

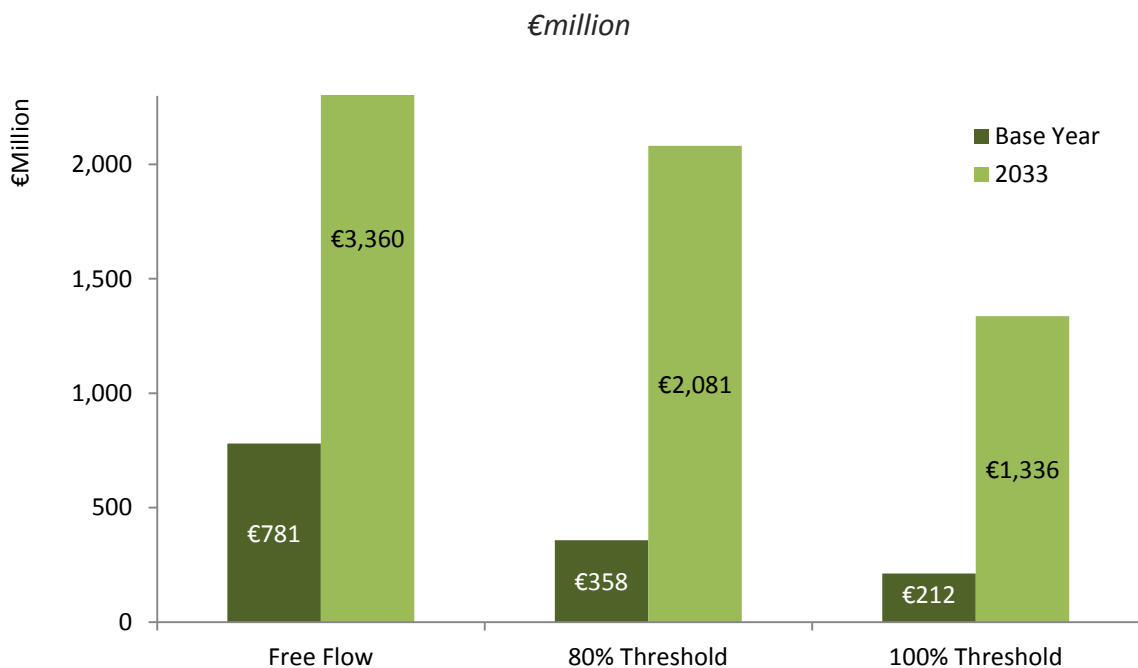
Appendix C Congestion Analysis

The following section outlines the primary analysis that was undertaken on congestion in the GDA. The estimated cost of aggravated congestion, some detailed modal analysis and potential hotspots are detailed and each of these informs the subsequent section around findings and policy implications.

C.1 Cost of Congestion under Three Scenarios

Using the methodology, outlined in the previous section, we have estimated the cost of aggravated congestion in the GDA. Figure C.1 presents the headline findings from the research. The annual cost of time lost to aggravated congestion in the 80% scenario is estimated to have been €358 million in the base year of 2012. The modelled output for 2033 indicates that the annual cost will rise to €2.08 billion in 2033 as result of demographic and economic growth. Given the lack of a single congestion definition internationally this research also provides estimates based on a free flow scenario and a 100% VoC scenario. The free flow scenario estimates aggravated congestion costs of €780 million in the base year and €3.36 billion in 2033 in the GDA. The 100% scenario estimates aggravated congestion costs of €212 million in the base year and €1.34 billion in 2033.

Figure C.1: Estimated Cost of Time Lost to Aggravated Congestion in GDA, 2012-2033,



Ideally, we would also have modelled the impact of aggravated congestion in the GDA on emissions and vehicle operating costs to fully estimate the transport user impact. As outlined, it was not possible to model these impacts at this stage of the research project. However, for indicative use we can analyse the likely magnitude of the impacts based on previous research carried out internationally.

In the majority of standard transport project appraisals value of time makes up the vast majority of the impact. Indeed and as previously outlined, other congestion studies carried out in other countries suggests, when assessing value of time, emissions and operating costs, that value of time accounts for between 90 and 92.5% of the cost. This would put the impact of aggravated congestion in emissions and vehicle operating costs in the region of €29 million and €40 million in the base year under the 80% capacity scenario. This is forecast to rise to between €169 million and €231 million in 2033. If such a result materialised, the cost of congestion would be between €387 million and €397 million at base and between €2.25 billion and €2.31 billion in 2033. However, without actually carrying out the necessary modelling work it is not possible to draw definitive conclusions over the total user cost of congestion including emissions and vehicle operating costs. In addition, neither of these studies estimated ‘wider economic impacts’ – these have the potential to be substantial.

C.2 Breakdown of Congestion Costs

As previously stated this congestion analysis details the level of congestion pertaining to the modes of private car, goods vehicle and bus within the GDA. As such it looks at congestion on the road network and does not analyse any issues of congestion on rail, light rail or active travel, although the demand and operation of these modes are accounted for in the model. Given the fact that the impacts and dynamics of car and bus use are analysed individually, it is possible to draw out some comparative conclusions. The following section sets out the headlines from the congestion analysis broken down for each time period and mode. The full results follow in Section C.4. The analysis details where the cost of congestion arises in the GDA and who bears it.

Table C.1: Annualised Cost of Aggravated Congestion by Scenario and Time Period: Base

	Free Flow	80% Scenario	100% Scenario
AM	€225,956,057	€136,531,306	€77,795,987
IP	€303,043,667	€66,783,179	€25,957,581
PM	€251,781,500	€154,423,508	€108,134,589
Total	€780,781,223	€357,737,992	€211,888,157

Table C.2: Annualised Cost of Aggravated Congestion by Scenario and Time Period: 2033

	Free Flow	80% Scenario	100% Scenario
AM	€909,321,713	€670,006,576	€472,503,606
IP	€1,440,118,618	€633,014,803	€259,060,263
PM	€1,010,585,251	€778,163,270	€604,872,949
Total	€3,360,025,582	€2,081,184,648	€1,336,436,818

Based on the breakdown of the congestion analysis contained in Section XX, we can draw a number of high-level findings and conclusions. These two findings are demonstrated in Figures C.2 and C.3 below.

- Under the 80% scenario we can observe that the largest proportion of the costs of congestion are currently in the AM and PM peaks with 38% and 43% shares of the total cost respectively. The Inter-Peak period is responsible for the remaining 19%. This is expected given the heavier level of travel demand during the morning and evening periods in line with commuting and education trips. In 2033, the shares are almost equal, with AM accounting for 32%, PM for 37%, and Inter-Peak for the remaining 31%.
- Again, under the 80% scenario for the base year we can observe the overall share of the cost of congestion by mode. According to this research, 59% of the cost of congestion incurred is borne by personal vehicle users. 34% of the cost is then on goods vehicles and 7% on bus users. This is indicative of the high level of car use across the GDA as a means of travelling. However, the cost of delays to goods vehicles is expected to increase to 51% of the total cost by 2033 – this is due, in part, to the higher value of time attributed to business delay.

Figure C.2: Time and Modal Split of Cost of Aggravated Congestion (Baseline, 80% Scenario)

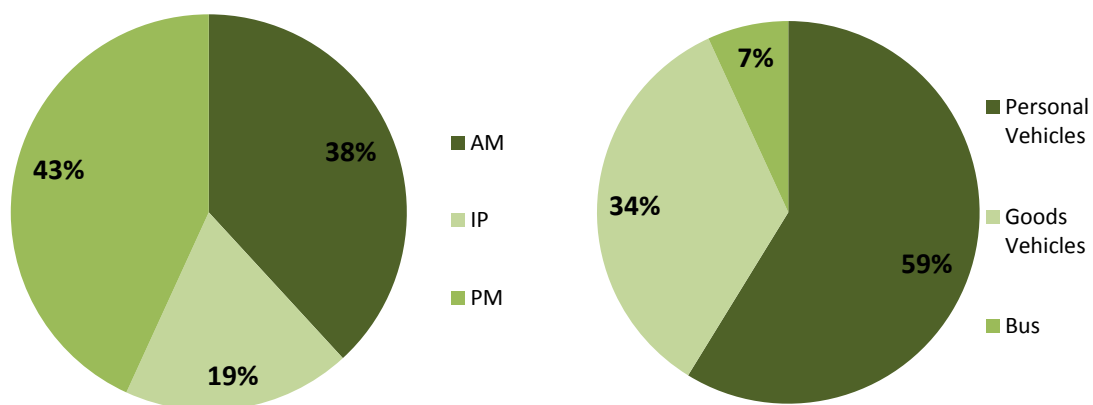
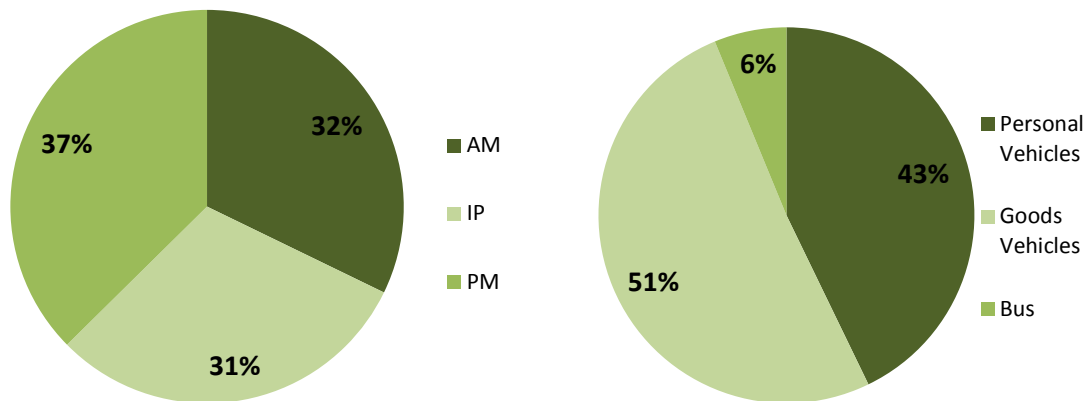


Figure C.3: Time and Modal Split of Cost of Aggravated Congestion (2033, 80% Scenario)



Furthermore, we can observe the overall drivers of potential future congestion costs in terms of time and mode with two primary developments;

- In the 80% scenario, the Inter-Peak period is forecast to encounter the largest increase in its cost of congestion, albeit from a low base. The 2033 Inter-Peak period rise by 848% in comparison to the base year cost as opposed to the AM and PM peaks which are each anticipated to rise by around 400%.
- In the 80% scenario, the cost of congestion to Goods Vehicles is expected to increase by 763% between the base and 2033 due in part to the higher value of time attributed to business delay. The cost of congestion to buses is estimated to increase by 428% and the cost to personal vehicles by 324%.

C.3 Congestion Hotspots Analysis

An additional piece of analysis was carried out to display the impact of congestion in the GDA in spatial terms. This serves a useful purpose in terms of further understanding where congestion arises. Congestion is mapped in the City Centre and the wider area to the M50 for cars, goods vehicles and buses in the base year for the AM peak period.

Each figure highlights the level of vehicle flow as well as the areas where link capacity exceeds specific thresholds. Areas highlighted with the amber circle are links where the volume over capacity ratio is between 80 and 100%. In addition, red circles are links where the volume over capacity ratio is in excess of 100%. It is important to note that these hotspots use the maximum observed VoC for the junction, not the flow weighted average value that is produced by SATURN. While the max VoC can hide a junction that is working effectively, only highlighting one failed movement, the weighted average from the model's software SATURN can hide a movement that is failing which is more important in relation to this study. Failing movements will often lead to diversions, lowering the flow for that movement and thus hiding it in the average. It is therefore easy to identify sections of the network which are congested based on the research carried out within this paper.

While this analysis usefully highlights the areas of the network where congestion is most prevalent in the AM peak, a number of caveats do need to be noted. Firstly, the results presented here are based on the modelling exercise undertaken for this research report. As such, they are an additional output rather than a specific project to determine the scale of route-level issues. Secondly, the analysis does not allow for an accurate assessment of the scale of congestion issues based on our methodology. While links may be classed in the 80%-100% band, there could feasibly be a 20% difference in the level of volume over capacity between the two. Finally, and most importantly, it is not necessarily the case that imposing a transport solution on any one (or on a selection of) link(s) will reduce the overall level of congestion. Transport networks are dynamic and as such solving any one issue is likely to shift the issue of congestion on to another element of the network. What is required is a more holistic transport solution analysis which fully anticipates the dynamic interaction between transport demand and supply.

Figure C.4: AM Base Canal - Personal Vehicle

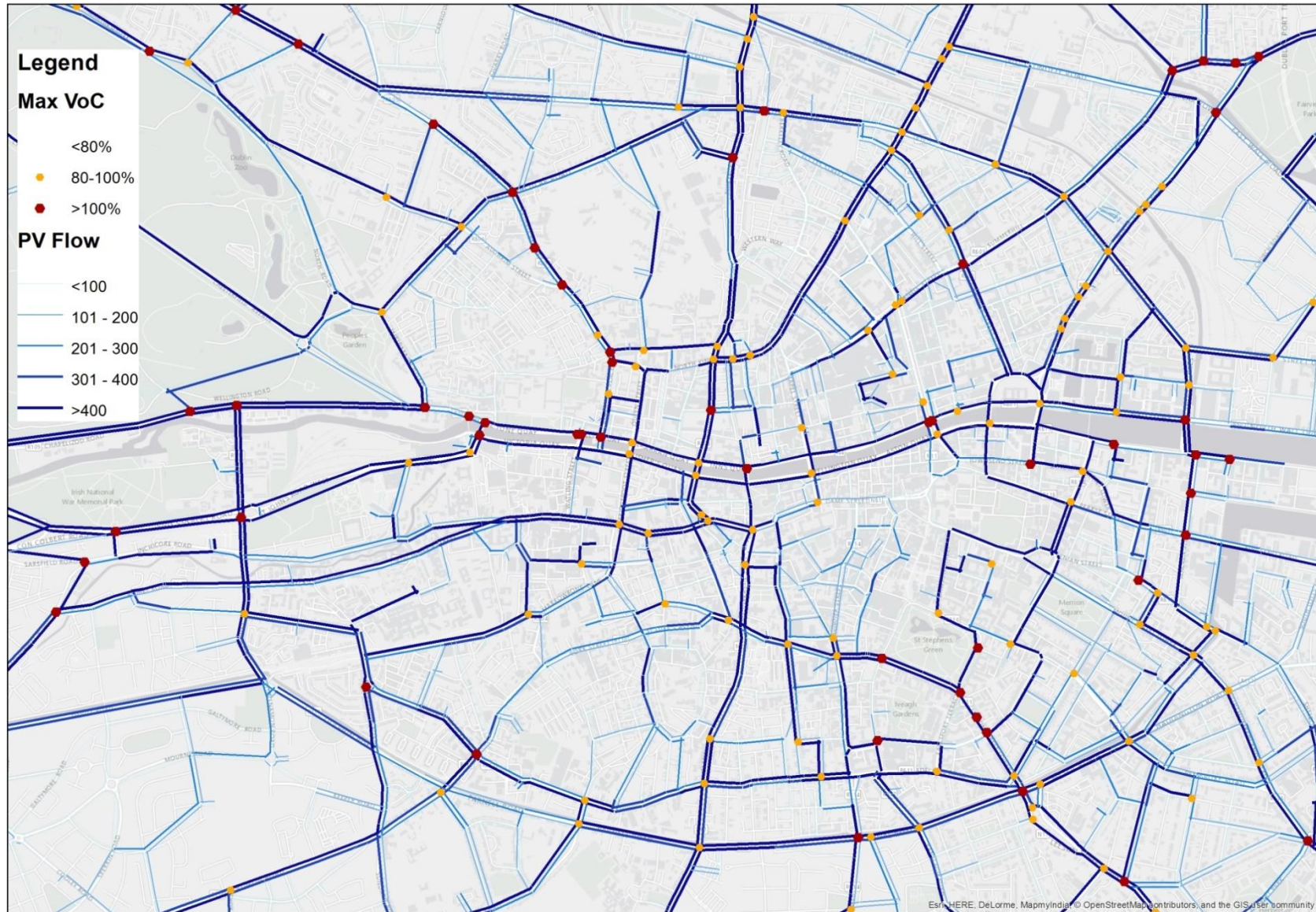


Figure C.5: AM Base Canal – Goods Vehicle

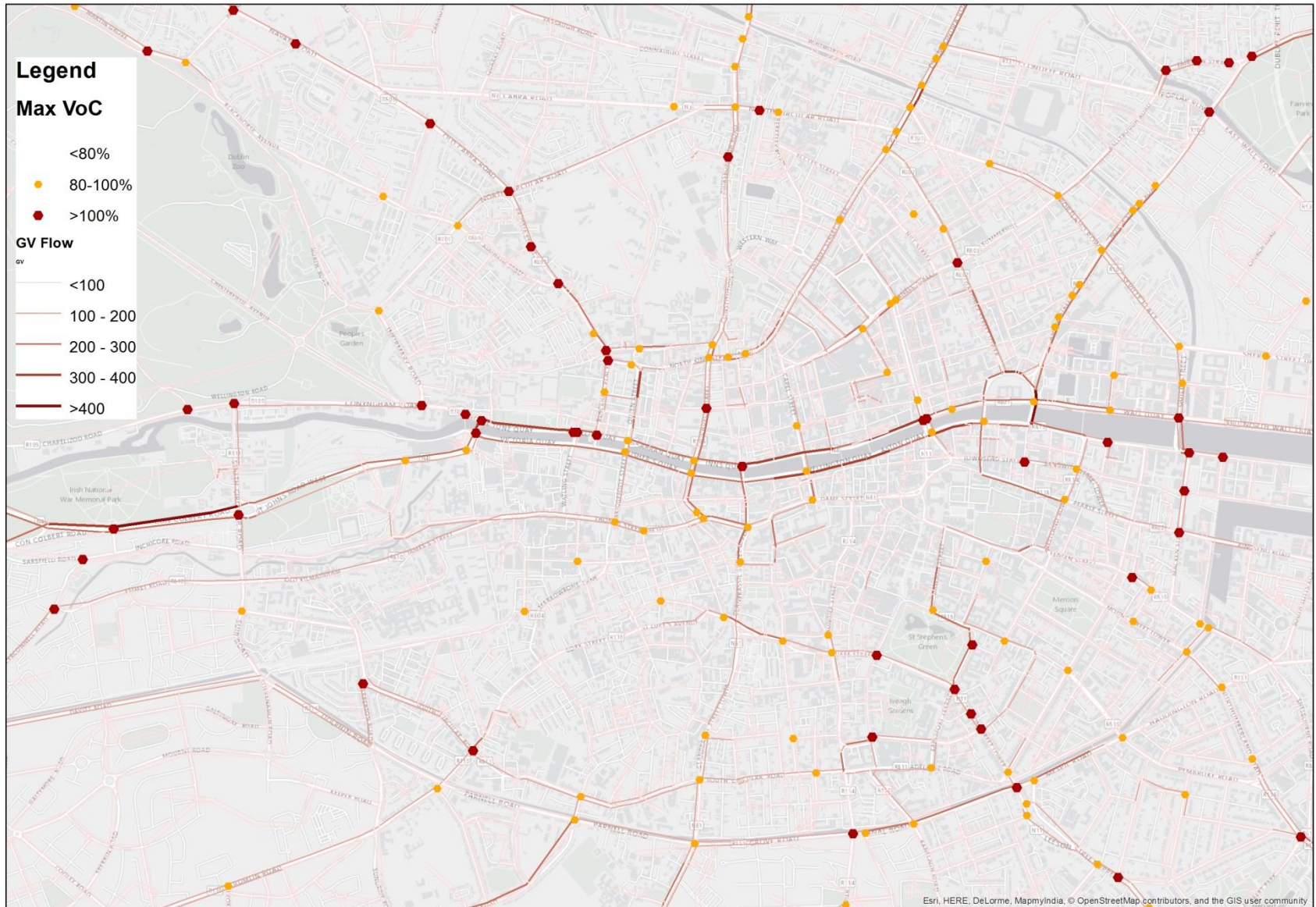


Figure C.6: AM Base Canal – Bus

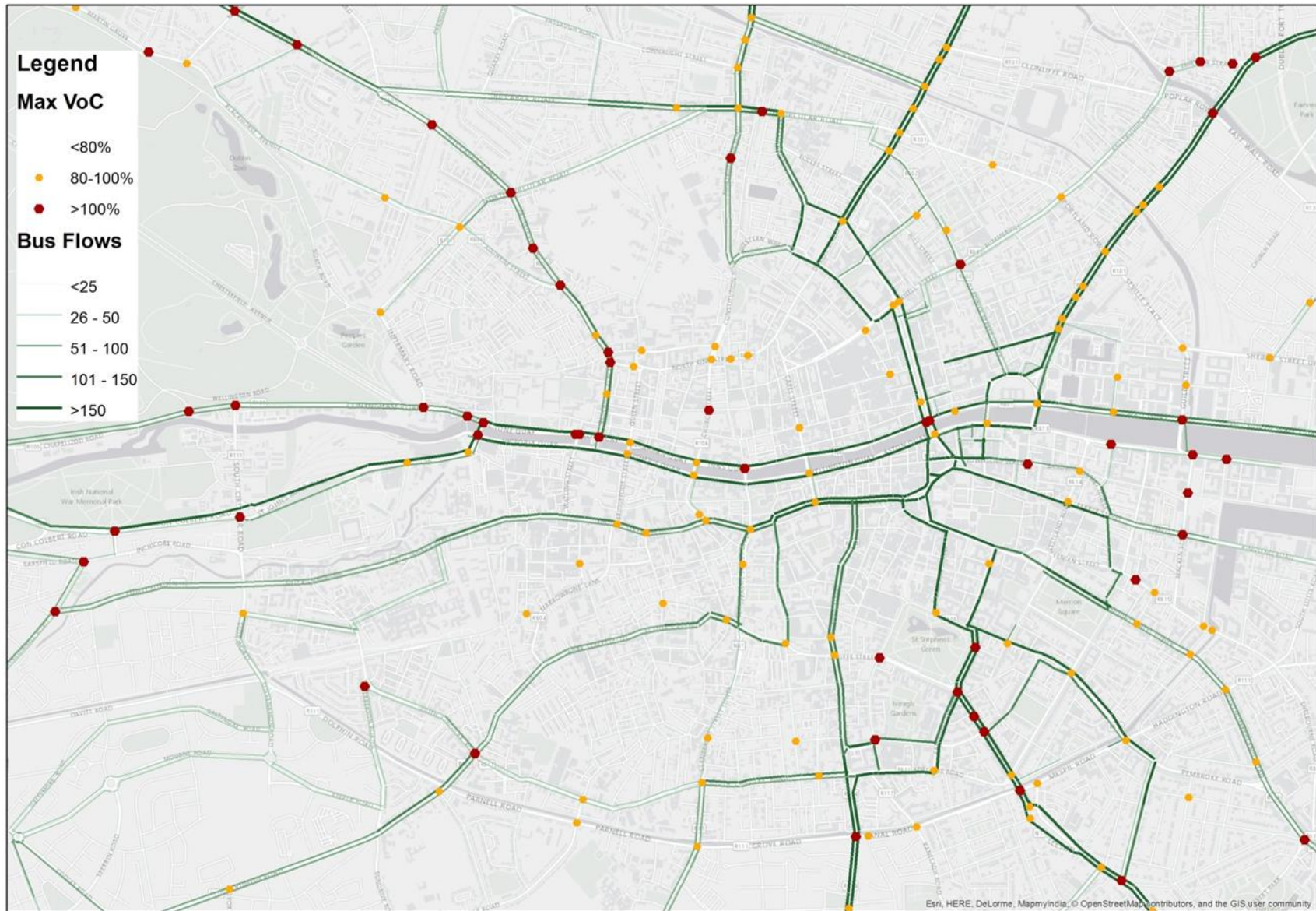


Figure C.7: AM Base M50 – Personal Vehicle

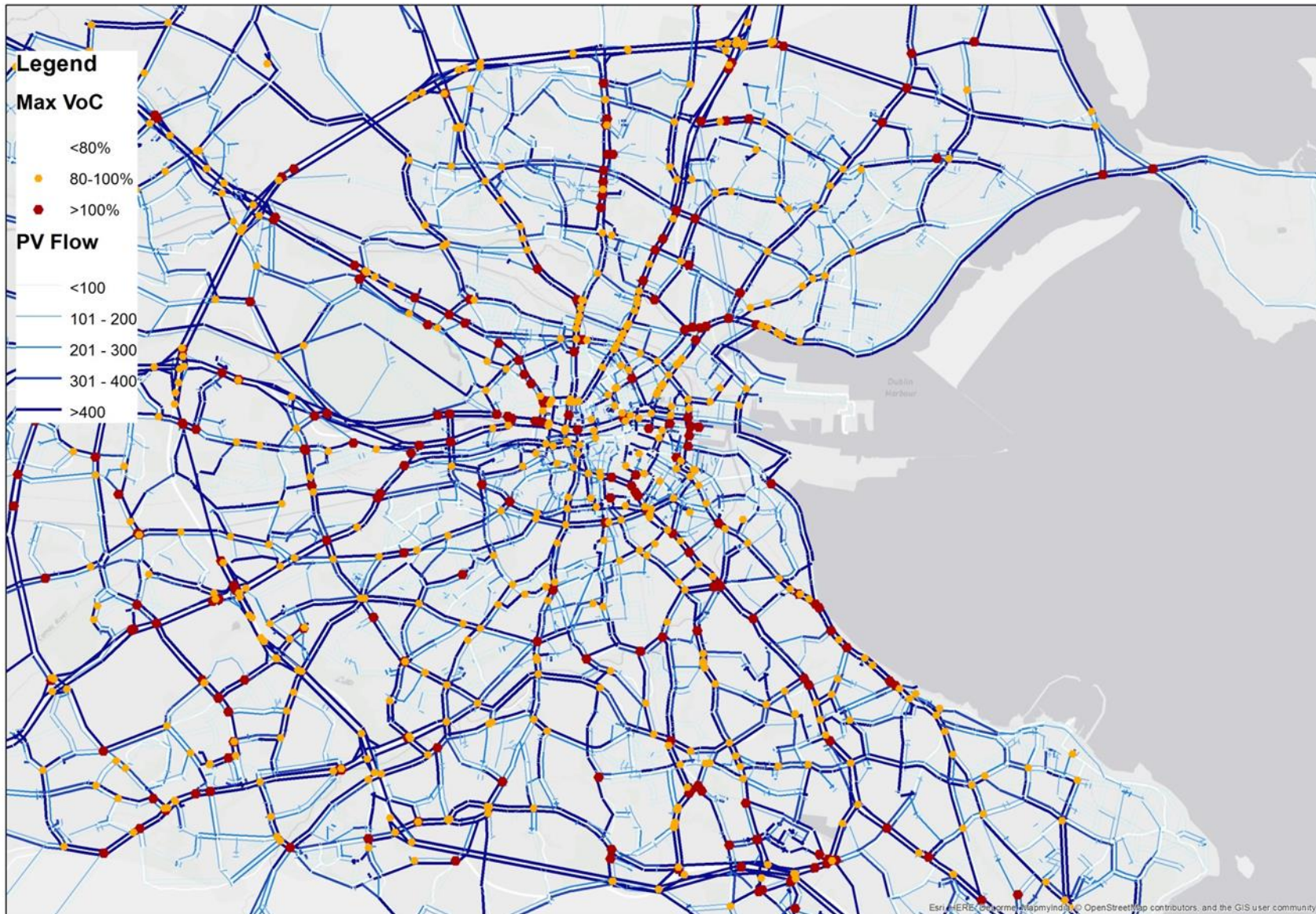


Figure C.8: AM Base M50 – Goods Vehicles

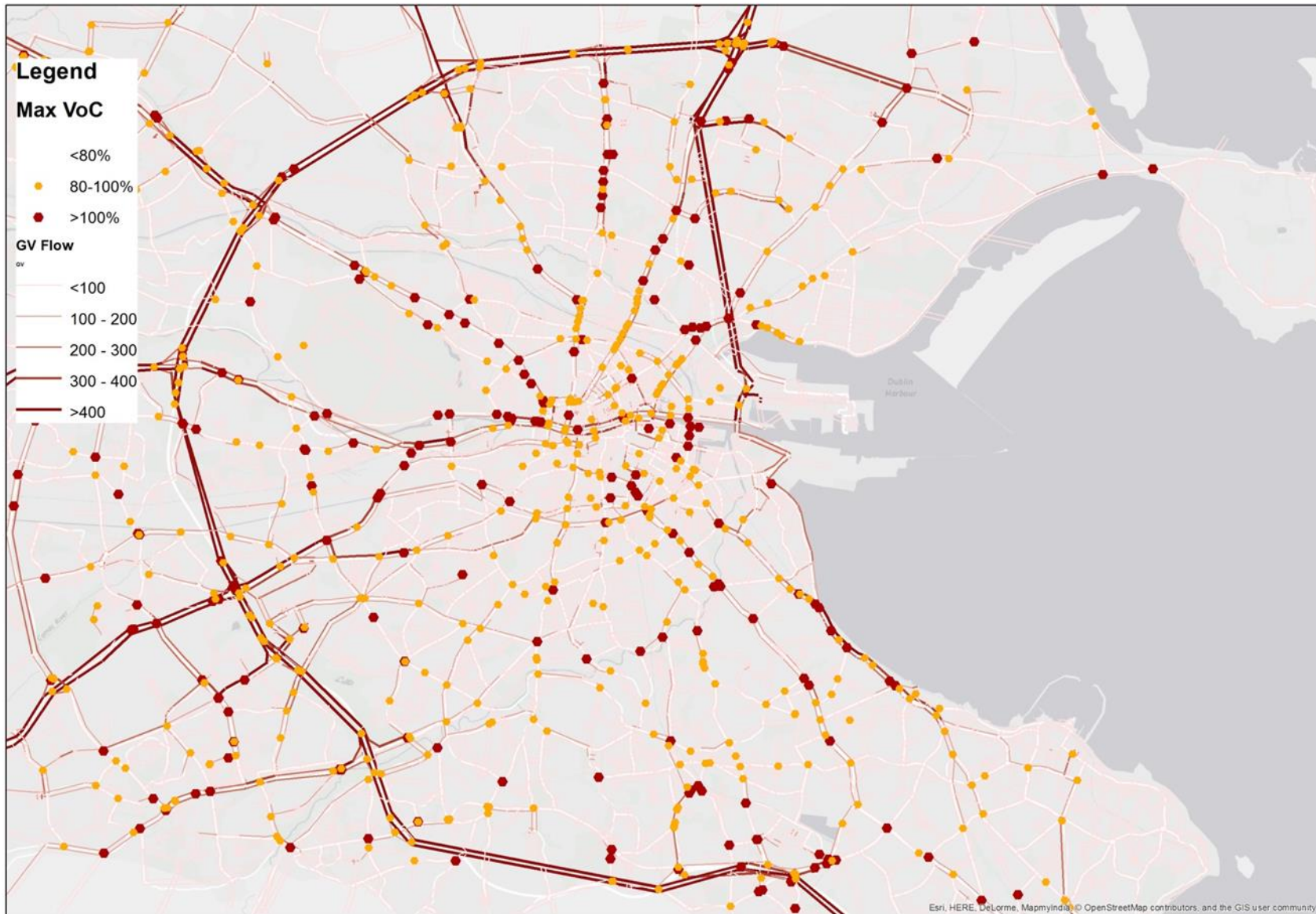
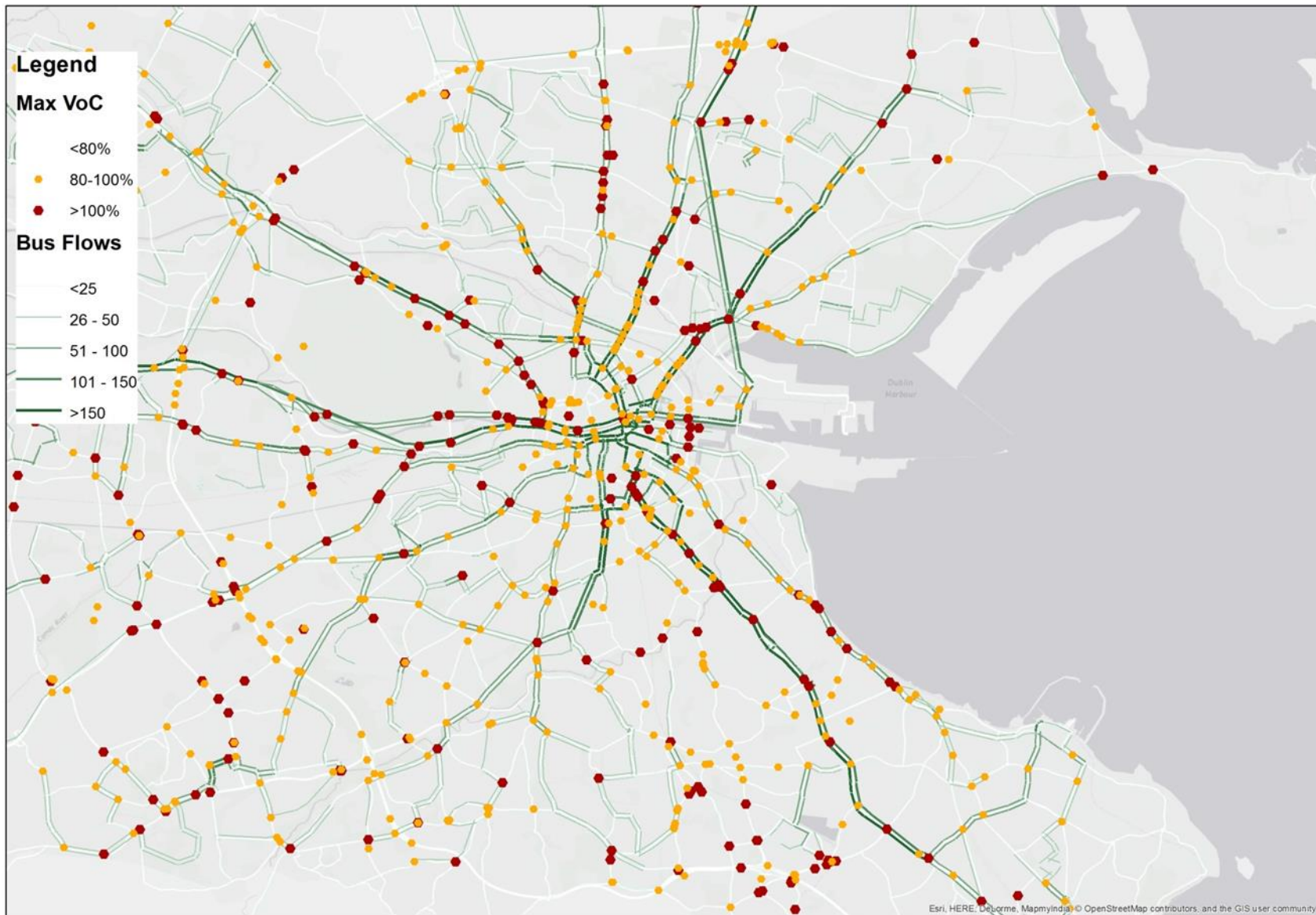


Figure C.9: AM Base M50 – Bus



The spatial analysis presented in the previous figures demonstrates where congestion hotspots arise on the GDA's transport network on an average morning. A number of relevant overview trends emerge;

- For Personal Vehicles, the main congestion hotspots within the City Centre are focused around the Quays and on a number of routes to them such as the East Link Bridge. In the wider network personal vehicle hotspots arise in the key routes between the M50 and the City Centre and on the key junctions of the M50.
- For Goods Vehicles, the main areas of flow are on the M50, Dublin Port Tunnel and main connecting routes such as Rock Road and the National Roads that link to the M50.
- For Buses, the main flows are linked to primary routes in to and out of the City Centre. Hotspots again emerge around the Quays and in key crossing routes on either side of the River Liffey.
- The general trend across the analysis is that congestion is an issue on the key arterial routes around and into the City Centre, as one would expect.

C.4 Detailed Congestion Analysis

The following appendix sets out the detail behind the modelled congestion analysis.

Results are provided for the individual 1 hour model runs in the AM, IP and PM Peaks. The results are broken down by vehicle type and location. All results are annualised for final annual figure.

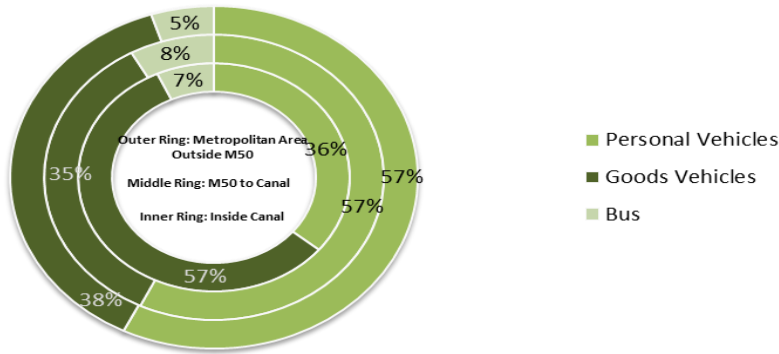
Tables C.3 and C.4: AM Peak Congestion Analysis (annualised € thousand) – Base Year and 2033

		AM Base									
		Free Flow	80%	100%	Con	Free Flow Difference		80% Difference		100% Difference	
Inside Canal	Personal Vehicles	€22,62 6.89	€25,83 3.02	€28,69 2.55	€31,50 8.72	€8,881.8 2	28 %	€5,675 .70	18 %	€2,816 .17	9 %
	Goods Vehicles	€16,77 1.57	€18,90 2.84	€20,70 2.72	€22,74 9.78	€5,978.2 1	26 %	€3,846 .94	17 %	€2,047 .06	9 %
	Bus	€11,44 9.76	€23,68 4.25	€25,14 1.33	€26,14 4.71	€14,694. 95	56 %	€2,460 .46	9 %	€1,003 .38	4 %
M50 to Canal	Personal Vehicles	€107,8 31.26	€122,1 98.41	€137,6 88.95	€162,1 69.27	€54,338. 02	34 %	€39,97 0.86	25 %	€24,48 0.32	15 %
	Goods Vehicles	€59,15 9.90	€67,22 4.59	€76,35 9.37	€91,54 6.83	€32,386. 93	35 %	€24,32 2.24	27 %	€15,18 7.46	17 %
	Bus	€18,05 6.13	€34,00 3.83	€37,03 4.69	€39,65 1.60	€21,595. 47	54 %	€5,647 .77	14 %	€2,616 .91	7 %
Metropolitan Area Outside M50	Personal Vehicles	€105,0 49.33	€121,1 49.77	€136,5 89.70	€152,4 50.42	€47,401. 09	31 %	€31,30 0.65	21 %	€15,86 0.72	10 %
	Goods Vehicles	€67,70 7.08	€78,46 6.10	€86,87 9.53	€99,04 7.18	€31,340. 10	32 %	€20,58 1.08	21 %	€12,16 7.65	12 %
	Bus	€8,372. 29	€14,98 6.15	€16,09 5.43	€17,71 1.76	€9,339.4 7	53 %	€2,725 .61	15 %	€1,616 .32	9 %

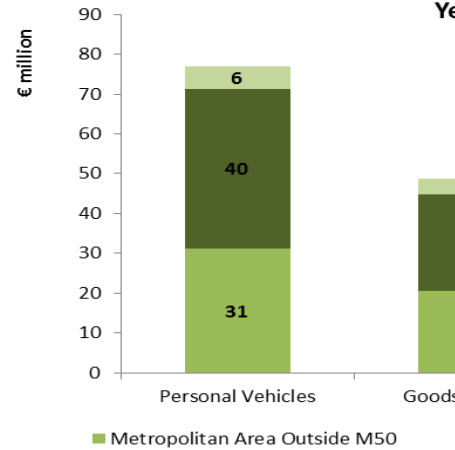
		AM 2033									
		Free Flow	80%	100%	Con	Free Flow Difference		80% Difference		100% Difference	
Inside Canal	Personal Vehicles	€43,28 0.54	€50,79 2.85	€60,60 7.01	€76,65 7.51	€33,376. 97	44 %	€25,86 4.65	34 %	€16,05 0.50	21 %
	Goods Vehicles	€55,11 4.42	€64,54 6.15	€75,75 3.90	€96,41 3.87	€41,299. 44	43 %	€31,86 7.72	33 %	€20,65 9.97	21 %
	Bus	€20,81 0.73	€41,83 7.13	€45,80 7.25	€48,55 7.47	€27,746. 74	57 %	€6,720. 34	14 %	€2,750. 22	6 %
M50 to Canal	Personal Vehicles	€200,8 30.87	€233,5 22.17	€269,1 77.65	€370,1 69.73	€169,33 8.87	46 %	€136,6 47.56	37 %	€100,9 92.08	27 %
	Goods Vehicles	€197,9 71.33	€230,5 35.86	€268,0 85.77	€380,2 41.56	€182,27 0.23	48 %	€149,7 05.70	39 %	€112,1 55.79	29 %
	Bus	€36,07 1.25	€65,81 7.57	€71,86 7.26	€83,42 5.75	€47,354. 50	57 %	€17,60 8.18	21 %	€11,55 8.49	14 %
Metropolitan Area Outside M50	Personal Vehicles	€209,4 62.70	€252,0 24.36	€295,2 02.55	€383,2 85.16	€173,82 2.46	45 %	€131,2 60.80	34 %	€88,08 2.61	23 %
	Goods Vehicles	€226,4 91.92	€273,4 28.41	€318,3 97.37	€428,0 77.56	€201,58 5.64	47 %	€154,6 49.15	36 %	€109,6 80.19	26 %
	Bus	€21,51 7.32	€38,36 1.69	€43,47 0.41	€54,04 4.18	€32,526. 86	60 %	€15,68 2.49	29 %	€10,57 3.76	20 %

Figure C.10: AM Peak Congestion Analysis (Comparison to 80% Scenario) – Base Year and 2033

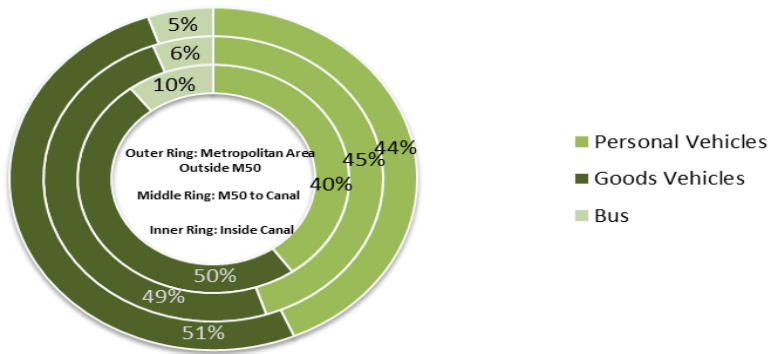
Cost distribution by Vehicle Type AM, Base



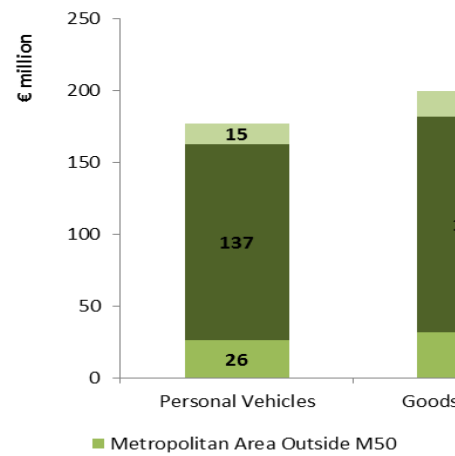
Cost of Congestion by Mod



Cost distribution by Vehicle Type AM, 2033



Cost of Congestion by Mod



Tables C.5 and C.6: Inter Peak Congestion Analysis (annualised € thousand) – Base Year and 2033

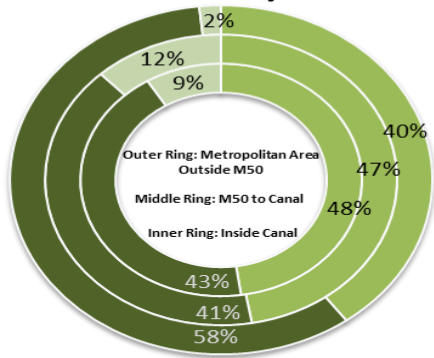
		IP Base									
		Free Flow	80%	100%	Con	Free Flow Difference	80% Difference	100% Difference			
Inside Canal	Personal Vehicles	€115,6 62.26	€128,2 74.97	€134,9 98.70	€135,5 82.29	€19,920. 03	15 %	€7,307 .32	5 %	€583.5 9	0 %
	Goods Vehicles	€111,8 90.80	€122,9 24.59	€129,2 67.26	€129,5 80.67	€17,689. 87	14 %	€6,656 .08	5 %	€313.4 1	0 %
	Bus	€26,41 5.40	€63,91 9.54	€64,89 5.41	€65,26 1.41	€38,846. 01	60 %	€1,341 .87	2 %	€366.0 1	1 %
M50 to Canal	Personal Vehicles	€430,0 53.06	€462,4 73.90	€471,4 79.64	€472,2 93.79	€42,240. 73	9 %	€9,819 .89	2 %	€814.1 5	0 %
	Goods Vehicles	€346,9 95.53	€374,7 07.13	€382,6 02.29	€383,1 96.41	€36,200. 88	9 %	€8,489 .29	2 %	€594.1 3	0 %
	Bus	€39,67 3.03	€89,64 2.35	€92,08 2.43	€92,13 7.26	€52,464. 23	57 %	€2,494 .90	3 %	€54.83 %	0 %
Metropolitan Area Outside	Personal Vehicles	€334,6 00.37	€356,3 49.32	€359,7 06.90	€368,5 91.32	€33,990. 95	9 %	€12,24 2.00	3 %	€8,884. 43	2 %
	Goods Vehicles	€334,9 16.62	€361,0 78.90	€364,7 84.71	€379,0 01.10	€44,084. 48	12 %	€17,92 2.20	5 %	€14,21 6.39	4 %

M50	Bus	€21,66	€38,76	€39,14	€39,27	€17,606.	45	€509.6	1	€130.6	0
		4.89	1.74	0.70	1.36	48	%	2	%	6	%

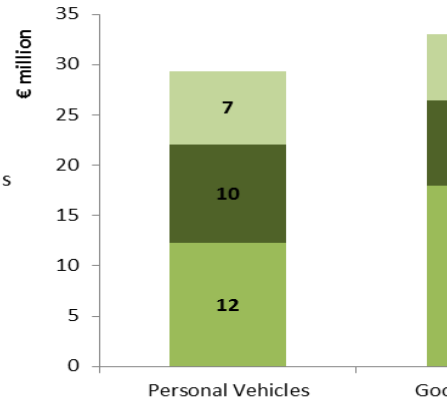
		IP 2033									
		Free Flow	80%	100%	Con	Free Flow		80% Difference		100% Difference	
Inside Canal	Personal Vehicles	€236,78 9.76	€273,58 8.75	€308,45 0.22	€337,75 0.23	€100,9 60.47	30 %	€64,16 1.48	19 %	€29,30 0.01	9 %
	Goods Vehicles	€369,95 2.17	€425,59 2.79	€480,62 7.81	€527,65 5.52	€157,7 03.34	30 %	€102,0 62.73	19 %	€47,02 7.71	9 %
	Bus	€51,627 .45	€118,24 2.26	€127,79 7.08	€130,48 6.77	€78,85 9.32	60 %	€12,24 4.51	9 %	€2,689. 68	2 %
M50 to Canal	Personal Vehicles	€879,77 8.78	€978,84 8.06	€1,049, 461.68	€1,086, 110.39	€206,3 31.61	19 %	€107,2 62.33	10 %	€36,64 8.71	3 %
	Goods Vehicles	€1,144, 071.76	€1,282, 274.64	€1,384, 341.12	€1,417, 224.68	€273,1 52.92	19 %	€134,9 50.04	10 %	€32,88 3.56	2 %
	Bus	€84,780 .13	€185,01 9.02	€201,51 9.98	€207,24 2.67	€122,4 62.54	59 %	€22,22 3.65	11 %	€5,722. 69	3 %
Metropolitan Area Outside M50	Personal Vehicles	€782,94 8.29	€884,09 4.82	€913,98 5.33	€952,14 5.74	€169,1 97.45	18 %	€68,05 0.92	7 %	€38,16 0.42	4 %
	Goods Vehicles	€1,109, 628.43	€1,266, 450.49	€1,318, 580.98	€1,383, 810.11	€274,1 81.68	20 %	€117,3 59.63	8 %	€65,22 9.14	5 %
	Bus	€62,731 .47	€115,30 1.22	€118,60 2.40	€120,00 0.76	€57,26 9.29	48 %	€4,699 .53	4 %	€1,398. 35	1 %

Figure C.11: Inter Peak Congestion Analysis (Comparison to 80% Scenario) – Base Year and 2033

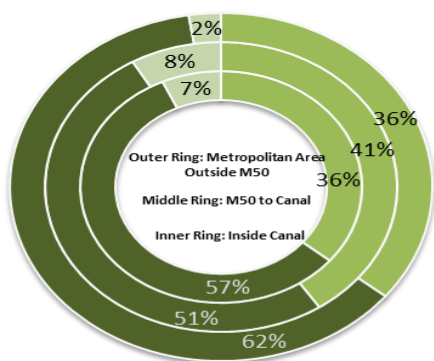
Cost distribution by Vehicle Type IP, Base



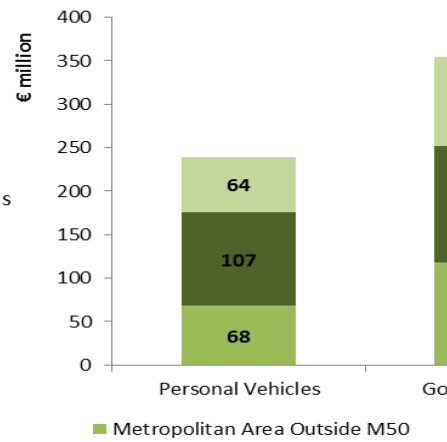
Cost of Congestion by Mode



Cost distribution by Vehicle Type IP, 2033



Cost of Congestion by Mode



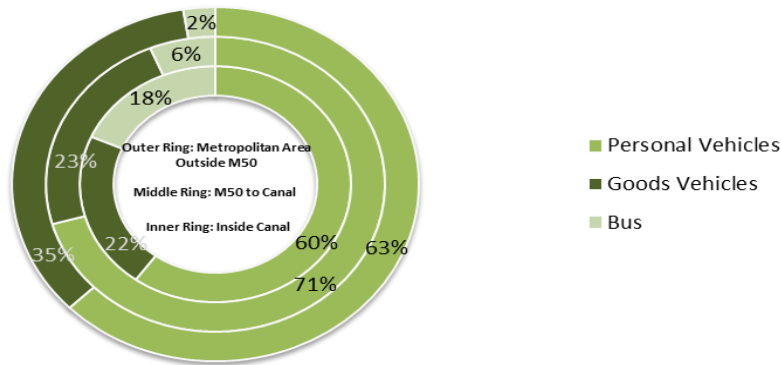
Tables C.7 and C.8: PM Peak Congestion Analysis (annualised € thousand) – Base Year and 2033

		PM Base									
		Free Flow	80%	100%	Con	Free Flow Difference		80% Difference		100% Difference	
Inside Canal	Personal Vehicles	€25,41 9.28	€29,14 3.40	€32,67 8.12	€36,36 8.35	€10,949. 06	30 %	€7,22 4.95	20 %	€3,690 .23	10 %
	Goods Vehicles	€10,44 4.62	€11,84 0.69	€13,13 4.18	€14,44 0.21	€3,995.6 0	28 %	€2,59 9.52	18 %	€1,306 .03	9 %
	Bus	€11,63 1.68	€27,52 4.95	€29,29 9.17	€29,74 1.30	€18,109. 62	61 %	€2,21 6.35	7 %	€442.1 3	1 %
M50 to Canal	Personal Vehicles	€120,0 15.33	€136,4 18.15	€150,3 40.45	€202,5 09.79	€82,494. 47	41 %	€66,0 91.64	33 %	€52,16 9.34	26 %
	Goods Vehicles	€44,55 8.79	€50,73 4.40	€55,81 9.04	€72,32 3.46	€27,764. 67	38 %	€21,5 89.06	30 %	€16,50 4.42	23 %
	Bus	€17,34 1.68	€38,26 4.09	€41,90 2.58	€44,14 2.85	€26,801. 17	61 %	€5,87 8.76	13 %	€2,240 .27	5 %
Metropolitan Area Outside M50	Personal Vehicles	€107,3 35.84	€124,2 37.19	€135,0 39.10	€154,8 59.68	€47,523. 84	31 %	€30,6 22.49	20 %	€19,82 0.58	13 %
	Goods Vehicles	€58,44 5.29	€67,67 6.87	€73,14 5.24	€84,63 6.54	€26,191. 25	31 %	€16,9 59.67	20 %	€11,49 1.30	14 %
	Bus	€7,479. 92	€14,19 0.68	€14,96 1.47	€15,43 1.75	€7,951.8 3	52 %	€1,24 1.07	8 %	€470.2 8	3 %

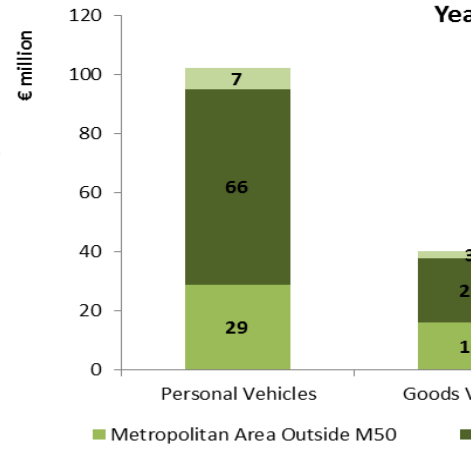
		PM 2033									
		Free Flow	80%	100%	Con	Free Flow Difference		80% Difference		100% Difference	
Inside Canal	Personal Vehicles	€50,94 4.12	€60,34 4.33	€70,75 4.47	€90,53 7.81	€39,593. 70	44 %	€30,19 3.48	33 %	€19,78 3.34	22 %
	Goods Vehicles	€35,01 8.49	€41,02 7.52	€47,64 7.60	€60,09 0.32	€25,071. 83	42 %	€19,06 2.80	32 %	€12,44 2.72	21 %
	Bus	€20,09 3.96	€46,90 0.27	€50,70 5.28	€53,84 9.84	€33,755. 88	63 %	€6,949 .57	13 %	€3,144 .56	6 %
M50 to Canal	Personal Vehicles	€230,1 81.14	€265,7 93.00	€305,0 45.42	€431,2 23.88	€201,042 .75	47 %	€165,4 30.88	38 %	€126,1 78.46	29 %
	Goods Vehicles	€146,9 94.51	€169,6 31.32	€196,5 41.19	€276,6 15.51	€129,621 .00	47 %	€106,9 84.19	39 %	€80,07 4.32	29 %
	Bus	€35,03 0.86	€74,24 8.98	€83,08 5.46	€92,22 9.00	€57,198. 14	62 %	€17,98 0.02	19 %	€9,143 .54	10 %
Metropolitan Area Outside M50	Personal Vehicles	€219,1 22.63	€258,7 68.94	€296,9 97.49	€420,9 55.93	€201,833 .30	48 %	€162,1 86.99	39 %	€123,9 58.44	29 %
	Goods Vehicles	€190,6 50.23	€226,1 57.44	€261,5 61.94	€470,1 50.70	€279,500 .47	59 %	€243,9 93.26	52 %	€208,5 88.76	44 %
	Bus	€20,55 3.88	€38,14 0.01	€41,96 3.28	€63,52 2.08	€42,968. 19	68 %	€25,38 2.07	40 %	€21,55 8.80	34 %

Figure C.12: Inter Peak Congestion Analysis (Comparison to 80% Scenario) – Base Year and 2033

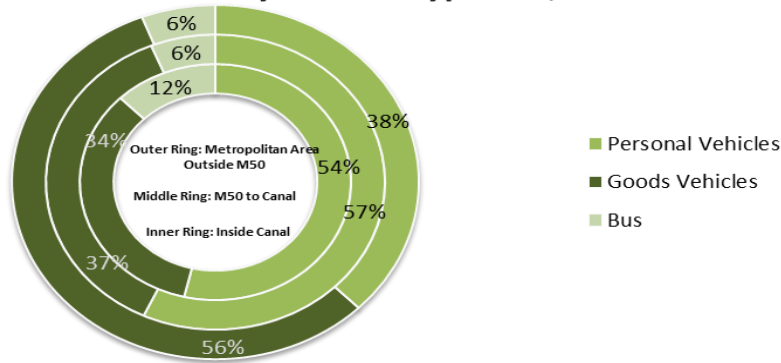
Cost distribution by Vehicle Type PM, Base



Cost of Congestion by Mode Year



Cost distribution by Vehicle Type PM, 2033



Cost of Congestion by Mode Year

