Signal Controlled Roundabouts:
Breaking the Rules by

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1.0 INTRODUCTION

An unusual origin-destination pattern at a small roundabout in Hamilton, Scotland led to an operational solution that contradicts two aspects of the current standard guidance (1,2, 3) for the design of signal controlled roundabouts.

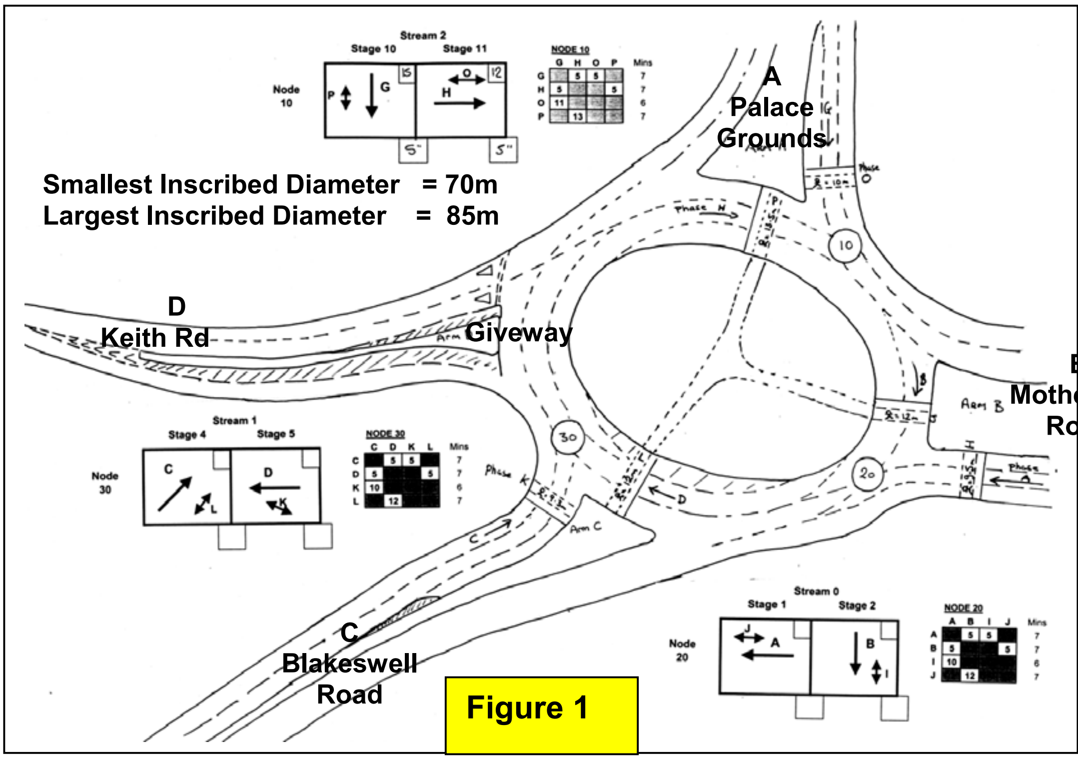


Figure 1

Current design guidance for Signal Controlled Roundabout Design directs you to (see Figures 2 and 3):-

a) Consider whether one or more approaches may remain uncontrolled.
b) Seek a cycle time that is as small as possible *(to minimise queuing inside the roundabout).*
c) Flare the approaches to optimise the available green time (most *of the green time is given to the gyratory links to keep internal queues small and to prevent block-back). Use LINSAT (4) to ensure flare usage (as opposed to flare length availability) is modelled.*
d) Use stop weightings on short internal links carrying newly entered traffic to deter the optimiser from finding timings that would immediately stop newly entered traffic – this for safety. Use the Transyt type 38 excess queue limit facility to deter long internal queues.
e) Use delay weightings on the approach links to encourage queuing here rather than within the roundabout.
f) Assemble a Lane/Flow Diagram and use this to properly construct the Link diagram and subsequently assign saturation flows. The new JCT program SIGROUND (5) has been produced to aid this exercise.
g) Convert all phase control data into stage based format for entry into the Transyt program.
h) Use the Transyt Graphs (Card type 35) to check platoon progression/s and adjust the Transyt run as necessary to achieve:-
   Maximim Capacity
   Satisfactory Progression Trails

Items (b) to (e) above were first advised in the TRL Research Report RR274 , 1990 (3).

Items (a) and (f) to (h) ideology have been developed and significantly refined since 1990, by specialist practicioners, in particular BCC and JCT. Transyt design of signal controlled roundabouts is now taught and demonstrated at both Public and In-House Transyt training courses by Barbara Chard , either for the Barbara Chard Consultancy, BCC (2,3) or for the JCT Consultancy .

2.0 THE HAMILTON ROUNDABOUT

Figure 1 shows the layout of the Hamilton roundabout (*smallest inscribed diameter = 70m, largest inscribed diameter = 85m*). Note that only 3 of the four arms are signal controlled.

Originally all four arms were signal controlled. The roundabout basically did not work! This was dramatically demonstrated one night by bagging the signals at the Keith Rd junction (Arm D).

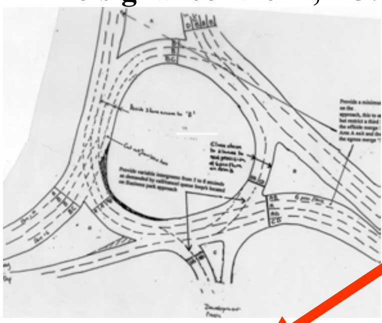
Note: This roundabout forms the northern limit of a linked signal control system that runs through the town centre of Hamilton. When linking roundabouts to associated networks, the authors advise modelling and finding a best solution first of all, just for the roundabout, then optimising the rest of the network around the already optimised roundabout.

Factors to Consider in Design:-

Consider not signalling an approach arm where:-

- The entry flow is low and there is sufficient stacking room for gap takers at the next stopline in the gyratory
- To avoid a three stage junction within the gyratory
- An upstream platoon exiting at the previous arm provides a natural 'gap'

To signal control 1, 2 3…. Or all Arms?

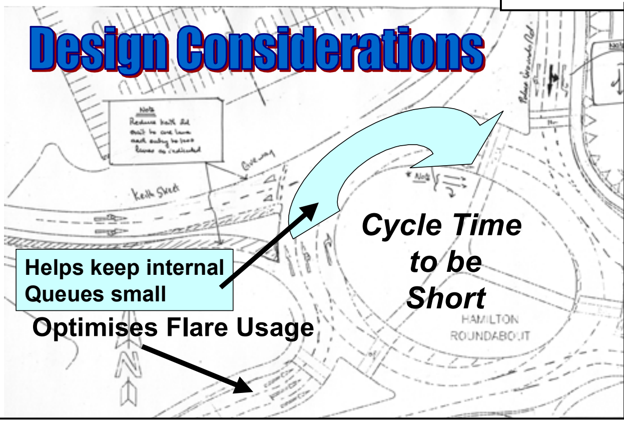


Some Guidance:

Low entry flow and sufficient stacking room ...

Avoid Three Stage Control at any entry

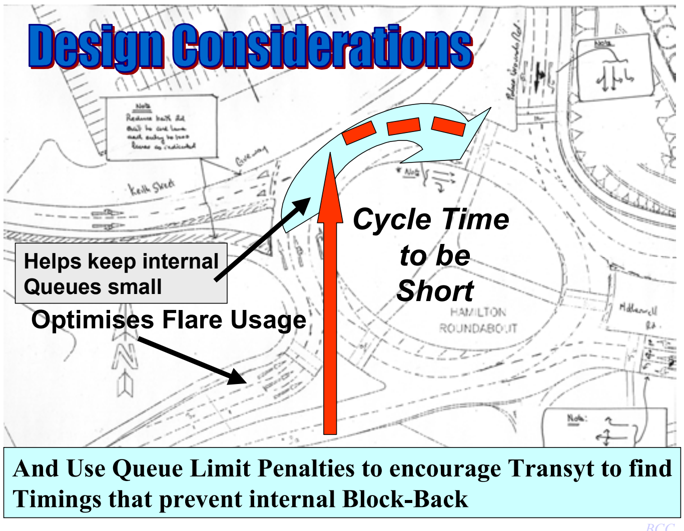
Did you know that most signal controlled roundabouts work best at Cycle Times of 60 seconds or less seconds. Many operating at higher cycle times are not at their most efficient and are the result of allowing Scoot to operate them in the peaks without cycle time length constraint



Degree of Saturation

Typical Degrees of Saturation for links in signal controlled gyratories are:-

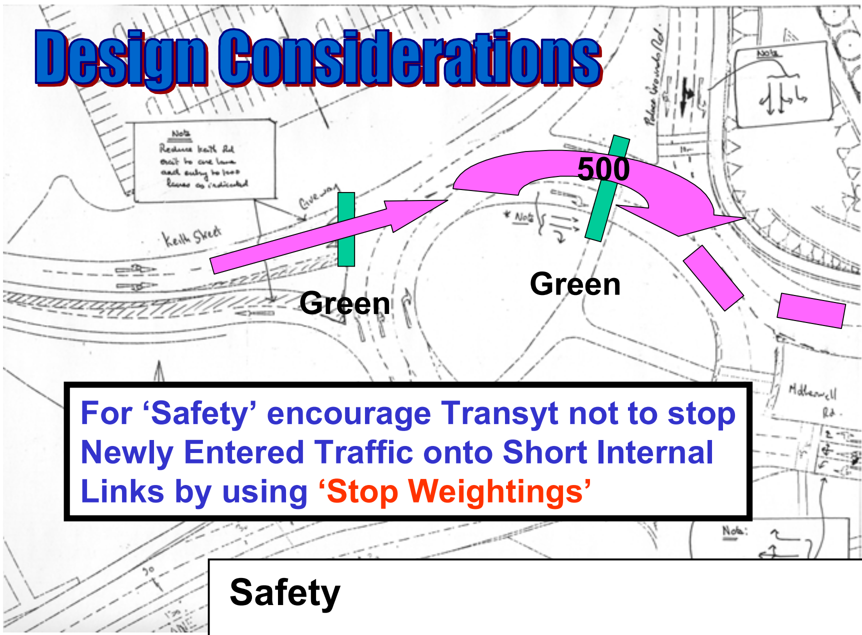
- **Approach links (Up to 95%) saturated**
- **Gyratory links (60 - 85%) saturated**



Blocking Back

When modelling signal controlled gyratories it is important to ensure that any spare capacity is given to the circulating links rather than the approach links. This is achieved by a combination of applying low delay and zero stop weightings on the approach links and queue limit penalties on the circulating links.

Figure 2

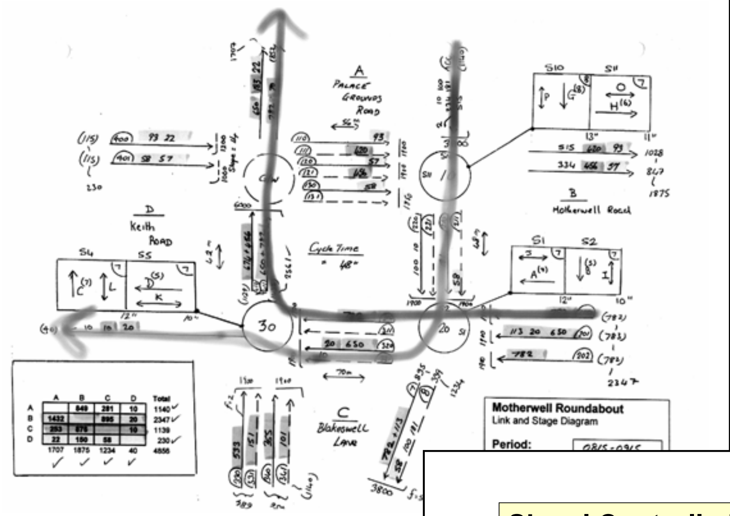


Safety

You need to dissuade the optimiser from stopping newly entered traffic onto short gyratory links. To do this:-

a) Model newly entered traffic using a separate link; and
b) Apply a stop weighting of say 500 on this link.

This will oblige the optimiser to try and find timings that permit this traffic to flow relatively uninterrupted into the gyratory and immediately through the next stopline on green



Checking Co-ordination

Remember to request Transyt Graphs to Check Progression around the roundabout is satisfactory / safe!

Signal Controlled Roundabouts Using Transyt

DESIGN CHECKLIST

- **Cycle Time needs to be short**
- **Need to Prepare and Work from a Lane Flow Diagram**
- **Need to use Shared Links**
- **Need to use Queue Limit Penalties on Internal Links**
- **Need to use -9999 (stop) 20% (Delay) on Approach Links**
- **Apply 500 stop weighting to links carrying newly entered traffic**
- **Need to Check Progression**
- **Need to ‘fine tune’ following implementation**

Figure 3

2.1 Traditional Signal Controlled Roundabout Design

The Saturday peak period follows traditional design methodology. The origin-destination matrix for this period is:-

	A	B	C	D	Total
A		1019	621	21	1661
B	1100		547	192	1839
C	342	510		18	870
D	72	153	81		306
	1514	1682	1249	231	4676

The design solution is summarised in Figure 4. The relevant Lane Flow, Link and Stage diagrams, and Transyt Files are given in **Appendix A**.

Figure 4A presents the initial Transyt run, and Figure 4B the fine tuning and adjustment subsequently made on site. Note that newly entered traffic from Palace Grounds Road (Arm A) and from Motherwell Road (Arm B) is not stopped.

2.2 Weekday PM Peak - Breaking the Rules!

The Weekday peak period posed an interesting problem. The origin destination matrix is as follows:-

	A	B	C	D	Total
A		2079	600	10	2689
B	819		1059	18	1896
C	274	501		10	785
D	62	189	100		351
	1155	2769	1759	38	5721

Note the massive increase in the left-turn movement from the north *(Arm A, movement A to B*).

This large movement is not matched anywhere else in the roundabout. Accordingly, progression imbalance is inevitable. Moreover, a considerably larger cycle time is wanted at this junction over that necessary at the other two junctions.

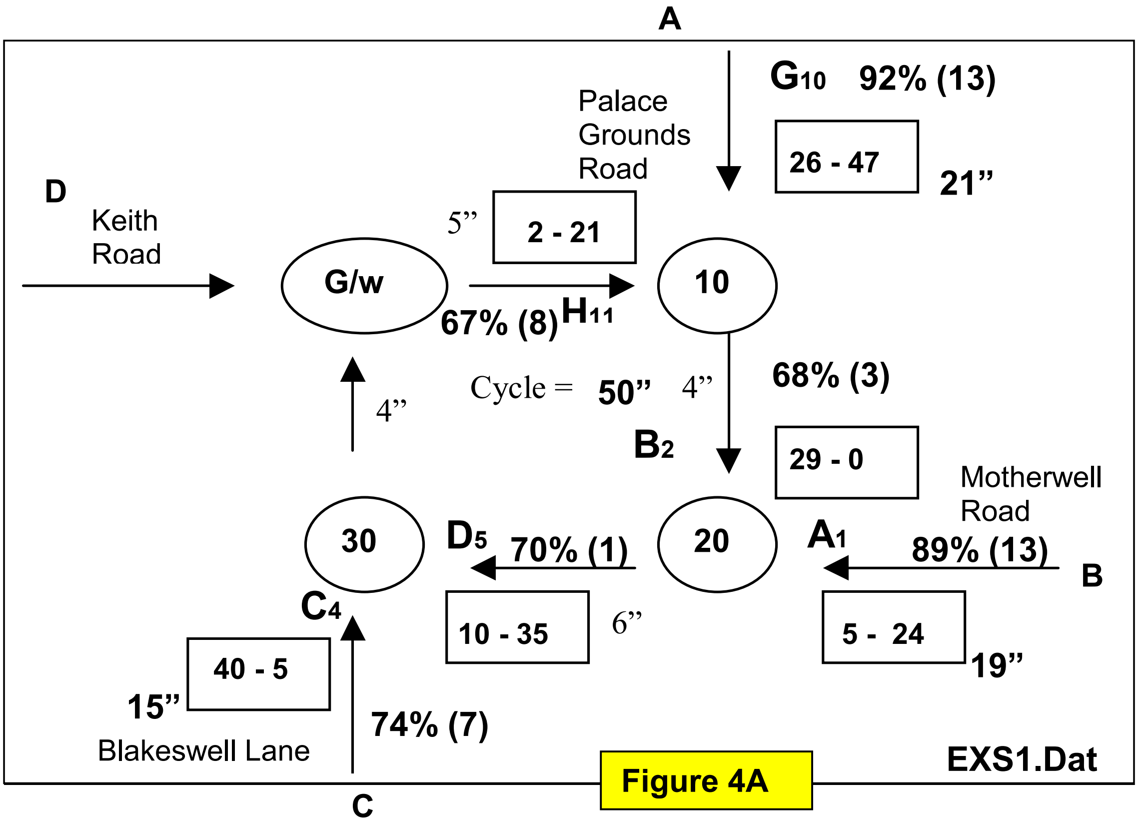


Figure 4A

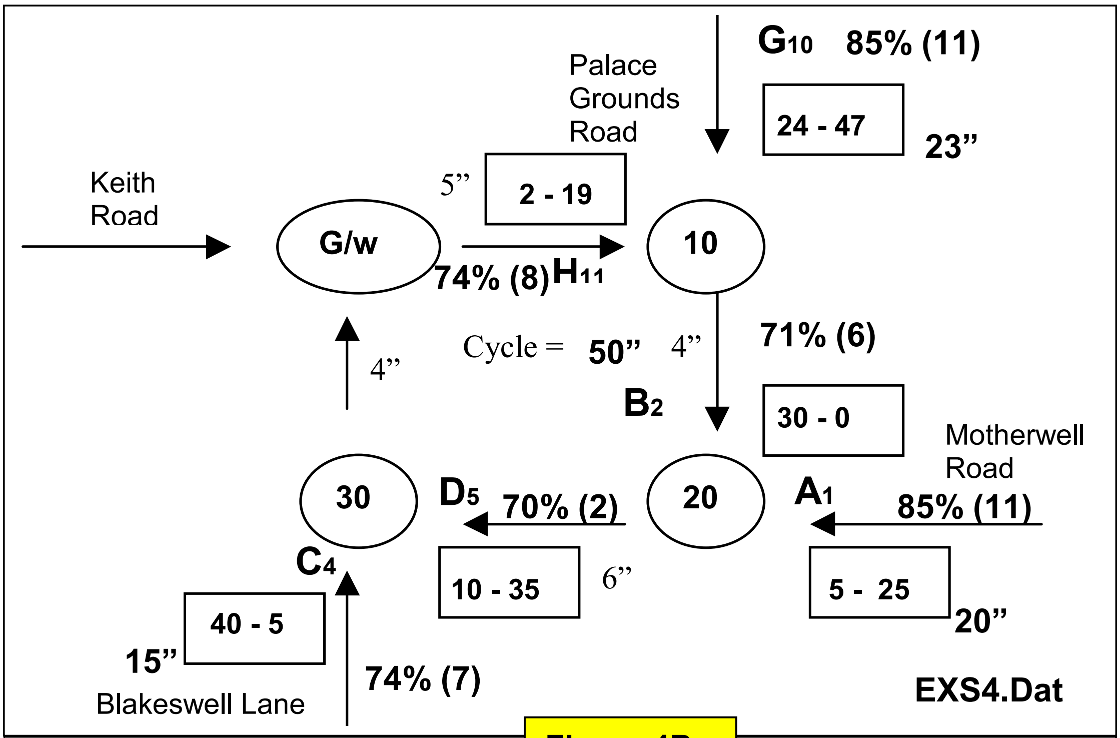
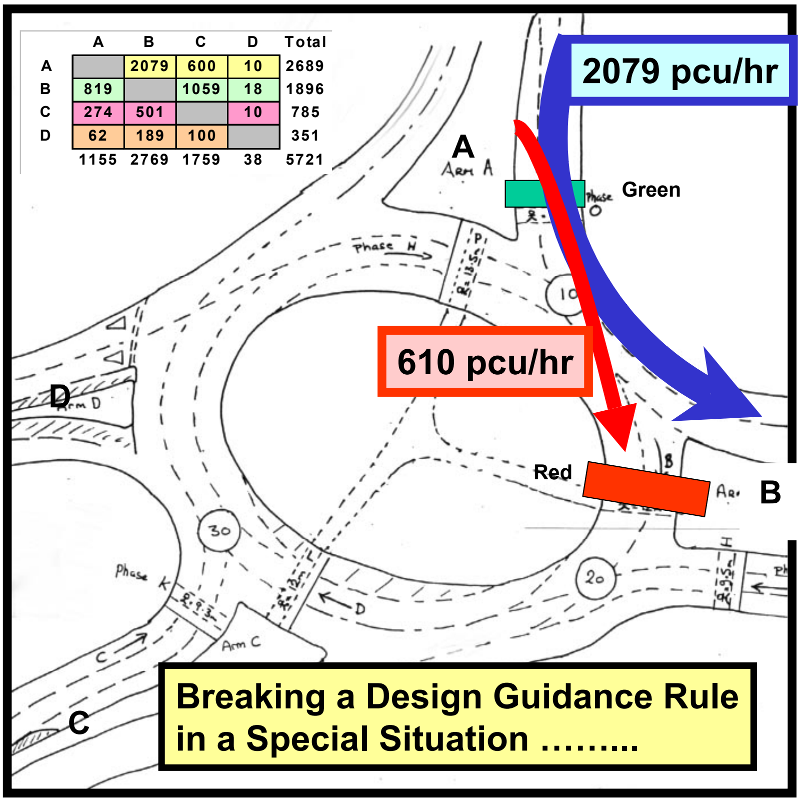
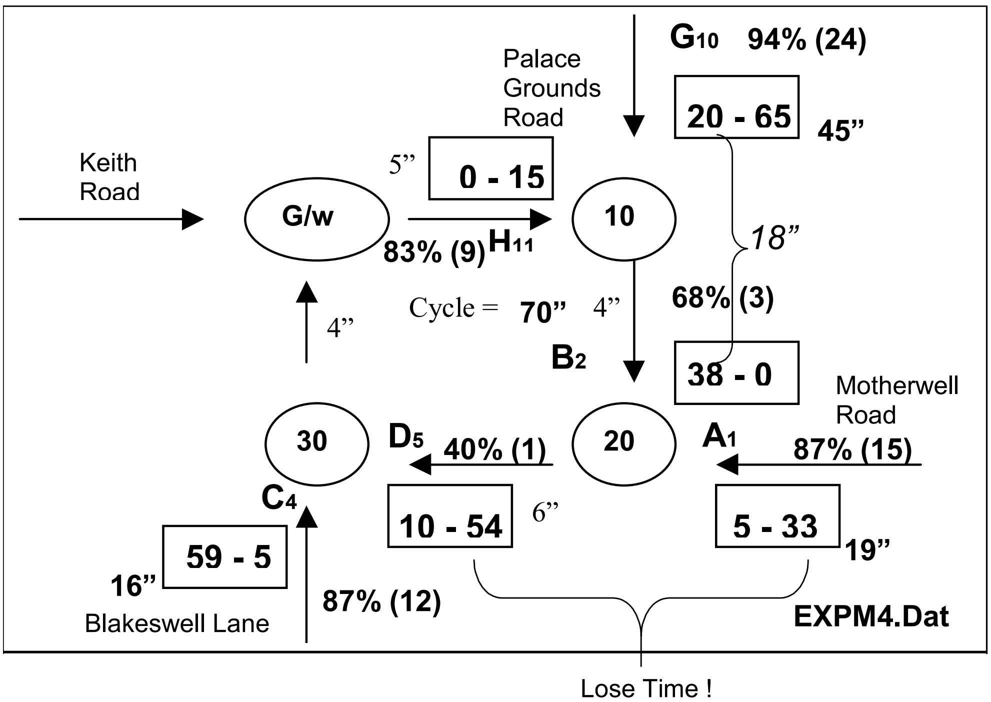


Figure 4B

Figure 4 Traditional Signal Controlled Design

An operational solution was found by breaking rule (d) in section 1, i.e. by allowing the newly entering traffic (A – C and A – D) to proceed onto a red light at the first stopline. Only in this way could the necessary large green time be given to approach A. The optimum timings are summarised below:-



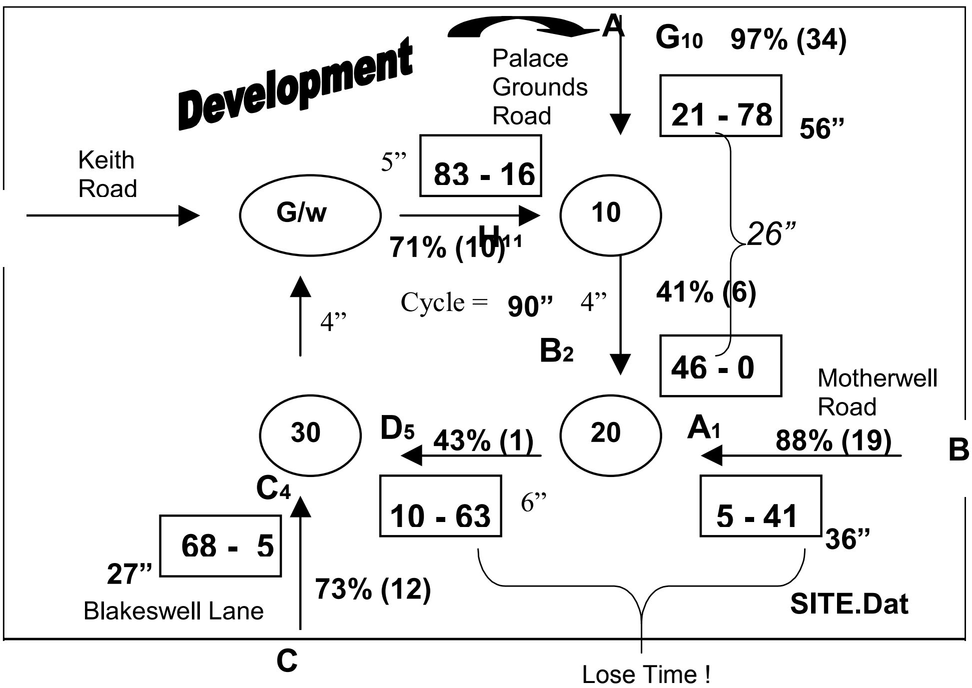


The relevant Lane Flow , Link and Stage diagrams, and Transyt Files for file EXPM4 are given in Appendix B.

Currently, the weekday pm peak period runs a whole town centre plan at 90" cycle. Thus currently on site, this roundabout is 'breaking another guidance rule' by running at a higher than recommended, cycle time. These timings are illustrated below and in Appendix B. Although the previously massive queues on the northern approach are now much reduced, the 90" cycle Plan is exceedingly 'uncomfortable and untidy' to view. Moreover, the wait on red for newly entered straight-ahead traffic from Arm A is uncomfortably long and poor queuing behaviour and lane usage from approach A leads to a lower than expected sat flow from this approach until the straight-ahead gyratory stopline goes green.

However, that said, drivers have adapted very quickly to the unusual progression pattern in the pm peak period and appear unconcerned that this pattern is markedly different from the much more traditional pattern present during other periods in the day.

Due to new development traffic expected shortly, the linking of this roundabout with the rest of the network may be abandoned in the weekday peak period and the 90" plan replaced with the 70" weekday pm plan presented above (EXPM4.dat). This will be aimed at achieving 'sweeter progression' for the B to A movement.



IN SUMMARY

The current guidelines for designing signal controlled roundabouts are generally sound. However, a situation can arise where due to a large imbalance in the origin-destination flows, innovative operational techniques may need to be explored and trailed if gross over-capacity on one approach is to be avoided. The authors have presented one such example in this paper. To date, the unusual progression pattern in the weekday pm peak period has not presented any safety problems. Please note that all innovative and/or unusual applications of signal control need to be monitored closely and/or adjusted in the first few weeks after implementation.

References

1. **Basic Transyt Training** - Comprehensive Design Guidence Notes for Beginners attending a BCC or JCT Transyt/TranEd Training course (2 or 3 day). Contact BCC on 01209 842181 or JCT on 01522 754681.

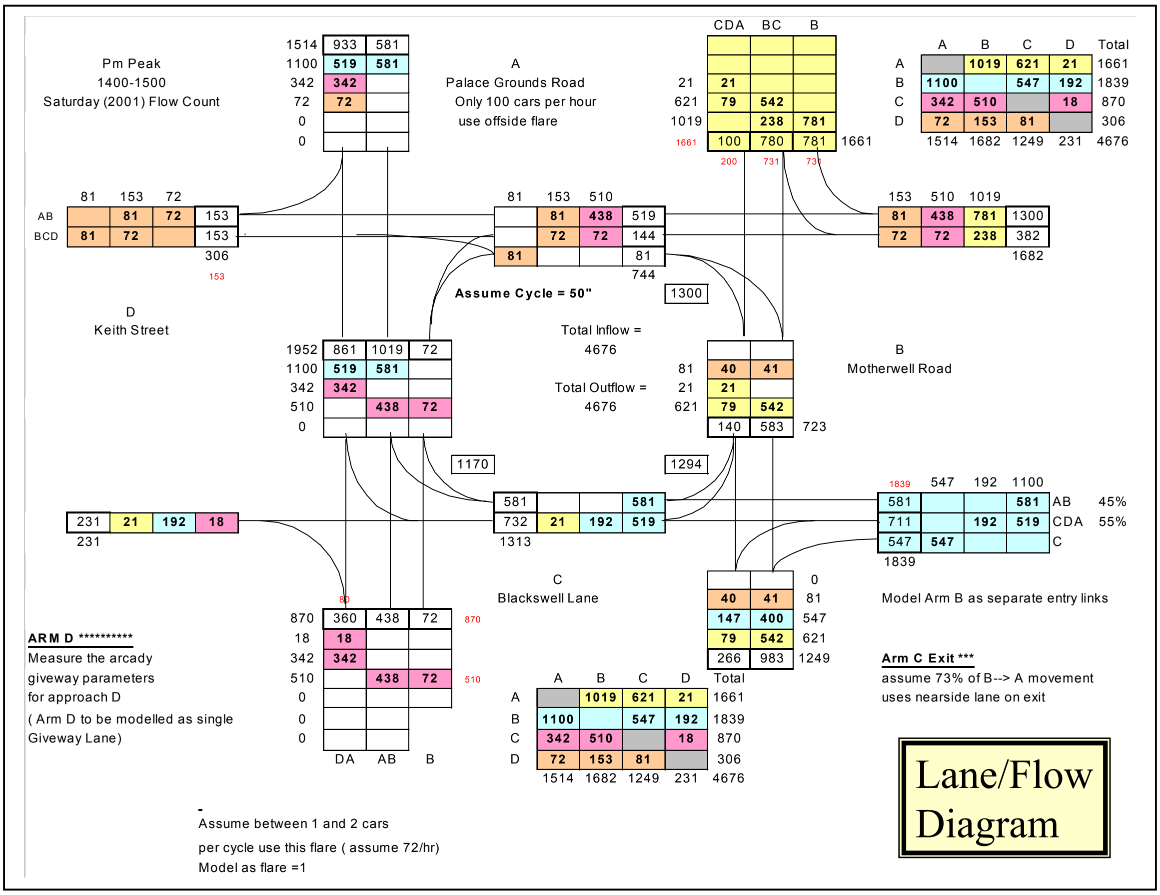
2. **Advanced Transtt Training** Comprehensive step-by-step guidance for building Lane/Flow Diagrams, Lane Flow balancing, assembly of correct Link structure diagrams, platoon assignment, and running and interpreting Transyt for two signal controlled roundabouts is presented. Other advanced features, including Phase to Stage data conversion and translation of Transyt output data to CLF plan format and are also covered. Comprehensive support notes on the course material are provided as a future reference guide at all BCC or JCT Advanced Transyt Training course/s (2 days). Contact BCC on 01209 842181 or JCT on 01522 754681

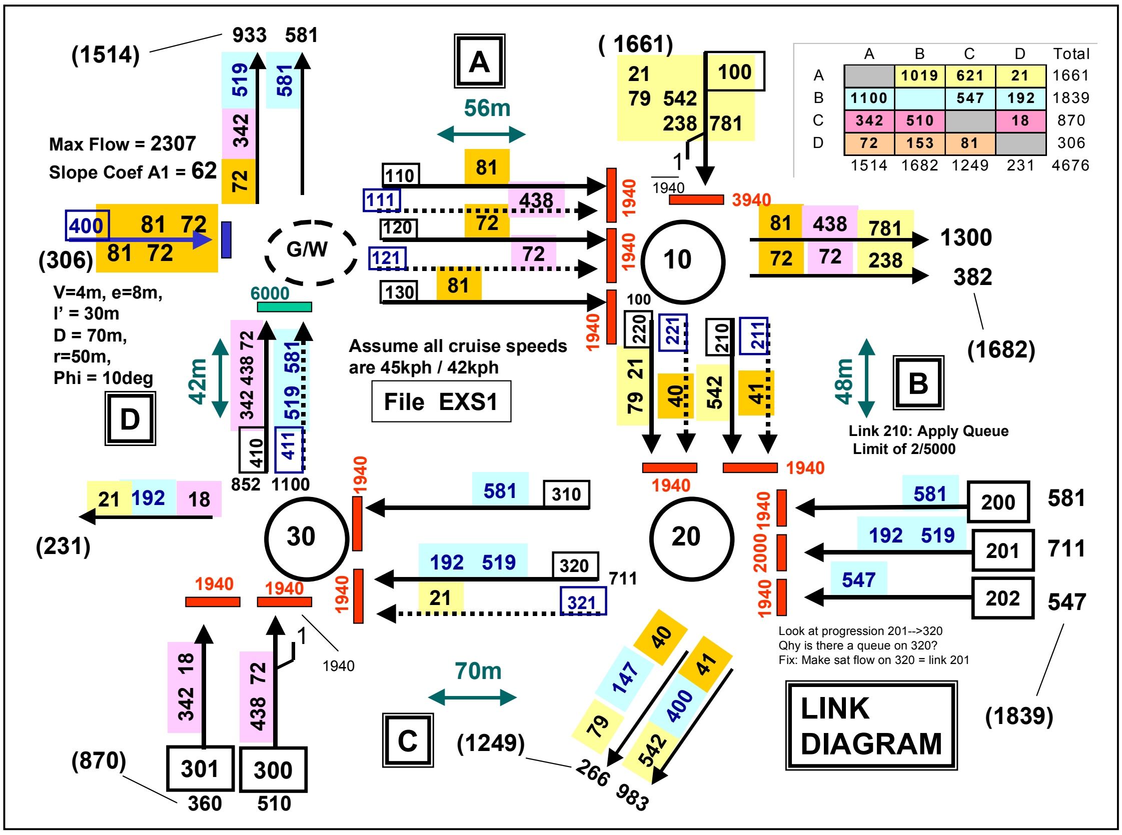
3. **TRL Report RR274** – The Use of Transyt at Signal Controlled Roundabouts by Lines C J and M R Crabtree (1990). Transport and Road Research laboratory , Crowthorne Berkshire Tel 01344 773131.

4. **LINSAT** JCT Flare program available FREE off the Internet. Contact JCT on 01522 754681

5. **SIGROUND** JCT Lane/Flow Program. Contact JCT on 01522 754681.

Appendix A


Pm Peak
1400-1500
Saturday (2001) Flow Count
A
Palace Grounds Road
Only 100 cars per hour
use offside flare
CDA BC B
A B C D Total
A 1019 621 21 1661
B 1100 547 192 1839
C 342 510 18 870
D 72 153 81 306
1514 1682 1249 231 4676
AB
BCD
D
Keith Street
Assume Cycle = 50"
Total Inflow =
4676
Total Outflow =
4676
B
Motherwell Road
AB 45%
CDA 55%
C
C
Blackswell Lane
Model Arm B as separate entry links
ARM D **********
Measure the arcady
giveway parameters
for approach D
(Arm D to be modelled as single
Giveway Lane)
DA AB B
Arm C Exit ***
assume 73% of B--> A movement
uses nearside lane on exit
Assume between 1 and 2 cars
per cycle use this flare (assume 72/hr)
Model as flare =1
Lane/Flow
Diagram


(1514)
933 581
(1661)
A
56m
Max Flow = 2307
Slope Coef A1 = 62
G/W
10
3940
1300
382
(306)
V=4m, e=8m,
l' = 30m
D = 70m,
r=50m,
Phi = 10deg
D
42m
Assume all cruise speeds
are 45kph / 42kph
File EXS1
(1682)
48m
B
Link 210: Apply Queue
Limit of 2/5000
(231)
30
20
581
711
547
70m
C
(1249)
Look at progression 201-->320
Qhy is there a queue on 320?
Fix: Make sat flow on 320 = link 201
LINK
DIAGRAM
(1839)
(870)
301 300
360 510

```
File EXS1:  Saturday Peak, Motherwell Roundabout
  1   50   50   60    2    3    1    1    0    0    1    2    0    0 1290  235
  2   10   20   30
  7  110  111
  7  120  121
  7  210  211
  7  220  221
  7  320  321
  7  410  411
 12   10    0   20    0   17
 12   20    0   19    0   16
 12   30    0   19    0   16
 30  400  410    0    0   62    0    0    0    0    0  200    0 2307
 31  100   10    1    5    2    0    0    0    0    0  200-9999 3940   20
 31  110   10    2    5    1    0    0    0    0    0   56    0 1940
 31  111    0    0    0    0    0    0    0    0    0   56
 31  120   10    2    5    1    0    0    0    0    0   56    0 1940
 31  121    0    0    0    0    0    0    0    0    0   56
 31  130   10    2    5    1    0    0    0    0    0   56    0 1940
 31  200   20    1    5    2    0    0    0    0    0  200-9999 1940   20
 31  201   20    1    5    2    0    0    0    0    0  200-9999 2000   20
 31  202   20    1    5    2    0    0    0    0    0  200-9999 1940   20
 31  210   20    2    5    1    0    0    0    0    0   48    0 1940
 31  211    0    0    0    0    0    0    0    0    0   48
 31  220   20    2    5    1    0    0    0    0    0   48    0 1940
 31  221    0    0    0    0    0    0    0    0    0   48
 31  300   30    1    5    2    0    0    0    0    0  200-9999 1940   20
 31  301   30    1    5    2    0    0    0    0    0  200-9999 1940   20
 31  310   30    2    5    1    0    0    0    0    0   70  500 1940
 31  320   30    2    5    1    0    0    0    0    0   70  500 2000
 31  321    0    0    0    0    0    0    0    0    0   70
 31  410    0    0    0    0    0    0    0    0    0   42    0 6000
 31  411    0    0    0    0    0    0    0    0    0   42
 32  100 1661    0    0    0   45
 32  110   81    0  400   81   45
 32  111  438    0  410  438   42
 32  120   72    0  400   72   45
 32  121   72    0  410   72   42
 32  130   81    0  400   81   45
 32  200  581    0    0    0   45
 32  201  711    0    0    0   45
 32  202  547    0    0    0   45
 32  210  542    0  100  542   45
 32  211   41    0  130   41   42
 32  220  100    0  100  100   45
 32  221   40    0  130   40   42
 32  300  510    0    0    0   45
 32  301  360    0    0    0   45
 32  310  581    0  200  581   45
 32  320  711    0  201  711   45
 32  321   21    0  220   21   42
 32  400  306    0    0    0   45
 32  410  852    0  301  342   45  300  510   45
 32  411 1100    0  310  581   42  320  519   42
 33  100 1940    1
 33  300 1940    1
 35  100  200  210  310  300    0  111
 38  210    2 5000
```

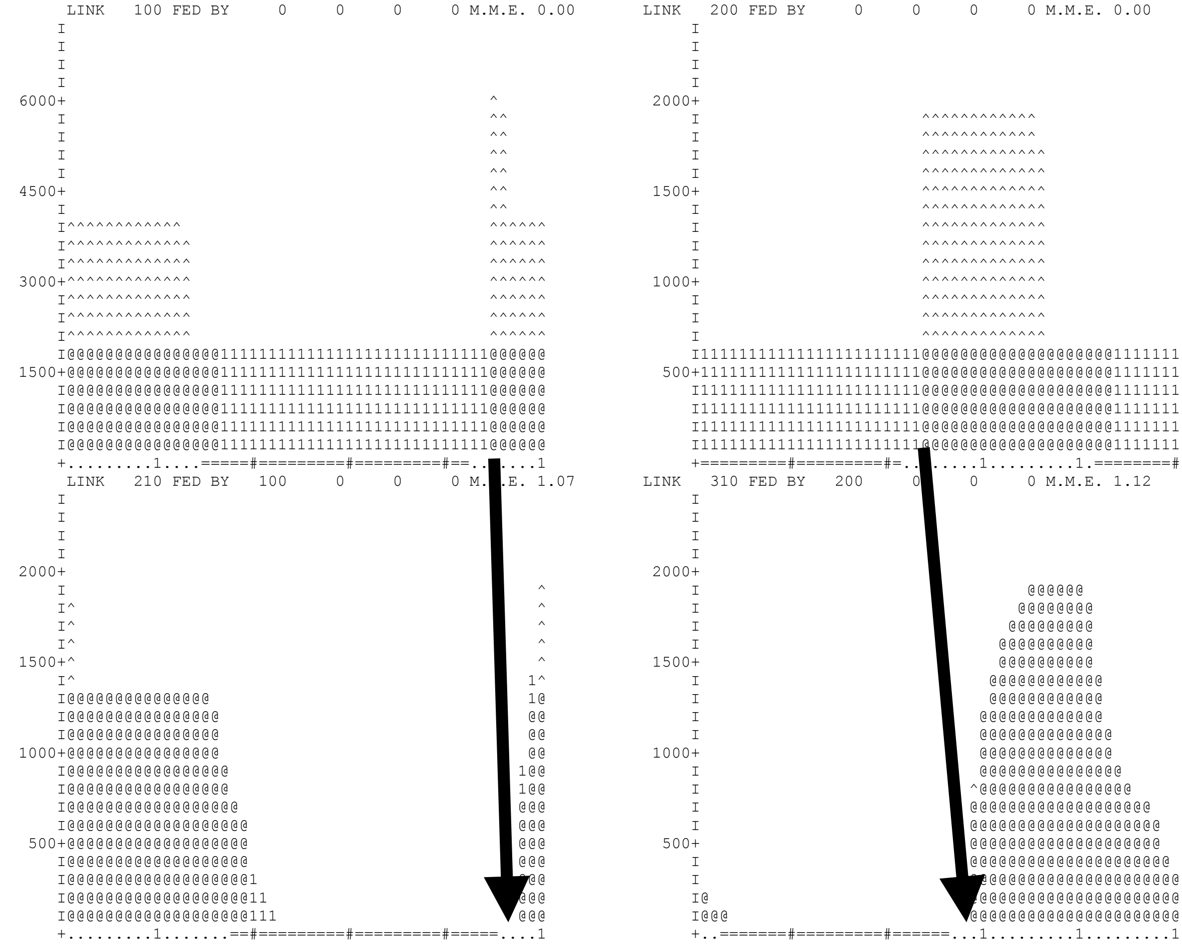
Zero on call Stage 1

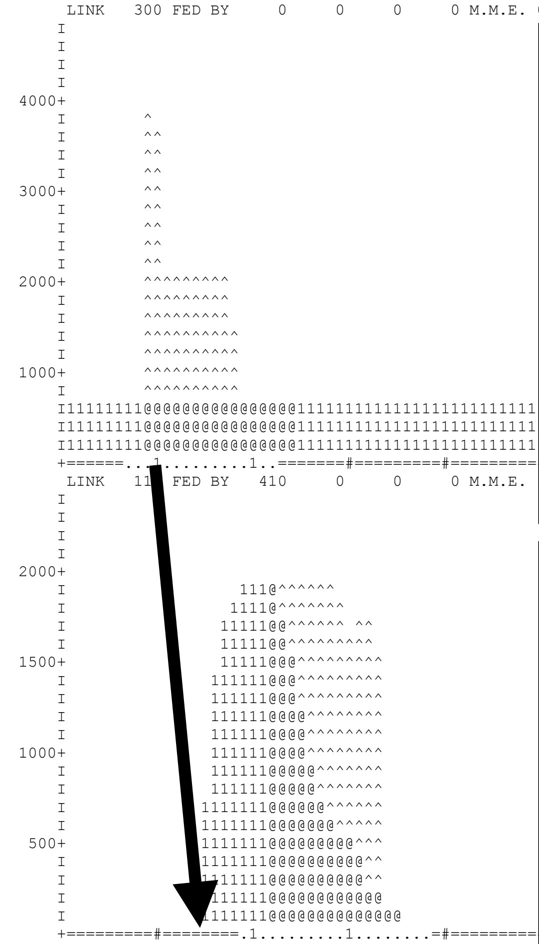
Saturday Peak

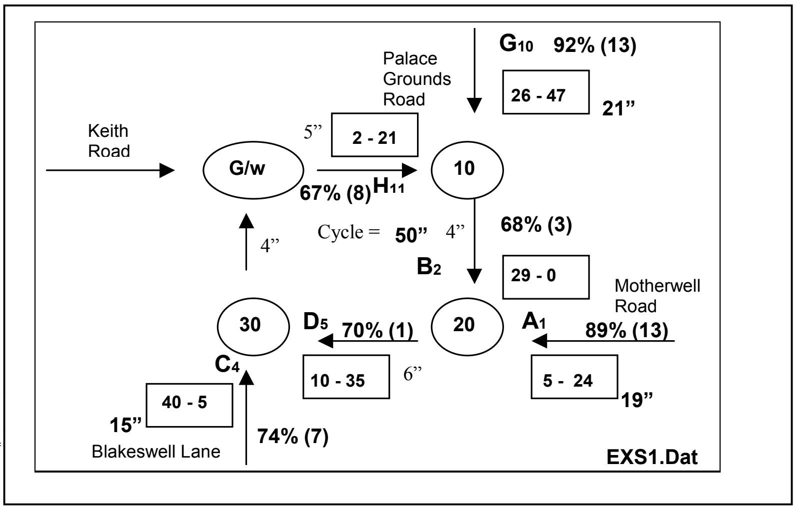
Node	C1	C2
10	21	47
20	0	24
20	35	5

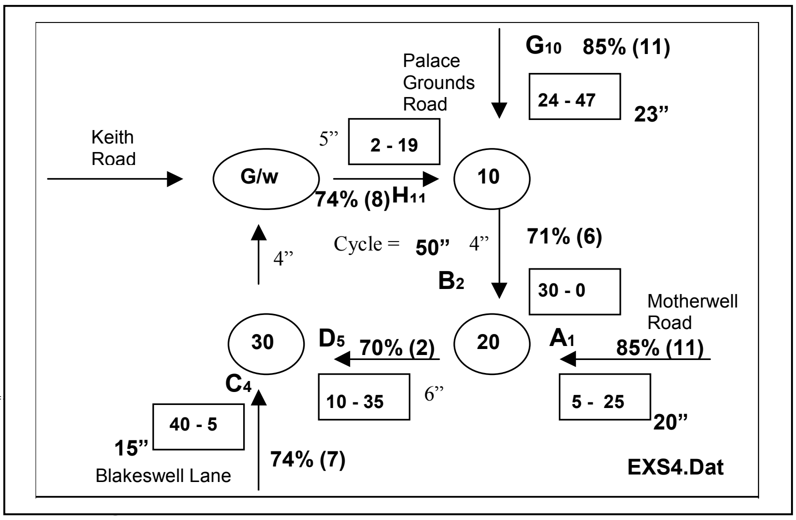
```
1Program TRANSYT     File EXS1:  Saturday Peak, Motherwell Roundabout                              Page  12
0     50 SECOND CYCLE  50 STEPS
0FINAL SETTINGS OBTAINED WITH INCREMENTS :-     7  20  -1    7  20    1  -1    1
  - (SECONDS)
0  NODE    NUMBER   STAGE    STAGE    STAGE    STAGE    STAGE   STAGE    STAGE
    NO    OF STAGES   1        2        3        4        5       6        7

    10        2      37       13
    20        2      16       40
    30        2       1       21
0 LINK    FLOW    SAT   DEGREE  MEAN TIMES  -------DELAY--------   ----STOPS----   ----QUEUE----  PERFORMANCE  EXIT   GREEN TIMES
 NUMBER   INTO   FLOW     OF     PER PCU    UNIFORM RANDOM+ COST   MEAN    COST    MEAN           INDEX.      NODE   START  START
          LINK            SAT   CRUISE              OVERSAT  OF    STOPS    OF     MAX.  AVERAGE  WEIGHTED SUM              END     END
                                      DELAY  (U+R+O=MEAN Q) DELAY  /PCU    STOPS         EXCESS   OF ( ) VALUES             1ST     2ND
       (PCU/H)  (PCU/H)  (%)   (SEC)  (SEC)    (PCU-H/H)    ($/H)   (%)    ($/H)   (PCU)  (PCU)     ($/H)                 (SECONDS)

   100    1661   4103f    92    16     24    5.9 +  5.3   (144.9)*   104  ( 44.2)     27             29.0        10     42  13
   110      81   1940S    67     4     17    0.2 +  0.2   (  5.1)     86  (  1.8)      8              6.8        10     18  37
   111     438    110L    67     5     12    0.7 +  0.8   ( 19.5)     90  (  8.8)      8             28.3        10     18  37
   120      72   1940S    19     4     12    0.2 +  0.1   (  3.0)     54  (  1.0)      1              4.0        10     18  37
   121      72    120L    19     5      5    0.0 +  0.1   (  1.2)     40  (  0.6)      1              1.8        10     18  37
   130      81   1940     10     4     11    0.2 +  0.1   (  3.3)     53  (  1.1)      1              4.4        10     18  37
   200     581   1940     75    16     22    2.1 +  1.5   ( 45.7)*    94  ( 13.9)      8              9.1        20     21  40
   201     711   2000     89    16     33    2.8 +  3.7   ( 83.2)*   117  ( 21.3)     13             16.6        20     21  40
   202     547   1940     70    16     20    1.9 +  1.2   ( 39.8)*    89  ( 12.5)      7              8.0        20     21  40
   210     541   1940S    68     4      7    0.1 +  1.0   ( 14.2)     19  (  2.6)      3   ( 0.0)*   18.2        20     45  16
   211      41    210L    68     4     26    0.2 +  0.1   (  3.8)    110  (  1.0)      3      +       4.8        20     45  16
   220     100   1940S    16     4      3    0.0 +  0.1   (  1.1)      9  (  0.2)      1              1.4        20     45  16
   221      40    220L    16     4     21    0.2 +  0.0   (  3.0)    102  (  0.9)      1              4.0        20     45  16
   300     510   2165f    74    16     24    2.0 +  1.4   ( 43.8)*    97  ( 12.6)      7              8.8        30      6  21
   301     360   1940     58    16     21    1.4 +  0.7   ( 27.2)*    89  (  8.1)      5              5.4        30      6  21
   310     581   1940     58     6      4    0.0 +  0.7   (  8.9)      8  (  1.3)      1             15.1        30     26   1
   320     711   2000S    70     6      6    0.0 +  1.1   ( 15.0)     12  (  2.1)      1             25.5        30     26   1
   321      21    320L    70     6     19    0.1 +  0.0   (  1.4)     99  (  0.5)      1              1.9        30     26   1
   400     306   2307     27    16      3    0.1 +  0.2   (  3.4)     25  (  1.9)      1              5.3
   410     852   6000S    33     3      0    0.0 +  0.1   (  1.4)      1  (  0.2)      0              1.6
   411    1100    410L    33     4      0    0.0 +  0.1   (  1.8)      1  (  0.2)      0              2.0
                  *** f - average saturation flow for flared link ***
0  TOTAL           TOTAL       MEAN          TOTAL     TOTAL    TOTAL        TOTAL        PENALTY       TOTAL
 DISTANCE          TIME       JOURNEY       UNIFORM   RANDOM+   COST         COST          FOR       PERFORMANCE
 TRAVELLED         SPENT       SPEED         DELAY    OVERSAT    OF           OF          EXCESS       INDEX
                                                       DELAY    DELAY        STOPS        QUEUES
  (PCU-KM/H)      (PCU-H/H)    (KM/H)     (PCU-H/H) (PCU-H/H)   ($/H)        ($/H)        ($/H)         ($/H)
0  1185.5           63.0        18.8          18.1      18.4    ( 163.0) + (   37.7)  +  (    1.4)   =    202.0      TOTALS
```


Saturday Peak

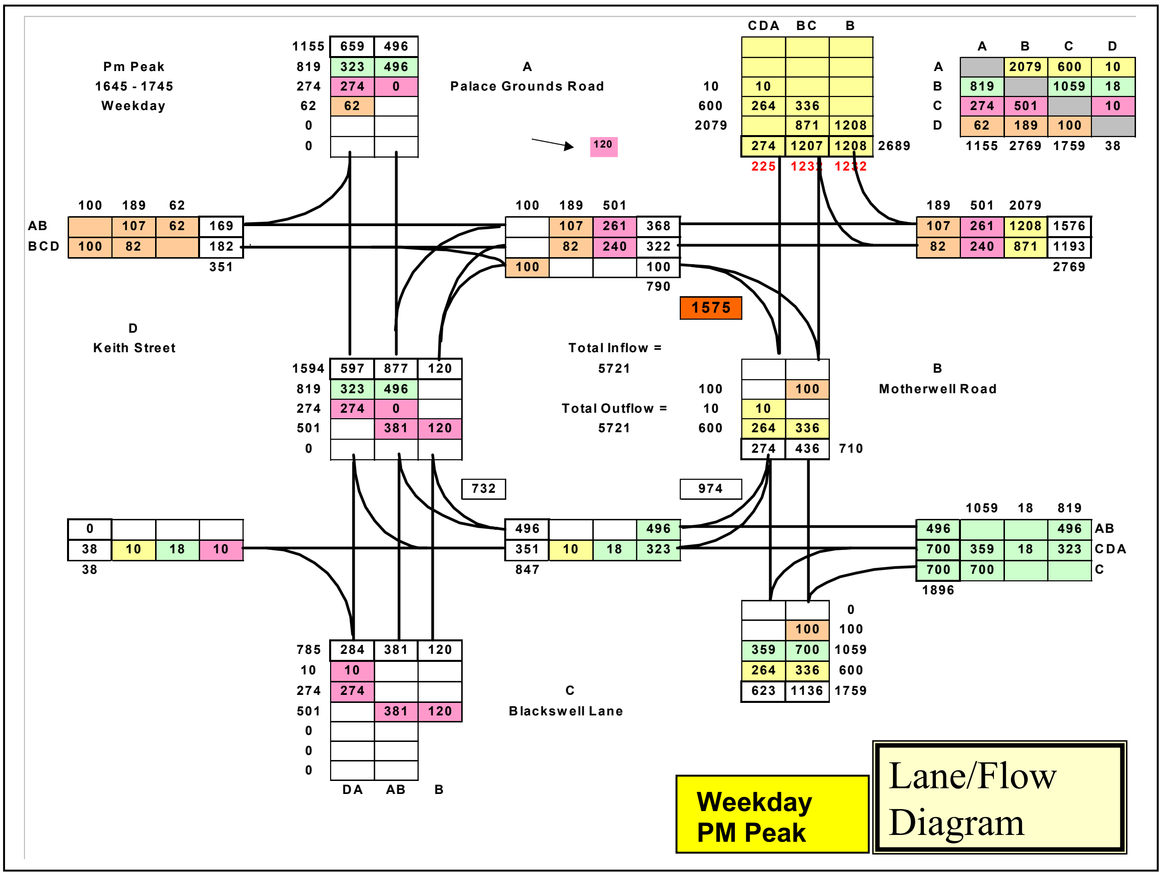

LINK 100 FED BY 0 0 0 0 M.M.E. 0.00
LINK 200 FED BY 0 0 0 0 M.M.E. 0.00
LINK 210 FED BY 100 0 0 0 M.M.E. 1.07
LINK 310 FED BY 200 0 0 0 M.M.E. 1.12


LINK 300 FED BY 0 0 0 0 M.M.E. 0.00
LINK 110 FED BY 410 0 0 0 M.M.E.

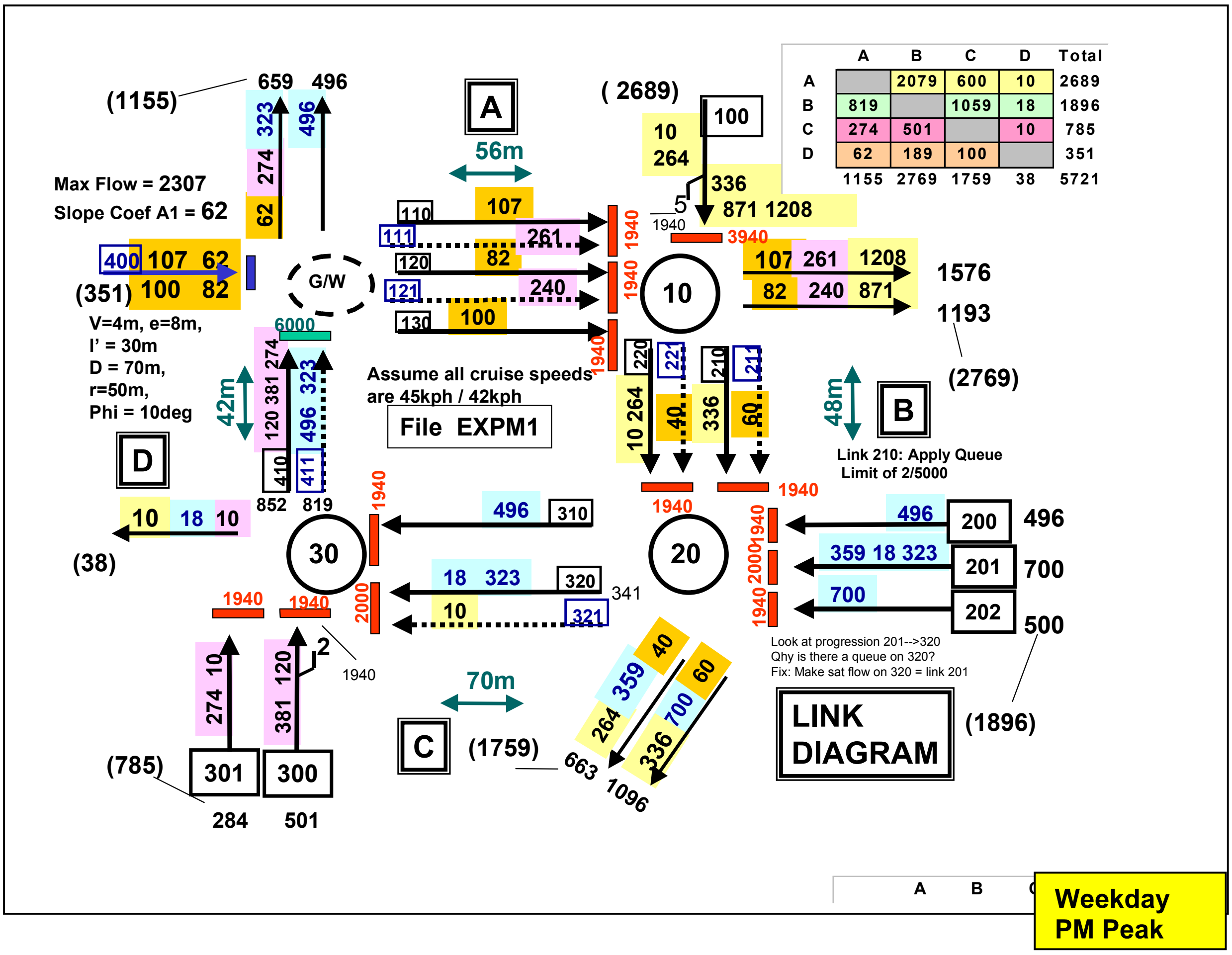

G10 92% (13)
Palace Grounds Road
26 - 47
21”
Keith Road
5”
2 - 21
G/w
10
67% (8) H11
Cycle = 50”
4”
68% (3)
4”
B2
29 - 0
Motherwell Road
30
D5 70% (1)
20
A1 89% (13)
C4
10 - 35
6”
5 - 24
19”
40 - 5
15”
Blakeswell Lane
74% (7)
EXS1.Dat


G10 85% (11)
Palace Grounds Road
24 - 47
23”
Keith Road
5”
2 - 19
G/w
10
74% (8) H11
Cycle = 50”
4”
71% (6)
4”
B2
30 - 0
Motherwell Road
30
D5 70% (2)
20
A1 85% (11)
C4
10 - 35
6”
5 - 25
20”
40 - 5
15”
Blakeswell Lane
74% (7)
EXS4.Dat

Appendix B



Pm Peak
1645 - 1745
Weekday
A
Palace Grounds Road
D
Keith Street
B
Motherwell Road
C
Blackswell Lane
Total Inflow =
5721
Total Outflow =
5721
Weekday
PM Peak
Lane/Flow
Diagram



Max Flow = 2307
Slope Coef A1 = 62
V=4m, e=8m,
l' = 30m
D = 70m,
r=50m,
Phi = 10deg
Assume all cruise speeds
are 45kph / 42kph
File EXPM1
Link 210: Apply Queue
Limit of 2/5000
Look at progression 201-->320
Qhy is there a queue on 320?
Fix: Make sat flow on 320 = link 201
LINK
DIAGRAM
Weekday
PM Peak

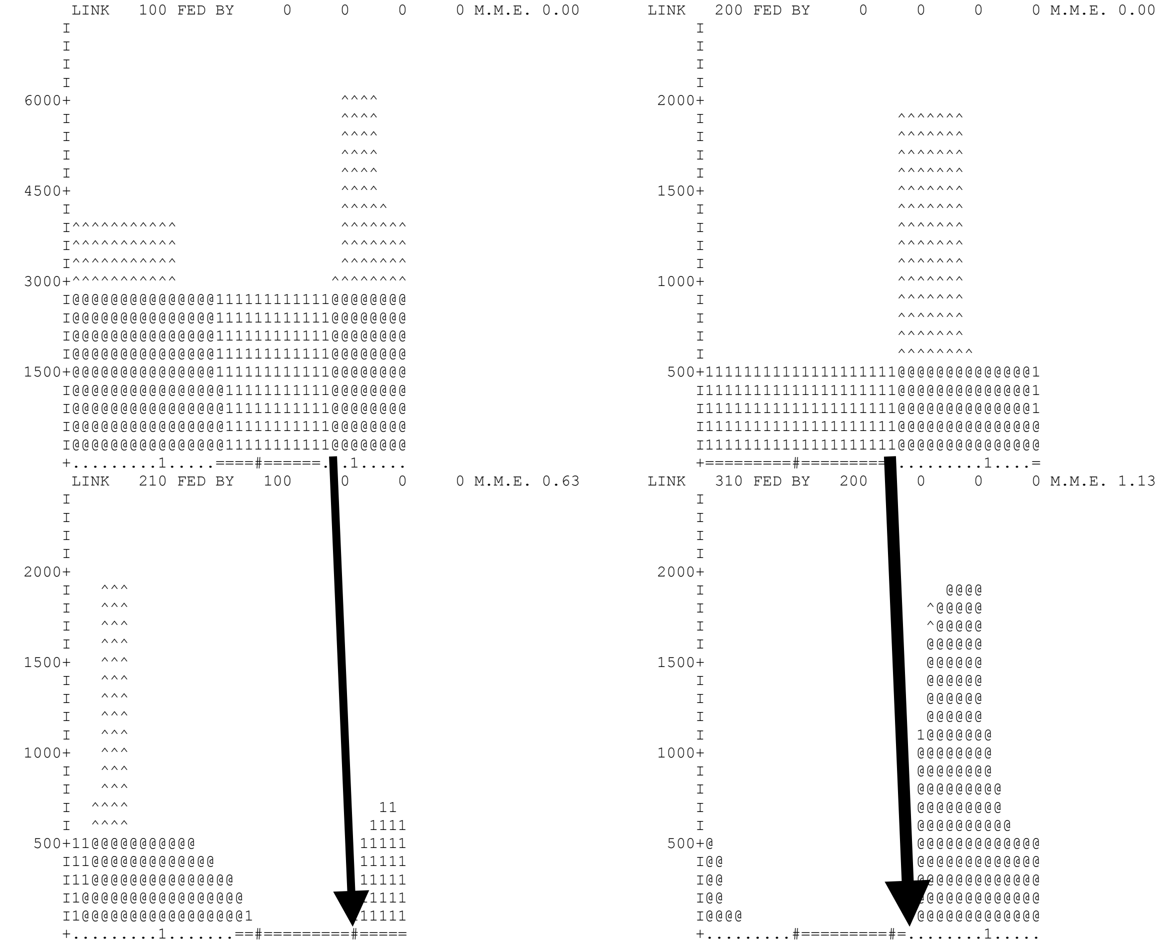
File EXPM4: Weekday Peak, Motherwell Roundabout

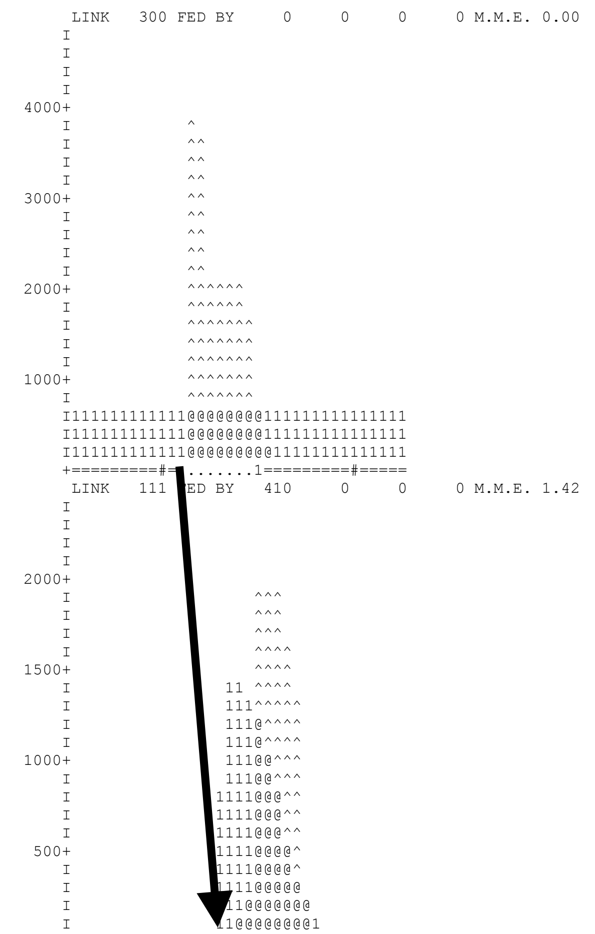
```
    1   70   35   60    2    3    1    1    0    0    1    2    0    0 1290  235
    2   10   20   30
    7  110  111
    7  120  121
    7  210  211
    7  220  221
    7  320  321
    7  410  411
   12   10    0   20    0   17
   12   20    0   19    0   16
   12   30    0   19    0   16
   30  400  410    0    0   62    0    0    0    0    0  200    0 2307
   31  100   10    1    5    2    0    0    0    0    0  200-9999 3940   80
   31  110   10    2    5    1    0    0    0    0    0   56    0 1940
   31  111    0    0    0    0    0    0    0    0    0   56  290
   31  120   10    2    5    1    0    0    0    0    0   56    0 1940
   31  121    0    0    0    0    0    0    0    0    0   56  290
   31  130   10    2    5    1    0    0    0    0    0   56    0 1940
   31  200   20    1    5    2    0    0    0    0    0  200-9999 1940   20
   31  201   20    1    5    2    0    0    0    0    0  200-9999 2000   20
   31  202   20    1    5    2    0    0    0    0    0  200-9999 1940   20
   31  210   20    2    5    1    0    0    0    0    0   48  100 1940
   31  211    0    0    0    0    0    0    0    0    0   48
   31  220   20    2    5    1    0    0    0    0    0   48  100 1940
   31  221    0    0    0    0    0    0    0    0    0   48
   31  300   30    1    5    2    0    0    0    0    0  200-9999 1940   20
   31  301   30    1    5    2    0    0    0    0    0  200-9999 1940   20
   31  310   30    2    5    1    0    0    0    0    0   70 2000 1940
   31  320   30    2    5    1    0    0    0    0    0   70 2000 2000
   31  321    0    0    0    0    0    0    0    0    0   70
   31  410    0    0    0    0    0    0    0    0    0   42    0 6000
   31  411    0    0    0    0    0    0    0    0    0   42
   32  100 2689    0    0    0   45
   32  110  107    0  400  107   45
   32  111  261    0  410  261   42
   32  120   82    0  400   82   45
   32  121  240    0  410  240   42
   32  130  100    0  400  100   45
   32  200  496    0    0    0   45
   32  201  700    0    0    0   45
   32  202  700    0    0    0   45
   32  210  336    0  100  336   45
   32  211   60    0  130   60   42
   32  220  274    0  100  274   45
   32  221   40    0  130   40   42
   32  300  501    0    0    0   45
   32  301  284    0    0    0   45
   32  310  496    0  200  496   45
   32  320  341    0  201  341   45
   32  321   10    0  220   10   42
   32  400  351    0    0    0   45
   32  410  775    0  301  274   45  300  501   45
   32  411  819    0  310  496   42  320  323   42
   33  100 1940    5
   33  300 1940    2
   35  100  200  210  310  300    0  111
   38  210    2 5000
```

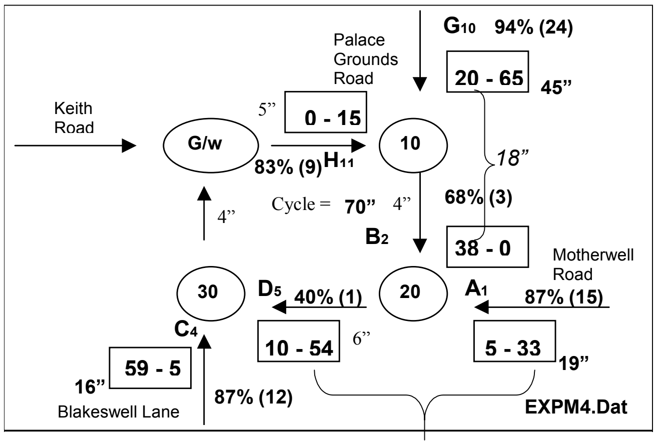
Zero on call Stage 1 at node 20:-

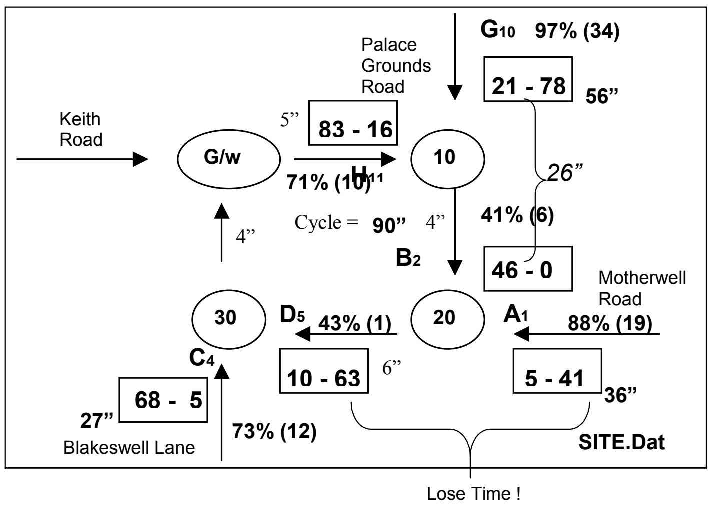
Node	C1	C2
10	15	65
20	0	33
20	54	5

```
1Program TRANSYT     File EXPM4:  Weekday Peak, Motherwell Roundabout                       Page  12
0      70 SECOND CYCLE  35 STEPS
0FINAL SETTINGS OBTAINED WITH INCREMENTS :-    10  28  -1  10  28   1  -1   1
  - (SECONDS)
0  NODE    NUMBER    STAGE    STAGE    STAGE    STAGE    STAGE   STAGE    STAGE
    NO    OF STAGES    1        2        3        4        5       6        7

    10        2       48       28
    20        2       33       66
    30        2       17       38
0 LINK     FLOW    SAT   DEGREE   MEAN TIMES  -------DELAY--------   ----STOPS----   ----QUEUE----   PERFORMANCE   EXIT    GREEN TIMES
 NUMBER    INTO    FLOW    OF      PER PCU    UNIFORM RANDOM+ COST     MEAN    COST    MEAN             INDEX.      NODE    START  START
           LINK           SAT    CRUISE              OVERSAT  OF      STOPS     OF     MAX.  AVERAGE   WEIGHTED SUM            END      END
                                       DELAY  (U+R+O=MEAN Q) DELAY     /PCU    STOPS          EXCESS   OF ( ) VALUES           1ST     2ND
        (PCU/H)  (PCU/H)  (%)   (SEC) (SEC)     (PCU-H/H)     ($/H)     (%)     ($/H)     (PCU)  (PCU)      ($/H)                 (SECONDS)

   100     2689   4331f    94     16     20     6.8 +  7.8  (188.5)*    86   ( 59.3)      53                   150.8      10       53  28
   110      107   1940S    83      4     45     0.7 +  0.7  ( 17.1)    112   (  3.1)       9                    20.1      10       33  48
   111      260    110L    83      5     28     0.4 +  1.6  ( 25.7)    100   (  5.8)       9                    42.5      10       33  48
   120       82   1940S    73      4     37     0.5 +  0.3  ( 10.8)     98   (  2.0)       7                    12.8      10       33  48
   121      240    120L    73      5     19     0.3 +  1.0  ( 16.2)     83   (  4.4)       7                    29.0      10       33  48
   130      100   1940     22      4     27     0.6 +  0.1  (  9.6)     78   (  2.0)       2                    11.6      10       33  48
   200      496   1940     62     16     22     2.2 +  0.8  ( 39.0)*    80   ( 10.1)       8                     7.8      20       38  66
   201      700   2000     84     16     32     3.6 +  2.6  ( 80.1)*   101   ( 18.0)      14                    16.0      20       38  66
   202      700   1940     87     16     35     3.7 +  3.2  ( 88.2)*   106   ( 19.0)      15                    17.6      20       38  66
   210      333   1940S    43      4      9     0.5 +  0.3  ( 10.3)     50   (  4.3)       5   ( 0.4)*          36.7      20        1  33
   211       60    210L    43      4     34     0.5 +  0.1  (  7.2)    105   (  1.4)       5      +              8.6      20        1  33
   220      274   1940S    34      4      8     0.3 +  0.2  (  7.4)     45   (  3.2)       4                    10.6      20        1  33
   221       40    220L    34      4     33     0.3 +  0.0  (  4.7)    104   (  0.9)       4                     5.6      20        1  33
   300      501   2363f    87     16     47     3.4 +  3.2  ( 84.2)*   118   ( 15.1)      12                    16.8      30       22  38
   301      284   1940     60     16     33     1.9 +  0.8  ( 33.7)*    96   (  7.0)       6                     6.7      30       22  38
   310      496   1940     40      6      2     0.0 +  0.3  (  4.3)      4   (  0.5)       1                    14.2      30       43  17
   320      342   2000S    27      6      2     0.0 +  0.2  (  2.4)      3   (  0.2)       0                     7.1      30       43  17
   321       10    320L    27      6      8     0.0 +  0.0  (  0.3)     39   (  0.1)       0                     0.4      30       43  17
   400      351   2307     26     16      3     0.1 +  0.2  (  3.6)     17   (  1.6)       2                     5.1
   410      775   6000S    27      3      0     0.0 +  0.1  (  1.1)      1   (  0.1)       0                     1.2
   411      820    410L    27      4      0     0.0 +  0.1  (  1.2)      1   (  0.1)       0                     1.3
                 *** f - average saturation flow for flared link ***
0  TOTAL           TOTAL       MEAN         TOTAL    TOTAL     TOTAL        TOTAL         PENALTY       TOTAL
  DISTANCE          TIME      JOURNEY      UNIFORM  RANDOM+    COST         COST           FOR       PERFORMANCE
 TRAVELLED         SPENT       SPEED        DELAY   OVERSAT     OF           OF           EXCESS       INDEX
                                                     DELAY     DELAY        STOPS         QUEUES
 (PCU-KM/H)      (PCU-H/H)     (KM/H)     (PCU-H/H)(PCU-H/H)   ($/H)        ($/H)          ($/H)        ($/H)
0  1348.8          79.3        17.0         25.8      23.5    ( 337.6) + (   63.0)  +  (  22.1)   =     422.7      TOTALS
```


LINK 100 FED BY 0 0 0 0 M.M.E. 0.00
LINK 200 FED BY 0 0 0 0 M.M.E. 0.00
LINK 210 FED BY 100 0 0 0 M.M.E. 0.63
LINK 310 FED BY 200 0 0 0 M.M.E. 1.13


LINK 300 FED BY 0 0 0 0 M.M.E. 0.00
LINK 111 FED BY 410 0 0 0 M.M.E. 1.42


Palace
Grounds
Road
G10 94% (24)
20 - 65
45"
Keith
Road
5"
0 - 15
G/w
10
83% (9) H11
18"
Cycle = 70"
4"
4"
68% (3)
B2
38 - 0
Motherwell
Road
30
D5 40% (1)
20
A1 87% (15)
C4
10 - 54
6"
5 - 33
19"
59 - 5
16"
Blakeswell Lane
87% (12)
EXPM4.Dat


G10 97% (34)
Palace
Grounds
Road
21 - 78
56"
Keith
Road
5"
83 - 16
G/w
10
71% (10) H11
26"
Cycle = 90"
4"
4"
41% (6)
B2
46 - 0
Motherwell
Road
30
D5 43% (1)
20
A1 88% (19)
C4
10 - 63
6"
5 - 41
36"
68 - 5
27"
Blakeswell Lane
73% (12)
SITE.Dat
Lose Time !

+=========#======...1.....====#=====