Plymouth Eastern Gateway Study; Paramics Modelling

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Model Development and Option Testing Report

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PLYMOUTH EASTERN GATEWAY STUDY; PARAMICS MODELLING

Description:

Model Development and Option Testing Report

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PLYMOUTH EASTERN GATEWAY STUDY; PARAMICS MODELLING

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1 INTRODUCTION

1.1 Background and Study Objective

1.1.1 As a member of the team of consultants commissioned by Plymouth City Council, SIAS was asked to undertake Paramics modelling of the Eastern Gateway as part of the wider study of the area's urban design, land use and transport issues. The overall study is directed towards tackling transport, development and environmental issues within the study area and creating a development framework for the future.

1.1.2 In stage two of the study, several options for tackling the problems of the Gateway area have been suggested. At this stage the Paramics modelling is being used to refine the options in terms of their transport components and suggest which options should be carried forward to the final part of the study. At this stage, the model application is fairly course and as such any results should not be seen as definitive in terms of design issues. The model is being used to provide guidance on possible components of future change.

1.2 Study Area

1.2.1 The study area stretches from Marsh Mills, along Embankment Road to Heles Terrace/Laira Bridge. The Paramics model stops short of Marsh Mills roundabout to the North, includes as far as Pomphlett roundabout to the East and just beyond Cattedown roundabout to the West. All modelling has been carried out using 2002 traffic flows.

1.2.2 There are nine model scenarios.

- Scenario 0 – Do-Nothing base model network with 2002 traffic flows,
- Scenario 1 - Do-Minimum; giving extra crossing time for pedestrians at signals along with new local road scheme to remove HGVs from Heles Terrace,
- Scenario 2 - Do-Minimum + PT Improvements; Extra bus lanes and bus priority (agreed that a lack of space meant that extra lanes were not possible - the model will show how much modal shift is needed to buses to allow traffic lanes to be removed),
- Scenario 3a - Do-Minimum + speed reduction + widening Heles Terrace + using rail bridge for PT - More capacity in Heles Terrace will give easier movement of traffic, removal of houses on Heles Terrace necessary,
- Scenario 3b - Do-Minimum + Bypass of Heles Terrace - A road from Finnigan Rd to Embankment Rd will remove through traffic from Heles Terrace and allow access to Western National Site,
- Scenario 4 - Do-Minimum + 3b + widening Gdynia Way to become two way – and removal of traffic from Embankment Road,
- Scenario 5 - Bypass At-Grade with Gdynia Way (through Embankment Road) would be kept as two way route to Marsh Mills and Bypass would be for Plymstock traffic,
- Scenario 6 - New Bridge + Bypass; Gdynia Way would be closed - a new bridge south of the existing would be used by traffic to the city via the bypass and the existing would be used by traffic heading for Marsh Mills. This removal of traffic would allow bus lanes on the existing Bridge,
- Scenario 7 – Northern Bypass; Bypass would be aligned along freight rail line to Friary Yard, Gdynia Way would remain open two way for Plymstock traffic,
- Scenario 8 – Northern Bypass + New Bridge; New bridge would link Pomphlett roundabout to Embankment Road removing Plymstock to Marsh Mills traffic from Laira Bridge,

1.3 Scope and structure of report

1.3.1 This report details the development of the Plymouth Gateway Model and explains the model test results. The model has been developed for a typical 2002 weekday for the following time periods:

- AM Peak (0700 – 1000)
- PM Peak (1600 – 1900)

1.3.2 Following the introductory chapter, Chapter 2 provides a short review of Paramics microsimulation modelling whilst Chapter 3 describes the traffic data and the surveys used.

1.3.3 Chapter 4 addresses the base network development whilst Chapter 5 details the base matrix development. Chapter 6 describes the calibration and validation elements of the base.

1.3.4 Chapter 7 describes the model test scenarios.

1.3.5 Chapter 8 summarises the main findings of the modelling of the initial test networks. Following the completion of these tests the report was issued as a draft and as a consequence some additional work was undertaken.

1.3.6 In the above context, Chapter 9 considers some specific testing aimed at examining the consequences of future year traffic demands. Chapter 10 discusses further testing of the proposed new Friary (northern) Boulevard.

1.4 Plymouth TTWA Paramics Model

1.4.1 The Plymouth Gateway model uses the existing travel to work area (TTWA) model of Plymouth as its base. The Gateway model has been created by cordoning off a section of the larger model to allow easier manipulation.

1.4.2 In following this process it is therefore inherent that additional congestion effects or network changes which might otherwise cause traffic to divert outwith the study area are not modelled. The model area has been selected to minimise any such likelihood and any such effects will be identified during future studies as they evolve.

2 PARAMICS MICROSIMULATION

2.1 Overview

2.1.1 Paramics is a suite of high performance software tools and represents a radical new approach to the understanding, representation and analysis of road traffic. Individual vehicles are modelled in fine detail for the duration of their entire trip, providing the accurate traffic flow information necessary for the analysis of congested road networks.

2.1.2 Paramics is the result of a six year collaboration between specialists in high performance software development and experienced traffic and transportation engineers, and has been designed for a wide range of applications where traffic congestion is the predominant feature.

2.1.3 A unified approach to traffic modelling has been adopted within Paramics as the same methodology and assumptions are applied to all traffic issues no matter what the scale or complexity of the study is. Thus, Paramics would treat traffic behaviour at a single isolated junction in exactly the same manner as it would treat traffic behaviour on the national road network. Paramics achieves this by simulating, at a speed faster than real time, the manner that each vehicle reacts to all other vehicles around it using simple rules of driver behaviour. As such Paramics represents an improvement upon traditional traffic modelling tools which use formulae that relate vehicle delay to traffic flow as a proxy for driver behaviour. All known components of driver behaviour likely to significantly affect traffic flow are represented, across the full range of road network types.

2.2 Driver and Vehicle Behaviour

2.2.1 The movement of individual vehicles within Paramics is governed by three interacting models representing vehicle following, junction (gap acceptance) and lane changing behaviour. All three model types are of a form well documented in transport research and accepted world-wide. The innovative aspect of Paramics is that these models are applied at the level of individual vehicles to simulate the traffic conditions of wide area transport networks, within the framework of an easily used software suite. Vehicle dynamics are relatively simple, combining a mixture of driver behaviour and some limitations based on vehicles' physical type and kinematics (e.g. size and acceleration/deceleration).

2.2.2 Individual driver behaviour is determined through the random allocation of *aggression* and *awareness* characteristics to the driver of each vehicle. Junction behaviour (gap acceptance), top speed, headway and propensity to change lane are all examples of quantities that vary according to these two behaviour parameters.

2.3 Road network

2.3.1 Paramics is sensitive to the definition of the road network, and the success of the model in reproducing the existing situation and forecasting changes in travel behaviour is largely dependent on the accuracy of the description of the road layout and geometry.

2.3.2 Unlike traditional models neither travel times nor proxies for junction capacities are defined in the traffic model. Instead the physical properties of the road network are defined (e.g. traffic signal timings, lane widths, lane arrangements at junctions, bus stop locations, on-street parking, etc.). The speed of each vehicle is determined by the interaction between vehicles within the constraints imposed by the road layout.

2.4 Public Transport

2.4.1 Each Paramics model contains a database of bus routes, timetable information, bus stop locations and bus stop dwell times for each bus service. Buses are subject to the same modelling treatment as other vehicles on the network in relation to the rules associated with vehicle following, gap acceptance and lane changing, with two exceptions. These are that buses follow fixed routes and are also forced to stop at their routes' bus stops if a passenger wishes to get on or off.

2.4.2 The model therefore simulates not only the impacts on public transport users of bus priority measures (e.g. bus activated signals), but also the impact on other road users caused by bus stop location and bus priority lanes. The model has also been shown to simulate the behaviour of buses queuing at busy bus stops and bunching together on congested roads.

2.5 Alternative Traffic Modelling Tools

2.5.1 Paramics offers a number of additional features to those offered by more traditional models (e.g. SATURN). These enhance the investigation of the traffic impacts of traffic management proposals and include the following:

- dynamic modelling (drivers react to conditions as they experience them);
- junction interaction including the effect of an overcapacity junction affecting the operational performance of another junction upstream (e.g. blocking back);
- conflicts and interactions between road users, such as buses queuing to access bus stops, lane blocking by goods vehicles, or incident modelling;
- sensitivity to highway design issues, such as vehicle restrictions, road alignment, turning radii, location of bus stops;
- sensitivity to transport policy issues such as on and off street parking restrictions; and
- a pollution emissions model sensitive to vehicle acceleration, deceleration and queuing vehicles.

2.5.2 Additionally, whilst the Paramics model reports traditional measures such as link flows (vehicles per hour), percentage of heavy vehicles and journey times in a manner similar to other modelling suites, Paramics presents the information visually. The visual presentation of information means that Paramics provides an ideal aide for public consultation.

3 TRAFFIC DATA

3.1 Introduction

3.1.1 The study required traffic data from various sources to enable the area to be modelled realistically.

3.1.2 This traffic demand data included:

- Turn counts for a number of major junctions,
- Automatic Traffic Counts for the main routes,

3.2 Traffic Counts

3.2.1 The traffic data was provided by Plymouth City Council. From the information received, the most recent counts carried out in 2002 and 2003 were used for validation of the model:

- 2003 turning counts for Cattedown Roundabout, Heles Terrace and the junction of Embankment Road and Old Laira Road.
- 2002 ATC counts for the A374 Embankment Road, A379 Laira Bridge and A374 Exeter Street.

3.3 Traffic Signal Data

3.3.1 The traffic signals data was taken from the TTWA model.

3.4 Bus Data

3.4.1 The bus information from the original TTWA Paramics model was used.

4 BASE NETWORK DEVELOPMENT

4.1 Link coding

4.1.1 All links are coded consistent with the full road width using the widths provided within the TTWA area wide Paramics model.

4.1.2 All bus priority measures such as bus lanes and bus gates within the study area are modelled as bus only.

4.1.3 All access restrictions and banned turns have been modelled.

4.1.4 There are three types of junctions within the study area: priority junctions, roundabouts and signal control junctions.

4.1.5 The aerial photo provided by Plymouth City Council, in conjunction with the on site observations made by SIAS, were used to correctly position the give way and stop lines and determine the permitted movements from each lane on a junction arm.

4.2 Route Choice Methodology

4.2.1 The model does not involve any significant route choice across the Plymouth network and applies fixed trip matrix assumptions in terms of origin and destination patterns. The application of the Paramics modelling technique does of course provide feedback on relative traffic throughput between the options tested, which would in the larger TTWA model affect the attractiveness of the wider corridor to traffic. It is not part of this localised Paramics exercise to attempt to evaluate these effects.

5 BASE MATRIX DEVELOPMENT

5.1 Introduction

5.1.1 In common with all other traffic model applications, a matrix of travel demand through the network is required for the simulation model. The matrix can be refined using link flow and junction turning count data at key locations within the network. A profile of travel demand variations throughout the simulation period and vehicle type classifications is also required.

5.1.2 The trip matrices were developed using junction turning counts and link counts for the following vehicle types:

- Cars and Light Goods Vehicles; and
- Heavy Goods Vehicles.

5.1.3 The matrices were developed for the following time periods:

- AM Peak – 0700-1000
- PM Peak – 1600-1900

5.1.4 The purpose of modelling the hour prior to and following the traditional morning peak hour was to identify any peak spreading that may be occurring and the impact of this peak spreading on network operation.

5.2 Zoning system

5.2.1 The zoning system comprises of 14 zones in total. The zones shown in Table 5.1 represent the zones in the model.

Table 5.1: Definition of Zones

Zone No.	Location
1	Embankment Road (North End)
2	Old Laira Road
3	Lanhydrock Road
4	Tothill Road
5	Exeter Street
6	Oreston Road
7	Billacombe Road
8	Friary Park
9	Coxside
10	Cattedown
11	St Jude’s
12	Embankment Lane/Stenlake Terrace
13	‘The Ride’
14	Prince Rock

5.3 Demand Profile

5.3.1 An appropriate profile was taken from the TTWA model to represent the fluctuations in traffic volumes through the peak periods.

5.4 Vehicle Classifications

5.4.1 Microscopic simulation enables individual characteristics of vehicle groups to be identified. The vehicle type assigned has influence on acceleration, braking and the size of the vehicle. All these factors contribute to how fast the vehicle is going and how quickly it can negotiate a bend.

5.4.2 These microscopic details bridge the gap on understanding how geometric features such as link speeds and visibility affect not just a particular vehicle group, but also how a vehicle's behaviour contributes to the operational environment of other vehicles.

5.4.3 The demand matrices developed for the Paramics Model have two user classes, cars/light goods vehicles and HGVs. Passenger Service Vehicles are added on to the model as a fixed route in accordance with the time-tabled routes. Once the buses have been assigned to the network they will be subject to the same level of congestion as that experienced by other vehicles.

5.5 Matrix totals

5.5.1 Appendix A contains the demand matrices that were estimated for the model runs.

6 MODEL VALIDATION

6.1 Introduction

6.1.1 The model validation exercise involved comparisons between modelled and observed link flows and journey times.

6.1.2 The GEH statistic is used in the validation of the model to compare the difference between an observed flow and assigned flow on a link and is defined as follows

$$GEH = \sqrt{\left(V_O - V_A\right)^2 / \left(0.5 \times \left(V_O + V_A\right)\right)}$$

6.1.3 Where Vo = observed traffic flow and Va = assigned traffic flow. The reason for using the GEH statistic rather than an absolute or relative flow difference is that it can cope with a wide range of traffic flows, whereas an absolute difference of 100 vehs/hr can be important in a flow of 200 vehs/hr it is largely irrelevant in a flow of several thousand vehs/hr.

6.1.4 The following comparison has been made:

- Link count summary

6.1.5 One hour peak period modelled flows were compared with the observed flows. The main entry roads into the gateway area were used for comparison as well as counts at Heles Terrace and Gdynia Way.

6.1.6 The model validation criteria specified in the Design Manual for Roads and Bridges Volume 12 will be used to present the validity of the estimated demand matrices. The following table is a selection of the model validation criteria presented in Table 4.2 of Chapter 4 Traffic Model Development.

Table 6.1: Model Validation; Acceptability Guidelines

Criteria and Measures		**Acceptability Guideline**
Assigned Hourly Flows		
1. GEH statistic	individual flows GEH<5	85% of all cases

6.2 Link count comparisons

6.2.1 Modelled and observed link counts have been compared for twelve points in the Gateway area, details of which are shown in Table 6.2

Table 6.2: Count Comparison Summary

	Location	nodes	Observed	Modelled	difference	GEH
AM						
	Laira Bridge to Heles Terrace	D184z:d172z	663	663	0	0.0
	Embankment Rd W to E at Heles Terrace	4733:d155z	746	680	-66	2.5
	Embankment Rd Inbound	d247:d195	2414	2343	-71	1.5
	Embankment Rd Outbound	D213:d214	1441	1492	51	1.3
	Exeter St Westbound	D318:4735z	2354	2571	217	4.4
	Exeter St Eastbound	C249:d501	1330	1512	182	4.8
	Laira Bridge Eastbound	3435:e740	1227	1163	-64	1.9
	Laira Bridge Westbound	E748:3435	2219	2159	-60	1.3
	Tothill Rd Northbound	D222z:d223z	583	576	-7	0.3
	Tothill Rd Southbound	D221z:d220z	741	638	-104	3.9
	Gdynia Way		2886	2838	-48	0.9
	Heles Terrace to Embankment Rd E	D156z-> d157y-> d155z	675	617	-58	2.3
PM						
	Laira Bridge to Heles Terrace	D184z:d172z	545	550	5	0.2
	Embankment Rd W to E at Heles Terrace	4733:d155z	1231	1255	24	0.7
	Embankment Rd Inbound	d247:d195	1576	1602	26	0.7
	Embankment Rd Outbound	D213:d214	1978	1755	-223	5.2
	Exeter St Westbound	D318:4735z	1812	1797	-15	0.3
	Exeter St Eastbound	C249:d501	2201	2182	-19	0.4
	Laira Bridge Eastbound	3435:e740	2231	1792	-439	9.8
	Laira Bridge Westbound	E748:3435	1379	1487	108	2.9
	Tothill Rd Northbound	D222z:d223z	597	647	50	2.0
	Tothill Rd Southbound	D221z:d220z	783	664	-119	4.4
	Gdynia Way		1541	1666	1	3.1
	Heles Terrace to Embankment Rd E	D156z-> d157y-> d155z	584	531	-53	2.2

6.2.2 The AM modelled flows fall well within the DMRB criteria with 100% within GEH 5, the PM modelled flows give 83% within GEH 5. Due to the localised nature of the model, the small number of recent observations available for validation and the closeness of fit to the DMRB criteria, it was felt that the PM model was sufficiently validated.

7 OPTION TESTING

7.1 Rationale

7.1.1 It was decided to create several test models, which were derived from the stage 2 options being developed for the study. The stage 2 option reference numbers have been indicated here in order that these can be readily cross-referenced to the information in the main study reports. These tests grouped together individual schemes into packages which could make up the transport options for the area, ranging from "do-minimum" to "do-everything" with several incremental packages in between. The test packages are described in detail below.

7.1.2 It must be noted that these test models only give a rough approximation of the impact of the options as no detailed engineering work has been undertaken to produce definitive designs for any of the schemes at this stage. The exercise is directed towards making general comparisons of operational performance data across the model area.

7.2 Scenario 0 – Base/Do-Nothing model

7.2.1 This model uses the existing TTWA Plymouth area wide model network data for comparison with the option models.

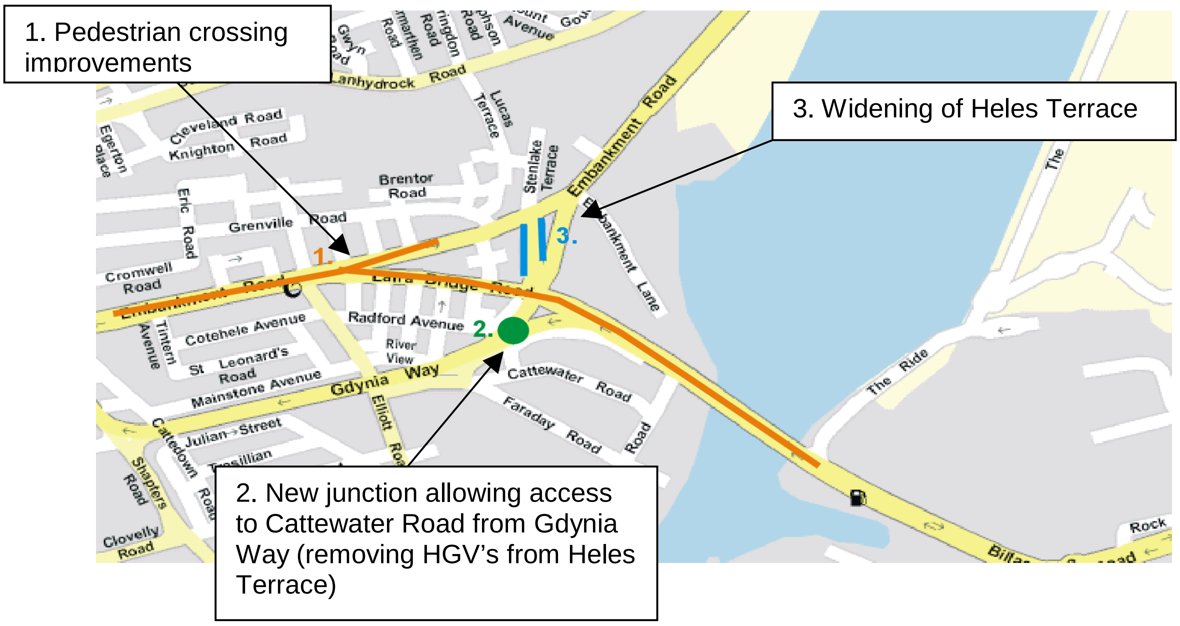
7.3 Scenario 1 – Do-Minimum

7.3.1 This model incorporates the stage 2 options 20, 22, 23 and 27. These options were modelled by increasing green signal times by 10 seconds for pedestrian crossings along Embankment Road and Laira Bridge, and placing a Southbound HGV restriction on Heles Terrace. In order to allow HGV access to the Cattedown Port area a new signalised junction was created allowing Gdynia Way traffic into Cattewater Road.

7.4 Scenario 2 – Do-Minimum + Public Transport Improvements

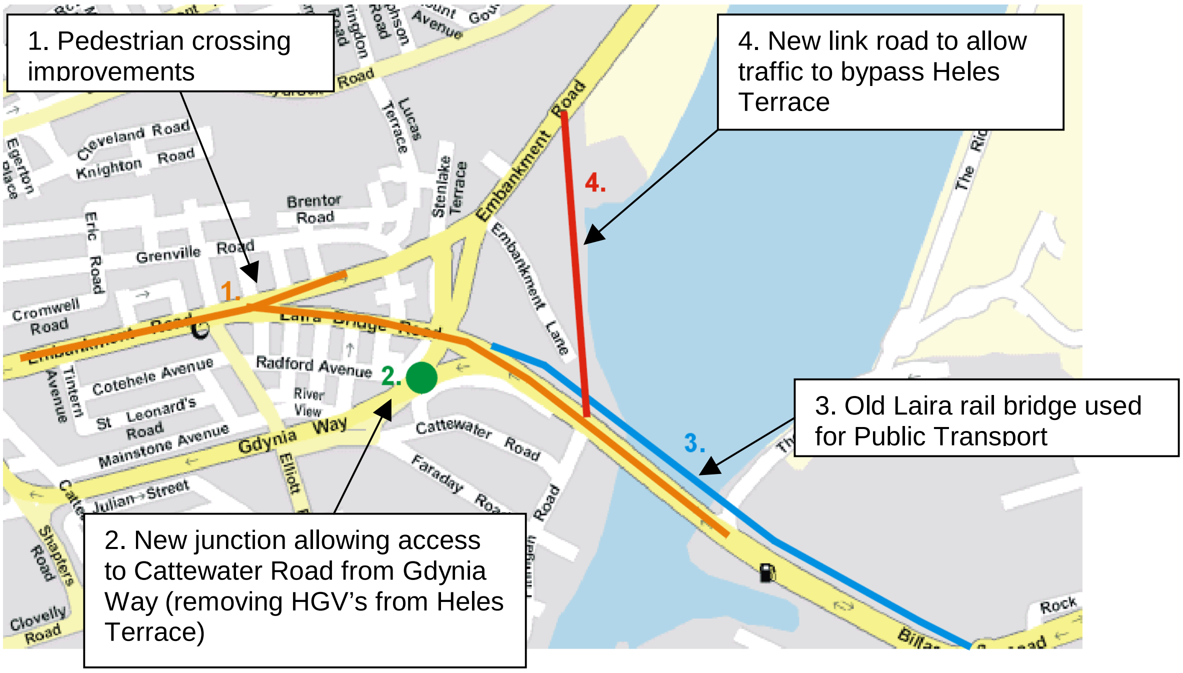
7.4.1 This model adds options 18 and 19 to the do-minimum network. The public transport options were modelled by adding bus lanes along the Laira Bridge and Embankment Road. Due to width restraints, no extra lanes were added to the existing road layout. Bus lanes were added to the left-hand lane of two lane sections.

7.5 Scenario 3a – Do- Minimum + Speed Reduction + Heles Terrace Improvements



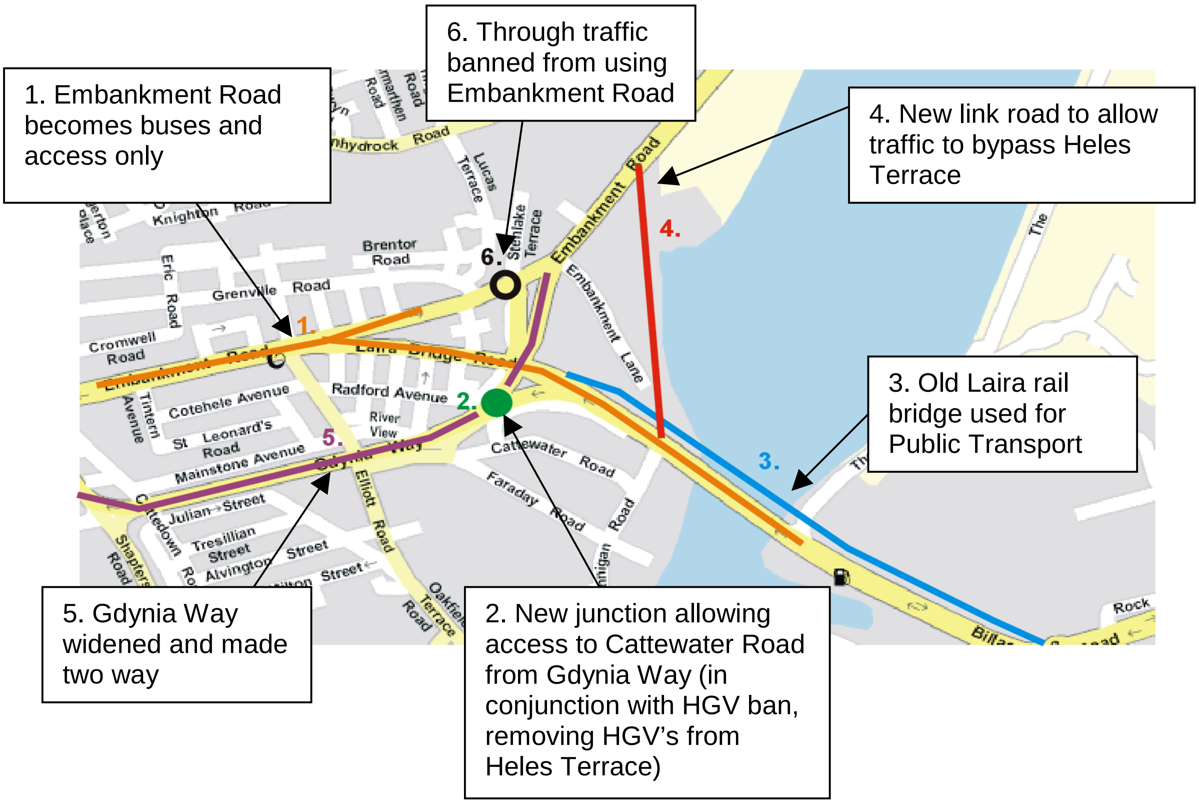
7.5.1 This scenario attempts to model option 21 of stage 2 by reducing the speed limit along Embankment Road by 10mph, this would replicate the effect of pedestrian crossings and other environmental improvements along the route. It was felt that, although not mentioned in the stage 2 report, Heles Terrace could be improved in terms of operation for buses. This was modelled by widening Heles Terrace to at least two lanes in both directions, in order to give buses easier movement into the bus stop and round the tight corners at either end. In this model buses from and to Plymstock were routed via a bus only link on the route of the Laira rail bridge in order to avoid the congested road bridge.

7.6 Scenario 3b – Do- Minimum + Heles Terrace bypass



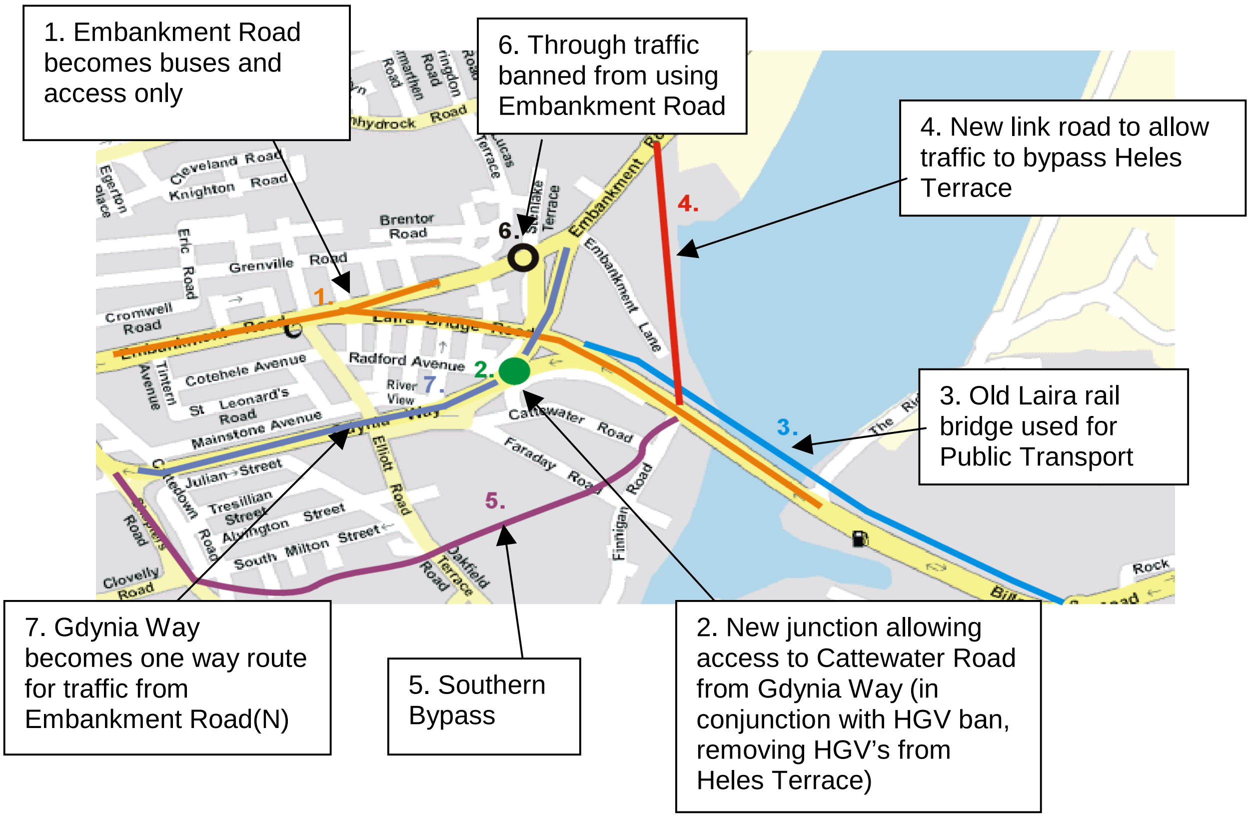
7.6.1 This model was designed as a step further for tackling the problems of excessive through traffic on Heles Terrace. The incorporation of option 30 from stage 2 means that traffic travelling from Plymstock to Marsh Mills and vice versa will no longer need to use Heles Terrace. At either end of the new road from Finnigan Road to Embankment Road, a signalised junction was created to allow this new traffic movement. The Laira rail bridge is also used for public transport in 3b.

7.7 Scenario 4 – Do- Minimum + Gdynia Way Enhancements



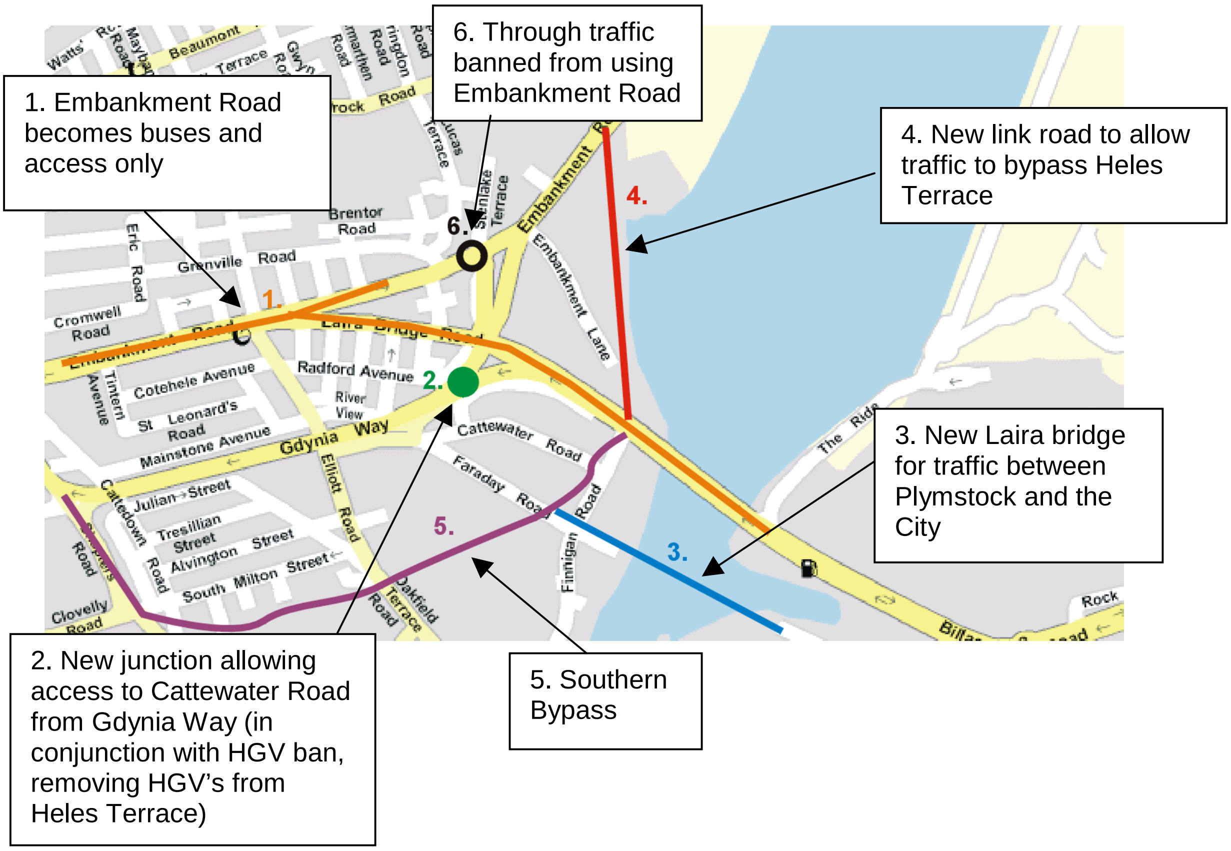
7.7.1 Scenario 4 gives a stepping stone to the full bypass options described below. Gdynia Way is widened to give two lanes in each direction and thus remove outbound traffic from Embankment Road. This model creates new signalised junctions where Laira Bridge Road and Gdynia Way meet and where Embankment Road traffic and Laira Bridge traffic meet on Gdynia Way. Another signalised junction is required on Embankment Road where it joins with Gdynia Way to allow buses to access the Western end of Embankment Road. The Heles Terrace bypass from 3b is also included.

7.8 Scenario 5 – Do- Minimum + Southern Bypass



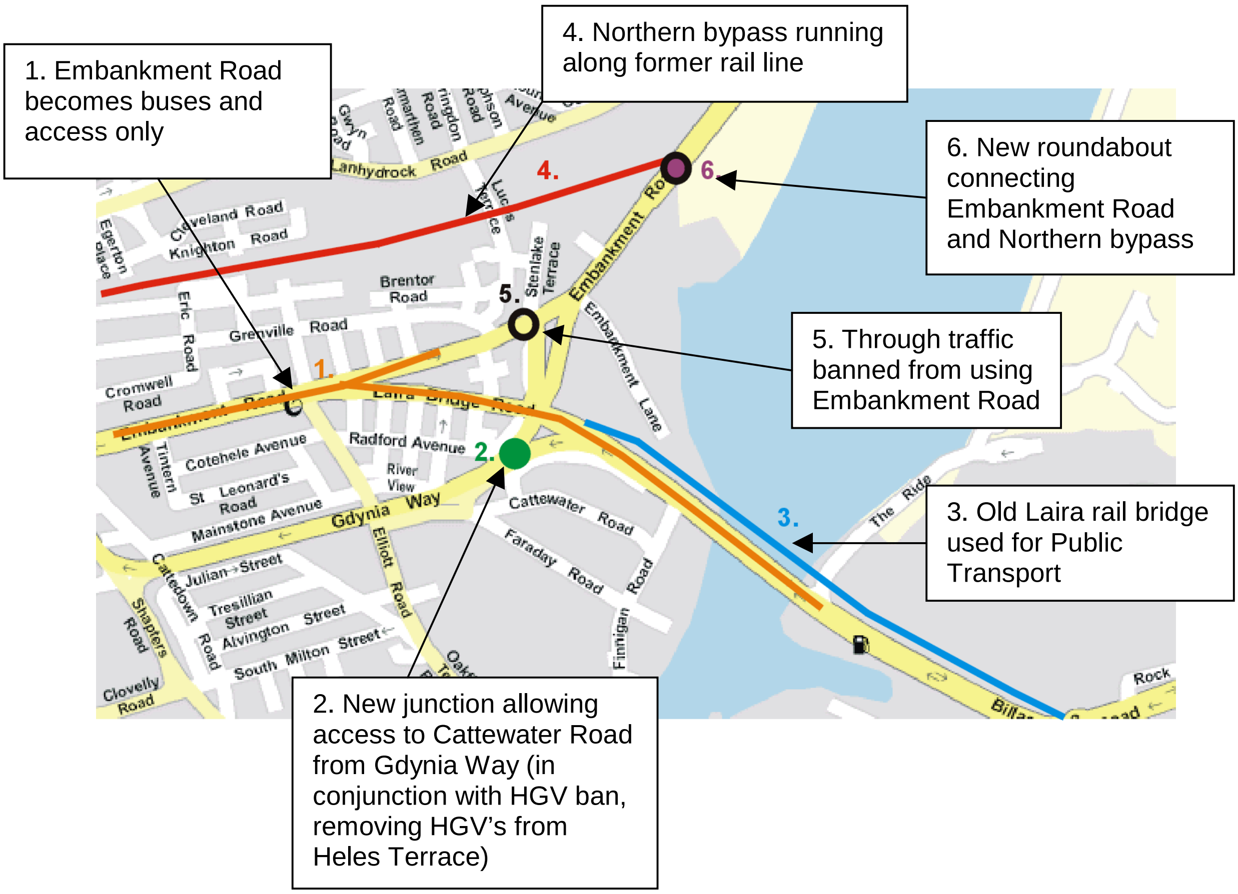
7.8.1 In order to remove traffic from Embankment Road a bypass through Cattedown was modelled which takes both the streams of traffic from Embankment Road North and the Laira Bridge. The bypass, which is at-grade, links with the Heles Terrace bypass at the junction of Finnigan Road and Laira Bridge Road. The road then takes a sweeping alignment crossing Oakfield Terrace Road and using the alignment of Shapters Road to join with Gdynia Way at the Barbican Approach junction. The bypass is a four lane, two-way road with signalised junctions where it crosses the existing roads. Embankment Road (W) becomes a bus and access only route and all through traffic is prevented from using it.

7.9 Scenario 6 – Do – Minimum + Southern Bypass + New Bridge



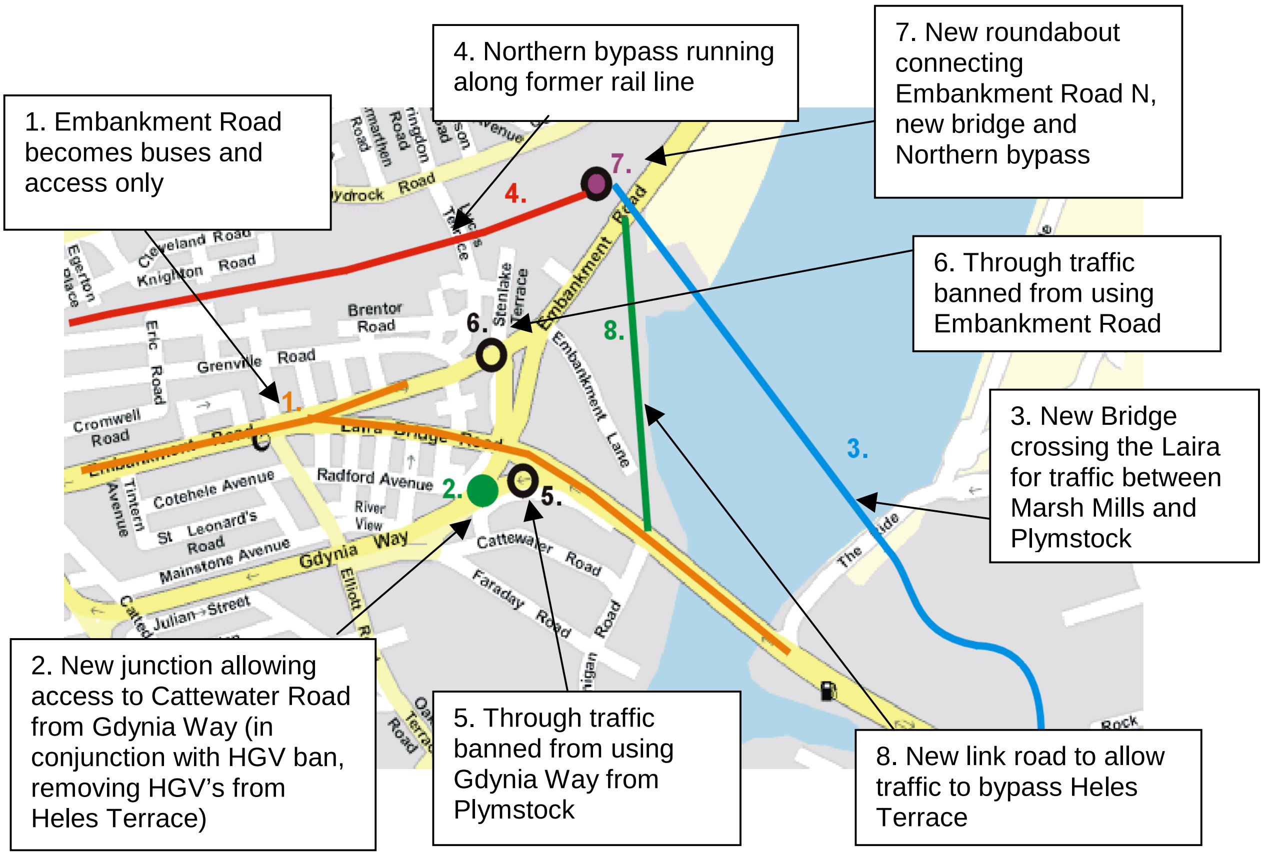
7.9.1 Scenario 6 adds a second Laira Bridge onto Scenario 5. This bridge is used purely by Plymstock traffic bound for the city centre and vice versa, traffic bound for Marsh Mills and Public Transport will use the existing bridge. The new bridge and its approaches start at the Safeway Roundabout in Pomphlett and cross to join the bypass road in Cattedown.

7.10 Scenario 7 – Do – Minimum + Northern Bypass



7.10.1 The realignment of the freight railway to the Port means that a corridor of land has been released to the North of Embankment Road running to Friary Yard. This model uses this for the alignment of the Embankment Road bypass. Gdynia Way is changed to a two-way route with one lane in either direction for Plymstock traffic only, whilst the new route performs a similar role for Marsh Mills traffic although with four lanes. Traffic from Marsh Mills to Plymstock and vice versa must still use Heles Terrace. A new roundabout is created at the junction of Embankment Road and the bypass and a signalised junction is created with Exeter Street at the western end of the road. The new road will use the natural topography and will therefore travel below Tothill Road.

7.11 Scenario 8 – Northern Bypass + New Bridge



7.11.1 The new bridge in this case starts at the Pomphlett Roundabout and travels across to the new roundabout on Embankment Road. It is therefore designed to take the traffic travelling between Marsh Mills and Plymstock and will free up capacity on the existing bridge for public transport. The roundabout in this test is west of Embankment Road with the old alignment of Embankment Road preserved for buses. A new vehicle actuated junction is created to allow the northbound buses to bypass the roundabout and continue their journey unimpeded.

8 MODEL TEST RESULTS

8.1 Introduction

8.1.1 Using the existing TTWA Paramics model and the indicative diagrams of the possible changes to the current highway network, SIAS Ltd developed nine Paramics models of the network scenarios described in the previous chapter.

8.1.2 The objective of the Paramics microsimulation model is to represent existing conditions in the network for the AM and PM peak periods and to model approximately the impact of the proposed options under these same traffic demands.

8.1.3 The matrix of traffic movements for the base model was developed from manual classified turning counts and Automatic Traffic Counters provided by Plymouth City Council. The model was validated against link and turning counts. The analysis indicates that the Paramics model is assigning the correct flows in the base model.

8.1.4 The above results indicate that the model is considered to represent adequately network conditions through the Gateway area and is therefore a suitable base for comparison with the proposed changes.

8.2 Scenario Test Results

8.2.1 A number of different statistics have been produced from runs of the test models in the AM peak. They include bus and vehicle journey times for the main routes through the model (between Marsh Mills, Plymstock and the City Centre), vehicle speeds through the model and traffic levels on Heles Terrace and Embankment Road (W). The results are shown in the tables below.

8.2.2 After some initial model tests of scenario's 4, 5 and 6 it was decided that these options would cause too much congestion on the network and have been discarded from the option development process. This additional congestion arises out of the extra junctions being introduced which have a direct operational impact on the study area.

8.2.3 Scenario 4 was discarded as too many conflicts were caused by opposing traffic streams when Gdynia Way was changed into a two-way road. It was also felt that there is insufficient land either side of Gdynia Way to allow enough lanes for the traffic volumes passing through the area.

8.2.4 Scenario's 5 and 6 delayed traffic too much because the southern bypass must cut through a number of existing roads and therefore signalised junctions were needed which are not seen on Gdynia Way at present. These models were effectively replaced by 7 and 8 as they have the same bypass principle but in a different location.

8.3 Vehicle Speeds

Table 8.1: Average Vehicle speeds (MPH)

JOURNEY	Base	Test 1	Test 2	Test 3a	Test 3b	Test 7	Test 8
City to Marsh Mills	27	26	24	26	27	32	36
Marsh Mills to City	38	36	37	37	32	21	29
City to Pomphlett	22	21	18	20	21	24	28
Pomphlett to City	31	23	25	26	18	25	26
Marsh Mills to Pomphlett	39	38	35	36	28	22	35
Pomphlett to Marsh Mills	35	31	29	34	26	24	37
Overall	**32**	**29**	**28**	**30**	**25**	**25**	**32**

8.3.1 It can be seen from Table 8.1 above that Tests 1, 2 and 3a have minimal effects on journey speeds for private vehicles due to the small scale of the proposals included in these test models.

8.3.2 Test 3b reduces vehicle speeds on the journeys into the City from Pomphlett by 13mph, this is due to extra queueing caused by the new signal junctions at the end of the new road at Laira Bridge Road. Speeds on the journey from Marsh Mills to the City are reduced by 6mph because of the new signalised junction on Embankment Road. It must be noted that at present vehicles speeds along the main routes are close to the speed limits as the present layout generally performs well.

8.3.3 The new junctions also cause reduced speeds for the traffic moving between Marsh Mills to Pomphlett, as they must negotiate both sets of signals on their journey. This causes a 10mph reduction in average speed in both directions.

8.3.4 Test 7 shows an improvement on vehicle speeds for traffic from the city centre, this is because of the use of the new Northern bypass which has fewer interruptions, such as signals, compared with the western section of Embankment Road.

8.3.5 Compared to speeds at present, Test 7 shows significant reductions in speeds for journeys from Marsh Mills and Pomphlett. The reduction in speeds for journeys from Marsh Mills is due to the new roundabout that causes delays not seen at present because of the grade separated nature of Gdynia Way.

8.3.6 Test 8 shows an improvement in vehicle speeds compared to 7, although not all the routes show speeds as fast as in the base, the overall speed for all routes is the same as in the base at 32mph. The routes showing a drop in vehicle speeds are Marsh Mills to the city, Pomphlett to the city and Marsh Mills to Pomphlett. The reductions for traffic from Marsh Mills can be attributed to the addition of the roundabout on Embankment Road, this causes delay on a route which at present flows freely to Heles Terrace. Pomphlett to the City traffic also experience slower speeds because of the roundabout and the 30mph speed limit on the new bridge which is lower than that on the present Laira Bridge.

8.4 Bus Journey Times

Table 8.2: Average bus journey times (seconds)

	Base	Test 1	Test 2	Test 3a	Test 3b	Test 7	Test 8
Overall	**418**	**418**	**409**	**422**	**407**	**525**	**426**
City to Plymstock	363	349	346	339	306	376	329
City to Marsh Mills	513	521	520	522	511	605	483
Plymstock to City	312	316	281	348	303	341	355
Marsh Mills to City	485	487	487	480	510	777	538

8.4.1 Bus journey times show, that in Test 1, extra pedestrian green time at crossings makes no difference to the overall bus journey times. In test 2 a small time saving is made when extra bus lanes are introduced with City- Plymstock bus journeys reducing from 363s to 346s and Plymstock-City journeys reducing from 312s to 281s.

8.4.2 Test 3a shows an increase in journey time for all the routes except those from the city to Plymstock and Marsh Mills to the city. An increase in journey time is experienced by buses travelling along Embankment Road due to the lower speed limits implemented in this model.

8.4.3 In Test 3a, the use of the old railway bridge for public transport gives benefits to Plymstock-bound buses but increases travel time for city-bound buses. Buses must wait for a green signal at the junction with Finnigan Road before proceeding towards the city, but in the outbound direction, buses can move onto the bus-only link in all stages of the signals.

8.4.4 Test 3b shows a slight decrease in bus journey times compared to 3a. Buses to Plymstock from the city have journey times which are reduced by 57 seconds whilst in the opposite direction journey times are very similar to the base. The bus only link does not join at the junction with Finnigan Road and therefore buses have an improved flow onto the link in both directions.

8.4.5 Increases in journey times are seen in Test 3b for the buses from Marsh Mills. This is due to the extra queueing experienced on Embankment Road caused by the new junction with the Heles Terrace bypass.

8.4.6 All the bus journeys are increased in Test 7. Journeys from and to Marsh Mills are significantly increased because of the need to pass through the new roundabout on Embankment Road and the queues of traffic generated by the roundabout. Routes to and from Plymstock are slightly longer because they are held up by traffic queued at the new signalised junction at Gdynia Way/Laira Bridge Road

8.4.7 The overall bus journey times for Test 8 are within 10 seconds of the base journey times. Improved journey times are seen for the outbound routes because of low traffic volumes on Embankment Road west and a bus-actuated signal allowing buses to bypass the new roundabout. Poorer journey times are seen for the city bound routes because of queueing on Exeter Street at the junction with the new bypass road. This could be resolved by allowing buses to circumvent the signals in a bus-only lane.

8.5 Vehicle Journey Times

Table 8.3: Average vehicle journey time (s)

	Base	Test 1	Test 2	Test 3a	Test 3b	Test 7	Test 8
City to Marsh Mills	328	328	369	334	327	270	248
Marsh Mills to City	256	267	264	265	307	594	320
City to Pomphlett	251	257	332	270	261	264	229
Pomphlett to City	183	261	232	226	340	266	243
Marsh Mills to Pomphlett	217	220	244	233	287	522	211
Pomphlett to Marsh Mills	243	279	288	253	324	375	227
Overall	**246**	**269**	**288**	**264**	**308**	**382**	**246**

8.5.1 In Test 1 increases in journey times are seen which can be attributed to the extra delays caused by increased pedestrian green times and the addition of a new signalised junction on Gdynia Way.

8.5.2 Greater increases in journey time are seen in Test 2 with the overall journey time increasing to 288 seconds. The reduced capacity caused by the addition of bus lanes has meant that journey times have increased, especially those starting in the city centre, these journeys must use Embankment Road west which has had the most severe reduction in capacity.

8.5.3 Test 3a gives overall journey times at a similar level to Test 1.The most significant increases in journey times are seen on the routes using Embankment Road east, as the speed limit reduction here will naturally give longer journeys. Other increases in journey time are created by the need for an extra signal stage for buses at the Finnigan Road/Laira Bridge road junction.

8.5.4 The overall average journey time for test 3b is over a minute slower than in the base scenario. This increase is caused by the new signal controlled junction on Embankment Road and the addition of an extra stage at the Finnigan Road/Laira Bridge Road junction. Journeys originating in the city centre have similar timings to those in the base model as vehicles are less affected by these junctions in an outbound direction.

8.5.5 Test 7 gives the longest overall journey time of all the test models with 382 seconds compared to the base journey time of 246 seconds. This is primarily due to the queueing caused by the new roundabout on Embankment Road which more than doubles the journey times from Marsh Mills. The addition of an extra signal controlled junction and the roundabout also increase journey times from Pomphlett to Marsh Mills by 132 seconds.

8.5.6 The overall journey times for Test 8 are the same as for the base scenario, however some individual routes are slower and some faster. Due to the removal of Gdynia Way all traffic from Pomphlett must now use the new bridge, which is a less direct route for city bound traffic and therefore takes longer. Traffic originating in Marsh Mills and heading for the city centre takes on average 64 seconds longer than in the base because of queueing from the new roundabout.

8.6 Embankment Road Traffic Volumes

Table 8.4: Embankment Road traffic volumes (3 hrs)

	Base	Test 1	Test 2	Test 3a	Test 3b	Test 7	Test 8
Embankment Rd East to MM	1829	1797	2030	1790	1796	63	28
Embankment Rd East to Plym	1701	1689	1272	1677	1742	48	206
Embankment Rd Westbound	45	69	54	79	74	0	117

8.6.1 In terms of traffic volumes on Embankment Road west it can be seen that Test 1 caused little change. Test 2 increased traffic volumes on the outbound stretch to Marsh Mills and decreased volumes on the stretch to Plymstock. The reduction in traffic on the southern fork of Embankment Road is due to a reduced capacity because of bus lanes, which means that the number of vehicles that can physically fit on the road has been reduced. This reduction in capacity has also led to vehicles re-routing via the northern fork and Heles terrace, creating the higher volumes seen on the Marsh Mills bound fork of Embankment Road.

8.6.2 Tests 3a and 3b gave very similar results to the base situation as no attempt was made to alter traffic on Embankment Road.

8.6.3 Test 7 gives the greatest reduction in traffic on Embankment Road, removing through traffic entirely and leaving just a small number of access trips.

8.6.4 Test 8 also reduces the number of trips significantly. However due to the congestion and increased journey distance when using the bypass a number of vehicles still use Embankment Rd as a through route. The traffic using it to travel to Plymstock is around 12% of that seen in the base. An increase is seen in the traffic volume going west on Embankment Road as this route is much more direct than the bypass, but the amount of traffic travelling west is still relatively small.

8.7 Heles Terrace Traffic Volumes

Table 8.5: Heles Terrace traffic volumes

	Base	Test 1	Test 2	Test 3a	Test 3b	Test 7	Test 8
Heles Terrace Nbound	1715	1668	1354	1624	154	1394	5
Heles Terrace Sbound	2071	1724	2077	1669	645	1428	194

8.7.1 Test 1 gives a reduced traffic volume on Heles Terrace southbound as the HGV ban on the road takes away this element of the traffic.

8.7.2 Test 2 sees a reduced volume northbound and an increase in southbound flows. This is due to the reduction in capacity on the links which have had lanes changed to bus only. As explained in paragraph 8.6.1 re-routing occurs which means some traffic going to Plymstock uses Heles Terrace to avoid congestion on Embankment Road. The reduction in northbound traffic can be explained by the reduced capacity on the Laira Bridge meaning fewer vehicles reaching Heles Terrace.

8.7.3 Test 3a gives similar results to test 1 with only the HGV ban having an effect.

8.7.4 The addition of the Heles terrace relief road in 3b results in a 90% reduction in traffic northbound. The reduction is less pronounced in the southbound direction because of traffic going from Marsh Mills to Plymstock re-routing through Heles Terrace instead of using the new relief road. This happens because the delays at signals at each end of Heles Terrace are less than the delays at each end of the relief road. In reality, this may happen to some extent, but the model exaggerates the effect.

8.7.5 Test 7 gives reduced flows in both directions. This is due to the new signal junction on Laira Bridge Road restricting the traffic which can reach the southern end of Heles terrace, and the roundabout on Embankment Road restricting the numbers of vehicles that reach the northern end.

8.7.6 Test 8 removes all but 10% of southbound traffic and almost all northbound traffic.

8.8 Conclusions from Test Results

8.8.1 It is recommended that Scenario 8 is taken forward as the Preferred Option for Stage 3 of the project. Scenario 3b is recommended as the Lower Cost option and the do-minimum option will be created by a mixture of Test 1 and Test 3a.

8.8.2 All the tests show that any scheme will be a compromise between reducing traffic volumes on the sensitive residential routes and maintaining journey times for buses and private vehicles. At present the area works well in terms of traffic flow and it is hard to maintain this when creating new junctions that are not grade-separated.

8.8.3 Scenario 8 (Preferred Option) removes the majority of through traffic from Heles Terrace and Embankment Road whilst maintaining overall journey times for vehicles, although journey times for some routes increase by up to 33%. Bus journey times also suffer but to a lesser extent, with an 11% increase on one route.

8.8.4 The lower cost option does not attempt to reduce traffic volumes on Embankment Road but only Heles Terrace. It does not involve as much infrastructure as Test 8 and does not perform as well in terms of journey times and vehicle speeds. It does however have a significant positive effect on Heles Terrace traffic volumes. With extra engineering work to create better junctions at either end of the relief road, the model may show traffic flow that is more in line with present conditions.

8.8.5 The do-minimum test gives better accessibility for pedestrians and cyclists in terms of crossing the major routes through the area, removes HGVs from Heles Terrace and enhances traffic flow on Heles Terrace. However, it does nothing to remove traffic from Embankment Road and will slow vehicle and bus journeys through the Gateway.

9 FUTURE TRAFFIC PRESSURES

9.1 Context

9.1.1 The tests referred to and documented in the previous chapter have been undertaken using 2002 traffic demand levels.

9.1.2 It would have been unhelpful to have attempted to examine a number of future year traffic demand levels for all test network. Aside from the computational effort involved, they would simply have illustrated much higher levels of congestion, an outcome that is surely contrary to the objectives of the study.

9.1.3 Consideration of these future pressures however are important when considering the model results explained in the preceding sections of the report. There is no doubt that traffic pressures will increase through the Gateway area as a consequence of general traffic growth and the considerable development pressures in the Plymouth area. Proposed and committed residential developments alone will have significant impacts. Without measures to manage, constrain or divert these pressures, their consequences within the study area will be higher levels of congestion for longer periods in the day.

9.1.4 A comprehensive and possibly radical strategy will be required if the Gateway area is to be redeveloped in a manner compatible with the vision developed by the study team in the course of this study. This will require courage on the part of the local authority, some careful and bold planning decisions, and not inconsiderable finance.

9.1.5 As a guide to the possible consequences of higher traffic levels, some selective testing has been undertaken for some of the test networks.

9.2 Methodology

9.2.1 A future year modelling exercise has already been undertaken by SIAS using the wide area Plymouth TTWA Paramics Model. This was carried out to assist those in the Council providing technical inputs to the recent Draft Structure Plan EIP. This exercise modelled predicted traffic growth resulting from proposed housing and employment developments around Plymouth, as well as natural growth to bring traffic up to the levels predicted by the National Road Traffic Forecast. A future year of 2016 was selected and the overall traffic increase was 18.4% throughout Plymouth.

9.2.2 The modelling work using the wide area Plymouth model included the highest level of proposed housing developments to the East of the Laira Bridge including the new settlement proposals at Sherford, for example. A table showing the future developments included in the model can be seen in appendix B.

9.2.3 In order to estimate the traffic growth that might be seen in the Gateway area consistent with the above work, runs of the base and 2016 models were carried out. Link flows for the major roads at the perimeter of the Gateway were compared in order to find the localised level of growth for the roads within the Gateway area.

9.2.4 The 2002 matrix was then factored up by applying the level of growth seen at the cordon points described above. The traffic levels on the following roads were increased by the figures below, giving an overall increase in traffic in the model of 14.9 %:

- Embankment Road – 24%
- Tothill Road – 23.8%
- Exeter Street – 20%

- Billacombe Road & Oreston Road – 37.9%

9.2.5 Once the 2002 matrix had been factored to these new higher levels for 2016, new model runs were carried out and statistics produced on bus and vehicle journey times, vehicle speeds and traffic volumes. These were then compared with the 2002 runs to show the level of change expected from future traffic growth.

9.2.6 The future runs were carried out only for the Base and Network Scenarios 3a, 3b and 8. Results are tabulated in the following section.

9.3 Model Results; Vehicle Speeds

Table 9.1: Average Vehicle speeds (MPH)

	Base 2002	Base 2016	Test 3a 2002	Test 3a 2016	Test 3b 2002	Test 3b 2016	Test 8 2002	Test 8 2016
City to Marsh Mills	27	21	26	21	27	20	36	42
Marsh Mills to City	38	30	37	22	32	20	29	18
City to Pomphlett	22	16	20	16	21	15	28	25
Pomphlett to City	31	25	26	22	18	17	26	25
Marsh Mills to Pomphlett	39	31	36	21	28	17	35	19
Pomphlett to Marsh Mills	35	32	34	31	26	23	37	34
Average	32	26	30	22	25	19	32	27

9.3.1 As would be expected with the addition of a significant level of extra traffic, average vehicle speeds throughout the model have decreased, by 6mph for the base model, 8mph for test 3a, 6mph for test 3b and 5mph for test 8. In the base and test 3a models, the worst reductions in speed were seen for vehicles travelling from Marsh Mills with a reduction of 8mph and 15mph respectively. Test 3b showed a similar trend with speeds for traffic travelling between Marsh Mills and the City reducing by 12mph, a reduction of 11 mph was seen for Marsh Mills to Pomphlett traffic. Test 8 shows a slight rise in speeds on the journey from the City to Marsh Mills, but also shows the greatest reductions in speed on the routes from Marsh Mills with similar reductions in speed as the other tests.

9.4 Model Results; Bus Journey Times

Table 9.2: Average Bus Journey Times (s)

	Base 2002	Base 2016	Test 3a 2002	Test 3a 2016	Test 3b 2002	Test 3b 2016	Test 8 2002	Test 8 2016
Overall	418	474	422	486	407	500	426	518
City to Plymstock	363	418	339	360	306	351	329	370
City to Marsh Mills	513	549	522	551	511	566	483	490
Plymstock to City	312	352	348	354	303	312	355	352
Marsh Mills to City	485	575	480	680	510	770	538	858

9.4.1 Bus journey times were also significantly affected by the addition of extra vehicular traffic with overall times increasing by 56 seconds in the base model, 64 seconds for test 3a, 93 seconds for test 3b and 92 seconds for test 8. As with the vehicle speeds the greatest increases in journey time were seen on buses travelling from Marsh Mills.

9.5 Model Results; Vehicle Journey Times

Table 9.3: Average Vehicle Journey Times (s)

	Base 2002	Base 2016	Test 3a 2002	Test 3a 2016	Test 3b 2002	Test 3b 2016	Test 8 2002	Test 8 2016
City to Marsh Mills	328	430	334	427	327	439	248	268
Marsh Mills to City	256	350	265	495	307	569	320	648
City to Pomphlett	251	367	270	379	261	383	229	254
Pomphlett to City	183	249	226	266	340	363	243	256
Marsh Mills to Pomphlett	217	293	233	464	287	562	211	492
Pomphlett to Marsh Mills	243	269	253	273	324	365	227	253
Average	246	326	264	384	308	447	246	362

9.5.1 As with the bus journey times, an increase is seen for overall vehicle journey times when traffic growth is included. In the base model an increase of 80 seconds is seen (33%), test 3a shows an increase of 120 seconds (45%), test 3b sees an increase of 139 seconds (45%) and test 8 shows an increase of 116 seconds (47%). The vehicle journey times for the routes from Marsh Mills are the worst affected and in test 8 journey times are doubled for the routes originating at Marsh Mills.

9.6 Embankment Road Traffic Volumes

Table 9.4: Embankment Road Traffic Volumes (3hrs)

	Base 2002	Base 2016	Test 3a 2002	Test 3a 2016	Test 3b 2002	Test 3b 2016	Test 8 2002	Test 8 2016
Embankment Rd East to MM	1829	2319	1790	2209	1796	2228	28	24
Embankment Rd East to Plym	1701	1972	1677	1999	1742	2025	206	256
Embankment Rd Westbound	45	103	79	114	74	73	117	118

9.6.1 In the base situation traffic increases by 27% in the Eastbound Marsh Mills direction, 16% in the Eastbound towards Plymstock and over 100% in the Westbound direction. For tests 3a and 3b traffic volumes increase by around 23% for Eastbound traffic towards Marsh Mills and 20% for Eastbound traffic towards Plymstock. Test 3a shows an increase of 44% for the westbound movement whilst test 3b shows no difference for this route. Test 8 shows little change in flows as through traffic is still barred.

9.7 Heles Terrace Traffic Volumes

Table 9.5: Heles Terrace Traffic Volumes (3hrs)

	Base 2002	Base 2016	Test 3a 2002	Test 3a 2016	Test 3b 2002	Test 3b 2016	Test 8 2002	Test 8 2016
Heles Terrace N Bound	1715	1789	1624	1776	154	136	5	12
Heles Terrace S Bound	2071	2489	1669	2083	645	909	194	193

9.7.1 The base model shows an increase on Heles Terrace of 4% in the Northbound direction and 20% in the opposite direction. Test 3a would result in future traffic volumes on Heles Terrace that are increased by just over 9% in a northbound direction and just under 25% in the southbound direction. Test 3b shows a small decrease in traffic in the northbound direction and an increase of 40% in the southbound direction. As with traffic levels on Embankment Road, test 8 shows little change for Heles Terrace when future year demands are modelled.

10 DESIGN OF FRIARY BOULEVARD (NORTHERN BYPASS)

10.1 Introduction

10.1.1 In previous tests of the model which included the Northern Bypass, the new road was modelled with two lanes running in each direction. As this may not lead to an ideal pedestrian environment it was suggested that the route should be tested with a single lane in each direction.

10.1.2 Two model tests were carried out with the two lane bypass; firstly with the bypass as the only route into the city from Marsh Mills and Plymstock, and secondly with Gdynia Way reopened for through traffic from Plymstock.

10.2 Results

Table 10.1: Vehicle Speeds (mph)

	Test 8	Test 8 with 1 lane	Test 8 with 1 lane and Gdynia Way
City to Marsh Mills	36	36	35
Marsh Mills to City	29	14	16
City to Pomphlett	28	29	28
Pomphlett to City	26	15	24
Marsh Mills to Pomphlett	35	21	19
Pomphlett to Marsh Mills	37	17	32
Overall	32	22	26

10.2.1 Vehicle speeds in the model without Gdynia Way drop dramatically overall, all routes are affected except for those beginning in the city. The effect of reducing capacity on the bypass is to create a bottleneck at the new roundabout and therefore create much greater queues on Embankment Road (N) and the new bridge.

10.2.2 With the introduction of Gdynia Way, vehicle speeds are slightly better overall as fewer vehicles must travel through the roundabout and along the bypass.

Table 10.2: Bus Journey Times (S)

	Test 8	Test 8 with 1 lane	Test 8 with 1 lane and Gdynia Way
Overall	426	454	433
City to Plymstock	329	330	331
City to Marsh Mills	483	464	462
Plymstock to City	355	381	370
Marsh Mills to City	538	641	567

10.2.3 Very little change is seen in the bus journey times as most routes are not affected by the queues generated on the arms of the roundabout. With the inclusion of Gdynia Way bus journey times are improved as smaller queues are seen in this model.

Table 10.3: Vehicle Journey Times (S)

	Test 8	Test 8 with 1 lane	Test 8 with 1 lane and Gdynia
City to Marsh Mills	248	246	255
Marsh Mills to City	320	808	707
City to Pomphlett	229	221	235
Pomphlett to City	243	551	271
Marsh Mills to Pomphlett	211	588	532
Pomphlett to Marsh Mills	227	576	276
Overall	246	498	379

10.2.4 As seen with the vehicle speeds, the journey times increase substantially when the two lane bypass is introduced especially so for journeys which must pass through the roundabout. An improvement in journey times is seen when Gdynia way is re-introduced but journey times are still significantly worse than in the original test 8.

Table 10.4: Embankment Road Traffic Volumes (3hrs)

	Test 8	Test 8 with 1 lane	Test 8 with 1 lane and Gdynia Way
Embankment Rd	28	30	13
Embankment Rd Eastbound	206	293	24
Embankment Rd West Bound	117	295	16

10.2.5 Embankment Road sees an increase in traffic when the bypass capacity is reduced, this is due to more vehicles using Embankment Road as a rat-run. When Gdynia Way is added traffic levels reduce to minimal volumes as Gdynia Way is now used by those vehicles which would have rat run through Embankment Road.

Table 10.5: Heles Terrace Traffic Volumes (3hrs)

	Test 8	Test 8 with 1 lane	Test 8 with 1 lane and Gdynia Way
Heles Terrace N Bound	5	40	12
Heles Terrace S Bound	194	217	208

10.2.6 Changing the capacity of the new link makes little difference to the traffic volumes found on Heles Terrace.

10.3 Conclusion

10.3.1 In order to create a bypass route which is a two lane road, the flow of traffic through the area will be severely hindered. Creating separate routes for Plymstock and Marsh Mills traffic improves traffic flow but does not perform as well as keeping the bypass as a four lane road.

A APPENDIX A: DEMAND MATRICES

Vehicle Matrix AM Peak (2002)

demand	period		1
matrix	count		1
divisor		10	

matrix	1														
from	1	0	15230	2122	2348	23967	8627	1325	432	1902	6656	3691	7451	501	821
from	2	13392	0	10	0	46	514	192	10	10	74	30	330	15	0
from	3	9428	625	0	0	0	0	0	0	0	0	0	0	0	0
from	4	1278	0	0	0	350	2493	2415	334	1382	4183	4529	192	48	478
from	5	12647	249	183	120	0	5979	5165	4293	2240	3524	760	551	384	2591
from	6	5787	279	1123	2707	11259	0	4360	173	492	2070	903	735	1000	10
from	7	3341	330	394	1429	19820	3420	0	82	803	1945	896	441	410	10
from	8	264	0	12	74	281	0	0	0	0	56	27	0	0	0
from	9	754	452	0	174	1970	38	37	46	0	15	13	10	10	15
from	10	3083	561	18	4313	2661	119	445	15	55	0	222	20	0	0
from	11	2397	72	186	3360	2261	638	1201	70	22	539	0	77	11	0
from	12	404	62	104	527	1009	429	210	0	12	18	888	0	0	0
from	13	221	0	0	18	392	138	357	0	0	0	0	0	0	0
from	14	60	0	0	121	5492	0	0	0	0	0	0	0	0	0

Vehicle Matrix PM Peak (2006)

demand period 3
matrix count 1
divisor 10

matrix	1														
from	1	0	21870	1633	2887	21337	16437	210	408	1758	4600	3623	2174	166	641
from	2	22227	0	32	0	773	1170	791	0	47	105	20	250	51	40
from	3	10006	34	0	0	33	41	24	0	0	0	0	0	0	0
from	4	4410	143	0	0	2168	7281	4560	131	416	919	346	560	128	875
from	5	24694	413	0	1193	0	14250	16674	9453	1197	993	2455	851	416	2612
from	6	8901	211	298	4043	6626	0	5020	0	458	346	1177	249	240	0
from	7	3882	346	447	2906	12194	4230	0	140	1209	3729	2974	153	410	222
from	8	4240	0	195	322	3451	0	0	0	0	520	142	0	0	0
from	9	3389	2152	0	598	6774	102	99	120	0	39	36	10	27	39
from	10	4952	875	29	6063	4827	130	488	26	58	0	236	10	0	0
from	11	3416	97	271	4064	3289	674	1269	108	34	570	0	29	11	0
from	12	138	19	37	153	336	110	54	0	0	0	225	0	0	0
from	13	782	0	0	50	1091	298	770	0	0	0	0	0	0	0
from	14	24	0	0	38	1939	0	0	0	0	0	0	0	0	0

B FUTURE YEAR DEVELOPMENTS

Table of Future Housing Developments factored into 2016 model demands

ADDRESS	TOTAL
LP039(rem) Royal William Yard ex Mills Bakery	144
Pottery Quay	200
Millbay Eastern Dock	180
Western Power Site Elliot Road	110
Land bounded by Cornwall Street (west), Armada Way	215
Land bounded by Mayflower Street (west), Armada Wa	192
28-29 Central Park Avenue Plymouth (Split Site)	220
Land adjacent to Plymouth Railway Station	100
Land at Ham Drive/Beacon Park	105
Bretonside	150
Land at Harbour Avenue / east of Sutton Road	416
Former Employment Land Manadon	100
Manadon South West	110
LP100 Former Radford Oil Fuel Depot	125
Plymstock Quarry and Works	700
Hooelake Quarry	150
East Sherford	1200
Chittleburn	1200
West Sherford	1100
Wiverton	1000
Woolwell 1	0
Woolwell 2	0
Tamerton	0