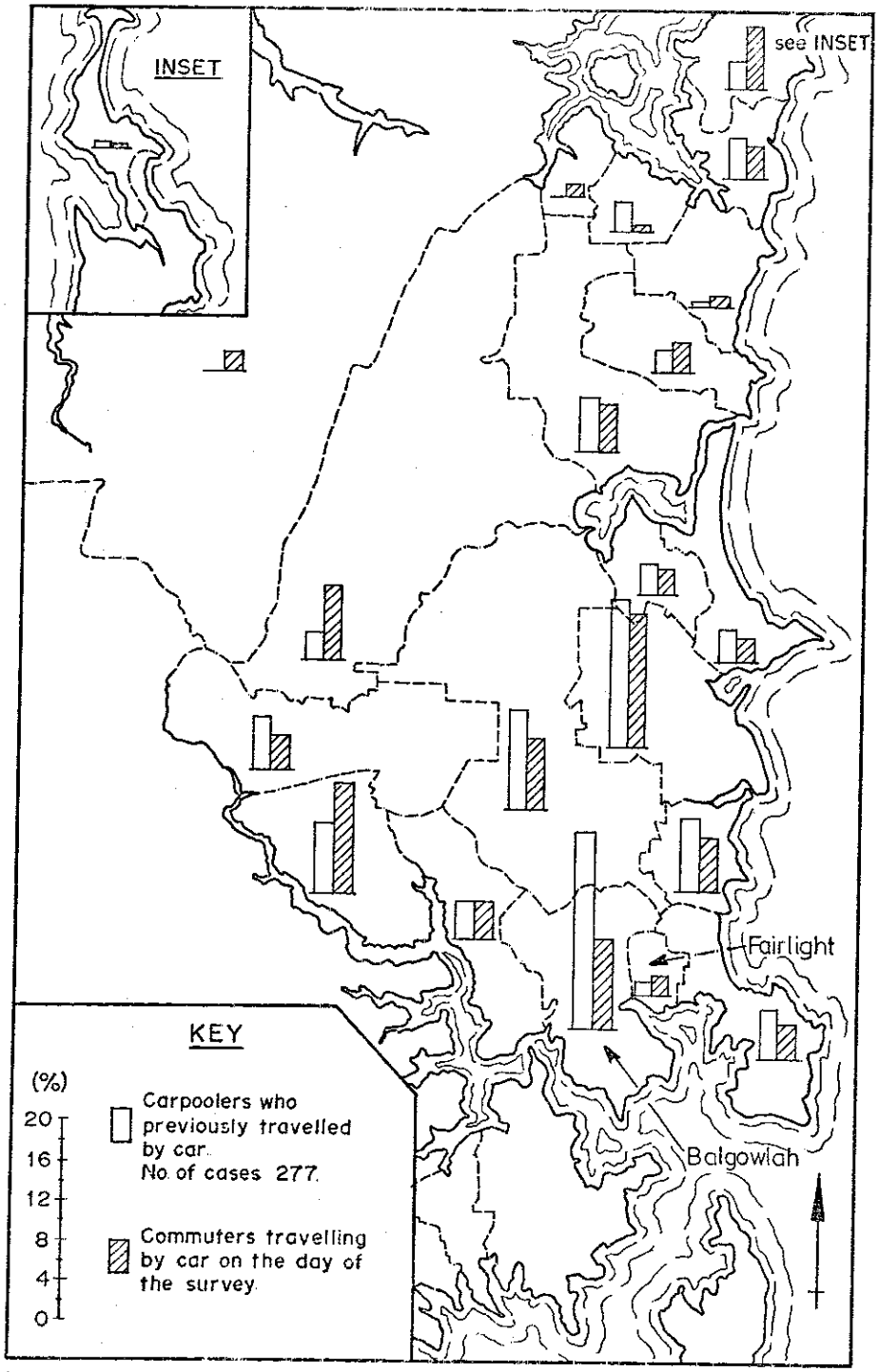

FIG 4 Percentage of Carpoolers Who Previously Travelled By Car Commuting From Each Postcode, Compared To The Percentage of All Present Car Travellers Commuting From Each Postcode

difference between the distributions of trips from the Warringah Peninsula origins,(1) but, again, these differences are not easily traced back to the effects of the transit lane. It appears that West of Wakehurst Parkway a number of bus travellers have changed to carpool. However, this may be misleading, for buses travelling over Roseville Bridge (i.e. those serving the area West of Wakehurst Parkway) were not included in the survey, so that commuters who have changed mode from buses travelling over Roseville Bridge are being compared to commuters travelling from the same suburb by bus over Spit Bridge. Nevertheless, it would seem that bus travellers travelling from postcodes South of Narrabeen Lagoon may be slightly more likely to change to carpooling than bus travellers travelling from postcodes North of Narrabeen Lagoon.

Figure 6 compares the origins of carpoolers who travelled by ferry before the implementation of the transit lane with the origins of commuters travelling by ferry on the day of the survey. The small number of carpoolers who stated that they previously travelled by ferry severely reduces the usefullness of his map, but it is included here for completeness. However, it does appear that commuters attracted to carpools from the ferry are those commuters living a long way from Manly Wharf (i.e. those for whom access to the ferry is most difficult).

Thus, attraction of commuters to carpools from other modes as a result of the transit lane has not been confined to any one part of the peninsula. While there may be a slightly greater tendency for new carpoolers to come from South of Narrabeen Lagoon than other areas, this is not necessarily due to a greater impact of the transit lane in this area. It may, at least partially, be explained by the natural variations in route choice throughout the peninsula.

Similar examination of the data reveals that commuters attracted to buses as a result of the transit lane have also been drawn from throughout the peninsula.

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1 As with all comparisons of the distribution of two sets of origins or two sets of destinations in this paper, the satistical distributions used to analyse differences is the Chi-Squared distribution. A contingency table of the two distributions of respondents' origins or destinations is constructed and the Chi-Squared distribution is used to determine whether or not the distributions might have been drawn from the same population. If ever origins or destinations must be aggregated as part of the test (e.g. to make expected number in that cell of the table five or more), where practicable, neighbouring origins or destinations are aggregated.

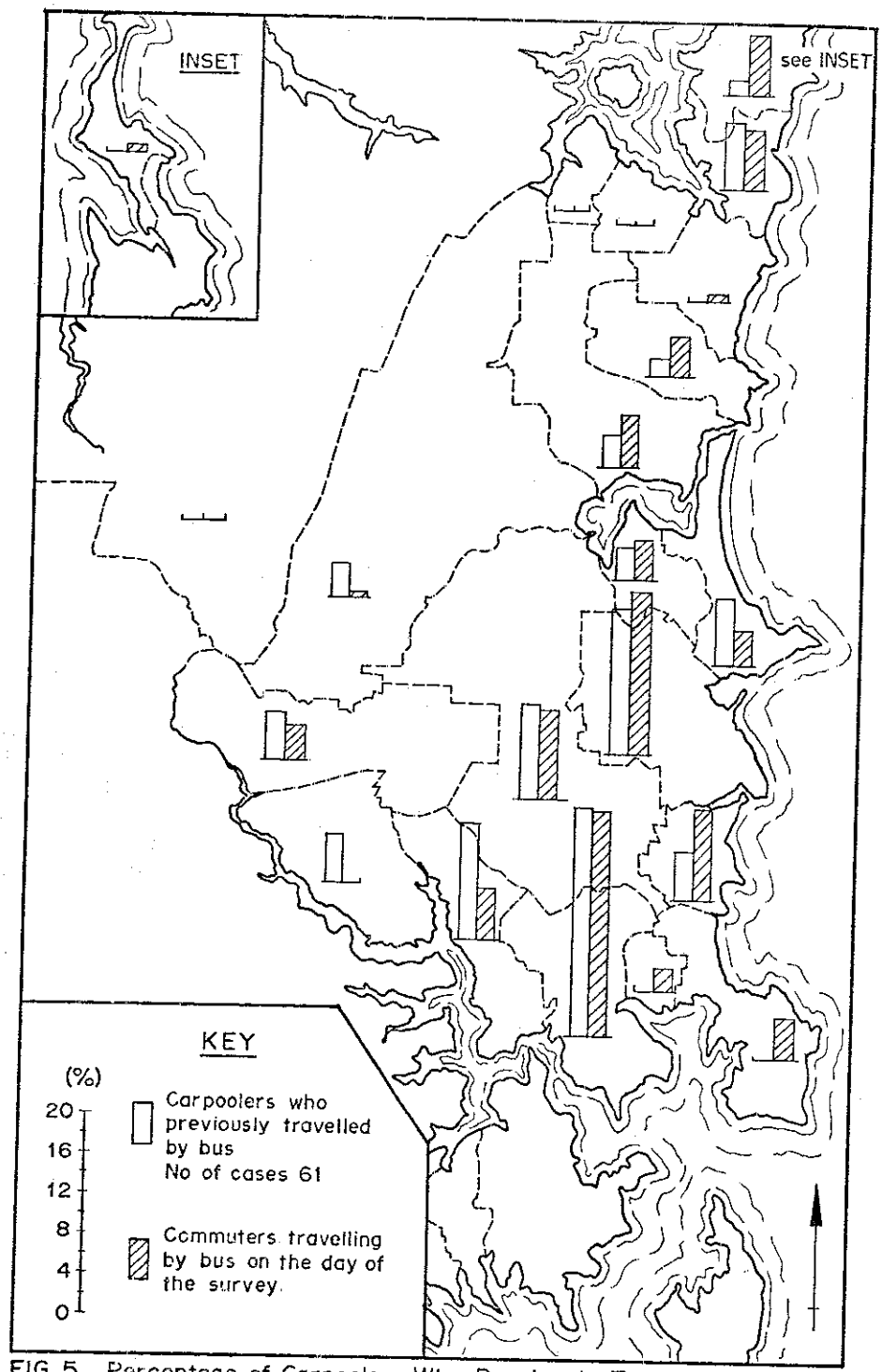

FIG. 5 Percentage of Carpoolers Who Previously Travelled By Bus Commuting From Each Postcode, Compared To The Percentage of All Present Bus Travellers Commuting From Each Postcode

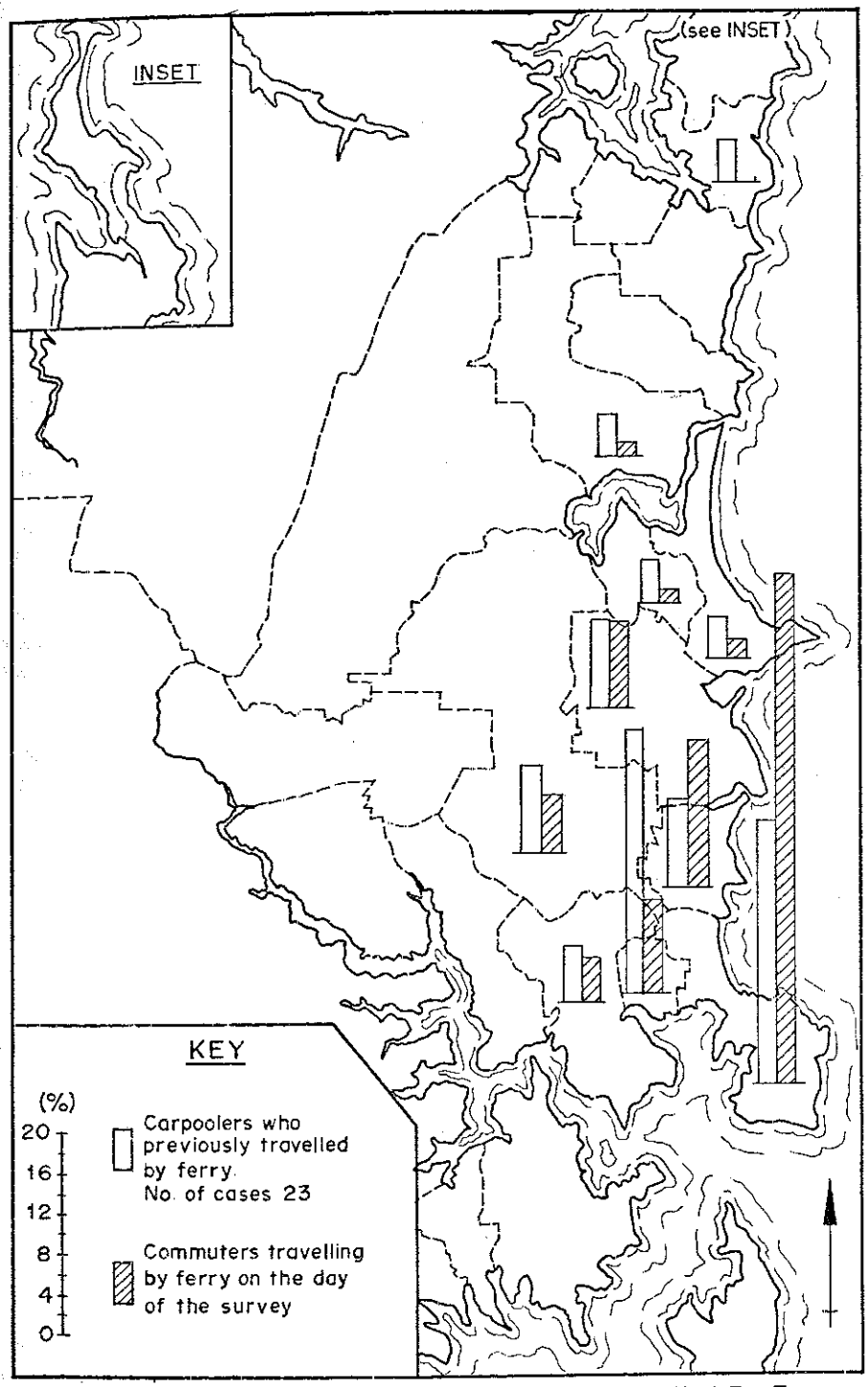

FIG 6 Percentage of Carpoolers Who Previously Travelled By Ferry Commuting From Each Postcode, Compared To The Percentage of All Present Ferry Travellers Commuting From Each Postcode.

Destinations

Table 11 compares the destinations of carpoolers who previously travelled by car, with the destinations of commuters travelling by car on the day of the survey. It also shows that car travellers who travel to the CBD are much more likely to change mode to carpool than other car travellers. On the other hand, Table 12 indicates that the reverse is true of the public transport modes.

While only 18.6 percent of all car travellers surveyed on the day of the survey were travelling to the CBD, 39.6 percent of car travellers who had changed mode to carpool commuted to the CBD. It may be that the high trip attraction density of the CBD has facilitated the formation of carpools among car drivers. Certainly this would be a factor, but it is also likely that traffic congestion and parking cost and restraint associated with car travel to the CBD has acted as a disincentive to car driving - supplementing the incentive for carpooling offered by the transit lane and its associated publicity.

While congestion and parking cost makes the CBD one of the least convenient destinations to travel to by car, the high level of public transport service to the CBD and the relatively low level to other areas makes the CBD the most convenient destination for public transport travel. As a result, the percentages of bus and ferry travellers who have changed to carpools and are travelling to the CBD are lower than the percentages of bus and ferry travellers travelling to the CBD on the day of the survey (Table 12 - see next page).

TABLE 11: DESTINATIONS OF FORMER CAR TRAVELLERS WHO CARPOOL AND PRESENT CAR TRAVELLERS

Destination	Carpoolers who previously travelled by car		Commuters who travelled by car on the day of the survey	
	No.	%	No.	%
CBD	84	39.6	1,110	18.6
Inner Ring	14	6.6	514	8.6
Second Ring	19	9.0	430	7.2
Third Ring	7	3.3	422	7.1
Northern Sydney	51	24.1	1,981	33.2
Roseville	9	4.2	849	14.2
Hornsby	3	1.4	153	2.6
Mosman	10	4.7	244	4.1
Far West	1	0.5	60	1.0
Outer Ring	0	0.0	79	1.3
Warringah Peninsula	13	6.1	126	2.1
TOTAL	211	100%	5,968	100%

Note: a) Numbers refer to actual number of respondents.

b) Figure 7 indicates the position of these aggregate destinations.

TABLE 12: DESTINATIONS OF FORMER BUS AND FERRY TRAVELLERS WHO CARPOOL AND PRESENT BUS AND FERRY TRAVELLERS

Destination	Carpoolers who previoulsly travelled by				Commuters who travelled on the day of the survey by			
	BUS		FERRY		BUS		FERRY	
	No.	%	No.	%	No.	%	No.	%
CBD	36	59.0	17	73.9	853	75.4	1,319	89.6
Inner Ring	3	4.9	3	13.0	15	1.3	87	5.9
Northern Sydney	16	26.2	0	0.0	197	17.4	5	0.3
Mosman	0	0.0	0	0.0	51	4.5	0	0.0
Other	6	9.9	3	13.0	16	1.4	61	4.2
TOTAL	61	100%	23	100%	1,132	100%	1,472	100%

Note: a) Numbers refer to actual number of respondents.

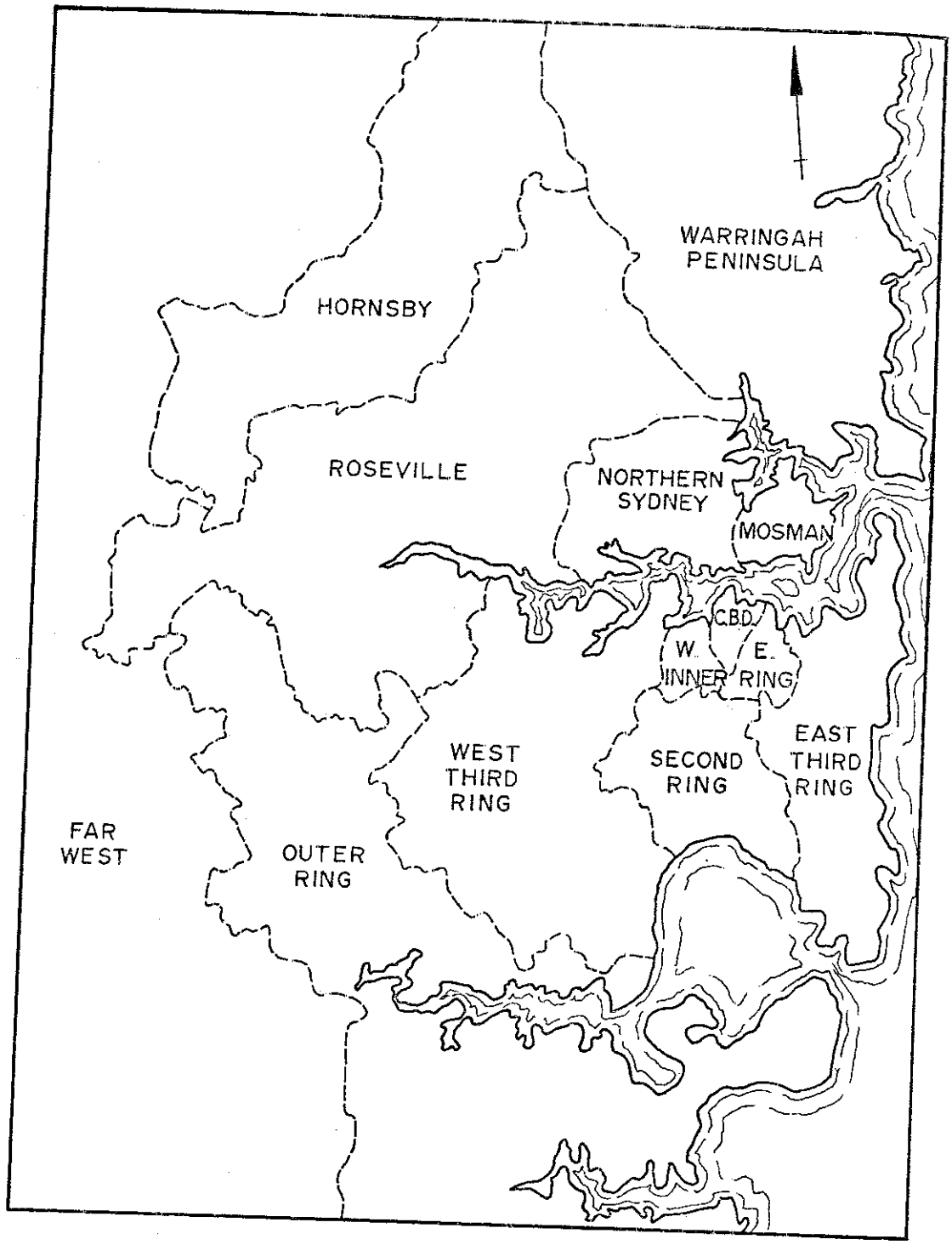

FIG. 7 Destinations of Commuters from The Warringah Peninsula

Carpooling therefore seems to attract commuters whose trips before they changed to carpooling were made to areas not well served by the mode by which they travelled. The differences in the destinations of carpoolers whose previous mode was either car or bus and commuters travelling by car or bus respectively on the day of the survey were both statistically significant at the 99 percent level, but the change from ferry to carpool was too small to make the differences significant. However, it is worth remembering that a similar, albeit still not statistically significant, tendency for carpooling to attract ferry travellers from origins least well served by the ferry was noted in the previous section.

It is interesting to note that the destinations of carpoolers who previously travelled by some other mode and carpoolers who have not changed their travel habits since the inauguration of the transit lane are not statistically different (Table 13). Even the destinations of the members of these two groups who travel via Spit Bridge are not significantly different. It would seem therefore that while the transit lane has preferentially attracted an identifiable group of commuters from non-carpool modes, these carpoolers cannot easily be differentiated (by destination) from other carpoolers. That is, the transit lane has had maximum effect at the margins of mode choice.

A similar trend can be noted for attractions to buses. Table 14 compares the destinations of bus travellers who previously travelled by car, carpool or ferry with the destinations of bus travellers who travelled by bus even before the introduction of the transit lane.

Table 14 indicates that a greater percentage of new bus travellers travel to the CBD (81.5%) than commuters who travelled by bus before and after the introduction of the transit lane (69.2%). As the CBD is the focal point of the Warringah Peninsula bus service, it would appear that commuters who have changed to bus tend to travel to the area best served by bus more than other bus travellers. As a majority of these commuters come from car and carpool, it would seem that traffic congestion and parking cost and restraint associated with car travel to the CBD has acted to supplement the incentive to travel by bus offered by the transit lane.

That is, the transit lane has preferentially attracted to buses a combination of those commuters for whom the bus provides a high level of service and those travellers commuting to areas with the worst level of car service. In each case these commuters tend to be travellers commuting to the CBD.

TABLE 13: DESTINATIONS OF PRESENT CARPOOLERS WHO HAVE CHANGED MODE SINCE 1974 COMPARED TO THE DESTINATIONS OF CARPOOLERS WHO HAVE CHANGED NEITHER ROUTE NOR MODE SINCE 1974.

DESTINATION	CARPOOLERS WHO HAVE			
	CHANGED MODE SINCE 1974		NOT CHANGED MODE NOR ROUTE SINCE 1974	
	Number	Percentage	Number	Percentage
CBD	152	47.9	187	40.1
Inner Ring	20	6.4	41	8.8
Second Ring	22	6.9	27	5.8
Third Ring	9	2.8	13	2.8
Northern Sydney	69	21.8	132	28.3
Roseville	9	2.8	25	5.4
Hornsby	3	0.9	3	0.6
Mosman	14	4.4	15	3.2
Far West	1	0.0	0	0.0
Outer Ring	0	0.0	3	0.6
Warringah Peninsula	17	5.4	18	3.9

Note: a) Numbers refer to actual number of respondents.

TABLE 14: COMPARISON OF DESTINATIONS OF NEW BUS TRAVELLERS AND BUS TRAVELLERS WHO TRAVELLED BY BUS BEFORE AND AFTER THE TRANSIT LANE

DESTINATION	BUS TRAVELLERS WHO PREVIOUSLY TRAVELLED BY CAR, CARPOOL OR FERRY		BUS TRAVELLERS WHO TRAVELLED BY BUS BEFORE AND AFTER THE TRANSIT LANE b)	
	No.	%	No.	%
CBD	75	81.5	413	69.2
Inner Ring	1	1.1	12	2.0
Second and Third Rings	1	1.1	7	1.2
Northern Sydney	8	8.7	105	17.6
Roseville	0	0.0	4	0.7
Mosman	1	1.1	18	3.0
Warringah Peninsula	6	6.5	38	6.4
TOTAL	92	100%	597	100%

Note: a) Numbers refer to actual number of respondents.

b) These commuters had also not changed their destination from 1974 to 1975.

CONCLUSION

Because it was only the second arterial priority lane in the world that has permitted carpools, the Spit Road Transit Lane was an important demonstration project. A number of important conclusions can be drawn from the analysis above.

1) The transit lane has not significantly altered the route choice of commuters who travelled by carpool both before and after the introduction of the transit lane. Nevertheless, as a result of attracting a large number of commuters from other modes, the route choice of car-poolers travelling from the Warringah Peninsula favoured Spit Bridge by an extra six percent after the transit lane was introduced compared to before the transit lane. Diversion of bus travellers from Roseville Bridge to Spit Bridge has been negligible.

2) The net diversion of car travellers (whose stated origins and destinations have not changed from 1974 to 1975) from Spit Bridge to Roseville Bridge is about 379 commuters. This respresents a diversion of about 327 cars. Approximately twenty carpool vehicles have been diverted from Roseville to Spit Bridge, so the overall diversion of vehicles from Spit to Roseville Bridge in the year following the transit lane's introduction is about 300 vehicles. This amounts to about 4.7 percent of the vehicles using Roseville Bridge whose occupants have not changed their origin or destination since the introduction of the transit lane.

3) The transit lane has induced a large number of commuters to adopt the carpool mode (approximately a 23.4 percent increase). This gain has been at the expense of all other modes.

Overall, more than twice as many car travellers as public transport travellers have changed to carpooling, although the proportion of public transport travellers who have changed mode is slightly greater (4.2 percent of public transport travellers compared to 3.7 percent of car travellers have changed mode since the introduction of the transit lane). Nevertheless, the transit lane has shown that priority lanes are an effective way of promoting carpooling at the expense of car travel.

It would seem that if commuters are given the same incentive to use public transport as to use carpools, carpool formation will not also be at the expense of public transport. For, while bus patronage was not seriously affected by the transit lane, ferry patronage appears to have fallen 9 percent.

4) Overall, the reduction in the number of cars travelling out of the peninsula is about 300 or 1.8 percent of all private vehicles

travelling via Roseville or Spit Bridges. As a result of the transit lane, more private vehicle commuters are being carried in fewer cars.

5) The attraction of commuters to carpools and buses from other modes as a result of the transit lane has not been confined to any one part of the peninsula.

6) Commuters attracted to carpooling tend to travel to areas least accessible by their previous mode. In particular, carpoolers who previously travelled by car tend to travel to the CBD more than car travellers who have not changed mode, while carpoolers who formerly travelled by bus or ferry tend to travel to the CBD less than bus and ferry travellers who have not changed mode.

However, the distribution of destinations of new carpoolers is not significantly different to the distribution of destinations of carpoolers who carpooled even before the introduction of the transit lane. It would therefore seem that the transit lane has had maximum effect at the margins of mode choice.

In general, one may conclude that the Spit Road Transit Lane has been successful in its attempt to induce mode switching to high occupancy vehicles. It also appears to have been successful in providing a better level of service to those high occupant vehicles. The implementation of such lanes at other sites, such as Victoria Road in Ryde, and the careful monitoring of their performance would appear to be a logical next step in an effort to make better use of existing transport infrastructure.

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