4. Engineering Assessment

4.1 Engineering Standards

4.1.1 The options were developed to current design standards and make use of best practice guidance as follows:

- Design Manual for Roads and Bridges (DMRB) – TD9 Highway Link Design
- DMRB – TD16 Geometric Design of Roundabouts
- DMRB – TD21 2+1 Roads (DRAFT STANDARD Version 3.5)
- The Traffic Sign Regulations and General Directions 2002 (TRSGD)

4.2 Engineering Description of Each Option

4.2.1 Table 4.1 provides a detailed description of each of the proposed scheme options and should be read in conjunction with the Plan & Profile drawings enclosed in Appendix A.

Table 4.1 – Engineering Description of Each Option

Option Number	Route	Description
0	Do Minimum	♦ Pavement Resurfacing ♦ Pavement Reconstruction ♦ Improvements to traffic signs and road markings within the study area ♦ Traffic signals at Smithston Bridge
1.1	Blue	♦ Blue S2 ♦ 7.3m single carriageway provision (2 x 3.65m lanes) + 1.0m hardstrips ♦ 10m carriageway provision for extent of climbing lanes (3.2m, 3.4m, 3.4m) + 1.0m hardstrips ♦ 1 No northbound (N/B) climbing lane from Broomknowes Roundabout to Chainage (Ch) 760m ♦ Total N/B overtaking opportunity = 760m ♦ 1 No southbound (S/B) climbing lane from Ch 4280m to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1020m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)
1.2	Blue	♦ Blue S2R ♦ 7.3m single carriageway provision as above ♦ 10m carriageway provision for extent of climbing lanes ♦ 1 No N/B climbing lane from Broomknowes Roundabout to Ch 760m ♦ Total N/B overtaking opportunity = 760m ♦ 1 No S/B climbing lane from Ch 4280m to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1020m ♦ At grade 60m ICD roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm) ♦ At grade 70m ICD, 4-arm roundabout with B7023
1.3	Blue	♦ Blue WS2+1 ♦ 12m carriageway (including hardstrips) provision for entire length with optimised overtaking opportunities ♦ N/B Overtaking Lanes between Broomknowes Roundabout and Ch1200m and Ch2800 – Ch3800m ♦ Total N/B overtaking opportunity = 2200m ♦ S/B Overtaking Lanes from Ch1550m – Ch2650m and Ch4150 to Smithston Roundabout ♦ Total S/B overtaking opportunity = 2350m ♦ At grade 60m ICD roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)
1.4	Blue	♦ Blue WS2+1R ♦ 12m carriageway provision as above ♦ N/B Overtaking Lanes between Broomknowes Roundabout and Ch1550m and Ch2850 – Ch3800m ♦ Total N/B overtaking opportunity = 2500m ♦ S/B Overtaking Lanes from Ch1900m – Ch2700m and Ch4150 to Smithston Roundabout ♦ Total S/B overtaking opportunity = 2050m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)

Option Number	Route	Description
2.1	Red	♦ Red S2 ♦ 7.3m single carriageway provision (2 x 3.65m lanes) + 1.0m hardstrips ♦ 10m carriageway provision for extent of climbing lanes (3.2m, 3.4m, 3.4m) + 1.0m hardstrips ♦ 1 No N/B climbing lane from Broomknowes Roundabout to Ch 760m ♦ Total N/B overtaking opportunity = 760m ♦ 1 No S/B climbing lane from Ch 4280m to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1020m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)
2.2	Red	♦ Red S2R ♦ 7.3m single carriageway provision as above ♦ 10m carriageway provision for extent of climbing lanes ♦ Total N/B overtaking opportunity = 760m ♦ 1 No S/B climbing lane from Ch 4280m to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1020m ♦ At grade 60m ICD roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm) ♦ At grade 70m ICD, 4-arm roundabout with B7023
2.3	Red	♦ Red WS2+1 ♦ 12m carriageway provision (including hardstrips) for entire length with optimised overtaking opportunities ♦ N/B Overtaking Lanes between Broomknowes Roundabout and Ch1200m and Ch2800 – Ch3800m ♦ Total N/B overtaking opportunity = 2200m ♦ S/B Overtaking Lanes from Ch1550m – Ch2650m and Ch4150 to Smithston Roundabout ♦ Total S/B overtaking opportunity = 2350m ♦ At grade 60m ICD roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)
2.4	Red	♦ Red WS2+1R ♦ 12m carriageway provision as above ♦ N/B Overtaking Lanes between Broomknowes Roundabout and Ch1550m and Ch2850 – Ch3800m ♦ Total N/B overtaking opportunity = 2500m ♦ S/B Overtaking Lanes from Ch1900m – Ch2700m and Ch4150 to Smithston Roundabout ♦ Total S/B overtaking opportunity = 2050m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm) ♦ At grade 70m ICD, 4-arm roundabout with B7023

Option Number	Route	Description
3.1	Yellow	♦ Yellow S2 ♦ 7.3m single carriageway provision (2 x 3.65m lanes) + 1.0m hardstrips ♦ 10m carriageway provision for extent of climbing lanes (3.2m, 3.4m, 3.4m) + 1.0m hardstrips ♦ 1 No. N/B climbing lane from Broomknowes Roundabout to Ch 890m ♦ Total N/B overtaking opportunity = 890m ♦ 2 No. S/B climbing Lanes from Ch 2070m – 2970m and Ch 4135m to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1965m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)
3.2	Yellow	♦ Yellow S2R ♦ 7.3m single carriageway provision (2 x 3.65m lanes) + 1.0m hardstrips ♦ 10m carriageway provision for extent of climbing lanes (3.2m, 3.4m, 3.4m) + 1.0m hardstrips ♦ 1 No. N/B climbing lane from Broomknowes Roundabout to Ch 890m ♦ Total N/B overtaking opportunity = 890m ♦ 2 No. S/B climbing Lanes from Ch 2070m – 2970m and Ch 4135m to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1965m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm) ♦ At grade 70m ICD, 4-arm roundabout with B7023
3.3	Yellow	♦ Yellow WS2+1 ♦ 12m carriageway provision (including hardstrips) for entire length with optimised overtaking opportunities ♦ N/B Overtaking Lanes between Broomknowes Roundabout and Ch1200m and Ch2800 – Ch3750m ♦ Total N/B overtaking opportunity = 2150m ♦ S/B Overtaking Lanes from Ch1550m – Ch2650m and Ch4100 to Smithston Roundabout ♦ Total S/B overtaking opportunity = 2200m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm)
3.4	Yellow	♦ Yellow WS2+1R ♦ 12m carriageway provision for entire length as above ♦ N/B Overtaking Lanes between Broomknowes Roundabout and Ch1450m and Ch2800 – Ch3750m ♦ Total N/B overtaking opportunity = 2400m ♦ S/B Overtaking Lanes from Ch1800m – Ch2650m and Ch4100 to Smithston Roundabout ♦ Total S/B overtaking opportunity = 1950m ♦ At grade roundabout tie-ins with existing A77 at southern and northern extents (Broomknowes 3-arm and Smithston 4-arm) ♦ At grade 70m ICD, 4-arm roundabout with B7023

4.3 Climate, Topography and Land Use

4.3.1 Altitudes range from 96m AOD on the lowest ground west of Maybole to 144m AOD on the ridge between East Enoch and Kirklandhill. The topography is a mixture of rolling and hummocky hills with some steep slopes on valley sides.

4.3.2 The climate is typical of lowland Ayrshire, being strongly influenced by the Gulf Stream and having mild winters, cool summers and an average annual rainfall of around 1100mm. Soils are typically at field capacity (i.e. replete with moisture) between early October and early March.

4.3.3 Land use is almost entirely agricultural with scattered livestock farms and some rural dwellings. The only significant non-agricultural land uses potentially affected by the scheme are the caravan park at Gallowhill and the land designated for residential development at Whitefaulds. There are several small commercial woodlands but none of these are directly affected by the route options.

4.3.4 Most of the route corridor is under grass, with some forage crops and fields of barley grown for animal feed. There are two dairy farms (East Enoch and Mid Brockloch) with the remaining farms in the area producing beef and sheep.

4.4 Geology, Geomorphology and Ground Conditions

4.4.1 The following summary and engineering assessment of the geology, geomorphology and ground conditions of the study area is based on information obtained during the course of a geotechnical desk study and site walk-over. A more detailed engineering assessment of the geology and ground conditions within the study area is available in a separate Geotechnical Preliminary Sources Study Report[4] prepared by Atkins in 2006.

4.4.2 The drift geology beneath the study area is dominated by Glacial Till (Boulder Clay) including occurrences as glacial moraine landforms. In addition to the Glacial Till limited occurrences of Glacial Meltwater Deposits (predominantly Sand and Gravels) are present beneath the Blue route alignment and localised Alluvium (intermixed gravel, sand clay and silt with some peat) is present towards the north-eastern extent of the route options under consideration.

4.4.3 Beneath the drift deposits the solid geology comprises Devonian aged Lower Old Red Sandstone strata (reddish brown and greenish grey sandstone with occasional bands of conglomerate, marl and tuffaceous sandstone). A single dyke of basaltic / doleritic composition underlies the proposed route alignments to the north-east of Maybole.

4.4.4 No significant occurrences of made ground or contaminated land are expected within the immediate vicinity of the route options under consideration.

4.4.5 In general the ground conditions present within the study area are expected to be good and not to pose significant engineering difficulty to the construction of the route options under consideration. The limited occurrence of Alluvium present beneath the route options may present difficulties due to poor strength and compressibility characteristics however, the potential difficulties are not uncommon for a scheme of this type and commonly employed engineering techniques are available to overcome potential difficulties.

[4] A77 Geotechnical Preliminary Sources Study Report – Issue 02, November 2006

4.5 Hydrology, Hydrogeology and Drainage

Hydrology

4.5.1 The surface hydrology of the area overlaps two separate river catchments. The area to the north of Maybole and approximately delineated by the B7023 is part of the River Doon catchment with all small watercourses and burns forming the Doon tributary network. The area approximately south-west of the B7023 route is part of the Water of Girvan catchment. As a result, all the proposed route options will discharge road surface drainage to both of these river catchments. However, only the section of carriageway from the Broomknowes tie-in to the B7023 crossing will drain to the Girvan catchment. The minor watercourses of interest are described in Section 2.3. At Laigh Grange Farm there is a small, artificial loch, most likely used for fishing or other recreational use. This loch appears to discharge overflow via a culverted channel into Brockloch Burn as well as probably receiving filtered inflow from further upstream.

4.5.2 The minor watercourses in the area are not monitored by SEPA for water quality. However, the River Doon tributary into which three of the affected watercourses drain, the Chapelton Burn, is monitored and was classified as A1 (Excellent) according to the 2005 SEPA River Quality Classification Map. The Chapelton Burn is designated as Salmonid waters. The River Girvan tributary that receives discharge from the burn near Broomknowes Farm is unmonitored and as a result is unclassified with respect to water quality. This burn flows into the Abbeymill Burn which is also designated as Salmonid waters.

4.5.3 The SEPA Indicative River & Coastal Flood Map (www.sepa.org.uk/flooding/mapping) indicates that the low-lying area immediately to the south-east of the existing A77 route between Nether Culzean and High Smithston is at risk of flooding from events with an annual probability of 0.5% (1 in 200 years). The flood map also indicates that a narrow strip of river bank between Holmes and High Smithston on Brockloch Burn is also at risk from the 0.5% event along with the low-lying ground surrounding the artificial pond at Laigh Grange.

4.5.4 The solid geology of the area consists of Devonian Lower Old Red Sandstone overlain by drift dominated by boulder clay and morainic accretions with some sand and gravel glacial deposits (BGS UK North solid geology and drift geology maps). The overall groundwater vulnerability classification for the Maybole district is “moderately permeable” but with superficial drift deposits of variable thickness that tend to impede groundwater recharge irrespective of soil classification (BGS Groundwater Vulnerability Map of Scotland).

Hydrogeology

4.5.5 The British Geological Survey (BGS) groundwater vulnerability and hydrogeological maps indicate the Lower Old Red Sandstone strata underlying the study area to be a locally important aquifer with moderate permeability. The drift deposits within the study area are not indicated to form significant aquifers but can be expected to have variable permeability.

4.5.6 Historical ground investigation records indicate groundwater levels to vary beneath the study area from less than 2m below ground level to 10m below ground level within the drift deposits and underlying Lower Old Red Sandstone strata. In general recorded groundwater levels become shallower from the south-west towards the north-east of the study area.

4.5.7 With the exception of excavations in Alluvial areas and cuttings formed below ground water level, groundwater is not expected to pose significant engineering difficulties to the proposed scheme. For excavations in Alluvial areas and cuttings formed below groundwater level significant groundwater flows may be encountered. This is likely to require the implementation of dewatering measures during construction. Furthermore, those cuttings formed below groundwater level are likely to require permanent slope drains to control groundwater seepages.

Drainage

4.5.8 No detailed drainage design has been undertaken at this stage however, it is anticipated that drainage of the new carriageway will be via an "over-the-edge" filter drain system. Petrol interceptors and attenuation ponds may also be required.

4.5.9 Detailed consultation with SEPA, SNH and the relevant Fishery Boards should be undertaken at DMRB Stage 3 to ensure that water quality targets are achieved.

4.6 Public Utilities

4.6.1 BT, 33kV and 11kV Scottish Power apparatus and Scottish Water apparatus are present within the study area and are affected by the proposals.

4.6.2 Preliminary information was sourced from utility companies under procedure C2 of the New Roads and Street Works Act 1991. The information returned indicated apparatus within the study area and affected by the route options. They are shown on the existing utilities drawings contained in Appendix A.

4.6.3 The diversions and/or re-routing of the apparatus are not expected to pose any special problems to the development of the scheme other than the usual implications affecting cost and programming.

4.6.4 It is also expected that properties such as East Enoch and Kirklandhill will take supplies from the apparatus indicated.

4.7 Structures

4.7.1 Table 4.2 below describes the principal structures anticipated following initial vertical design.

Table 4.2 – Anticipated Structure Requirements

Option No	Description	Anticipated Structures
1.1	Blue S2	▪ B7023 Culzean Road Overbridge ▪ Gardenrose Path Overbridge ▪ B7023 & B7024 Link Road Underbridge ▪ B7024 Alloway Road Overbridge
1.2	Blue S2R	▪ Gardenrose Path Overbridge ▪ B7023 & B7024 Link Road Underbridge ▪ B7024 Alloway Road Overbridge

Option No	Description	Anticipated Structures
1.3	Blue WS2+1	▪ B7023 Culzean Road Overbridge ▪ Gardenrose Path Overbridge ▪ B7023 & B7024 Link Road Underbridge ▪ B7024 Alloway Road Overbridge
1.4	Blue WS2+1R	▪ Gardenrose Path Overbridge ▪ B7023 & B7024 Link Road Underbridge ▪ B7024 Alloway Road Overbridge
2.1	Red S2	▪ B7023 Culzean Road Overbridge ▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Overbridge ▪ B7024 Alloway Road Underbridge
2.2	Red S2R	▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Overbridge ▪ B7024 Alloway Road Underbridge
2.3	Red WS2+1	▪ B7023 Culzean Road Overbridge ▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Overbridge ▪ B7024 Alloway Road Underbridge
2.4	Red WS2+1R	▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Overbridge ▪ B7024 Alloway Road Underbridge
3.1	Yellow S2	▪ B7023 Culzean Road Underbridge ▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Underbridge ▪ B7024 Alloway Road Underbridge
3.2	Yellow S2R	▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Underbridge ▪ B7024 Alloway Road Underbridge
3.3	Yellow WS2+1	▪ B7023 Culzean Road Underbridge ▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Underbridge ▪ B7024 Alloway Road Underbridge
3.4	Yellow WS2+1R	▪ Gardenrose Path Overbridge ▪ Kirklandhill Path Underbridge ▪ B7024 Alloway Road Underbridge

Safety Fencing

4.7.2 Due to the number of options considered at Stage 2 detailed vehicle restraint system design has not been undertaken. The provision of safety fencing at the location of hazards shall be provided in verges for a bypass in accordance with the requirements of TD19 – Requirement for Road Restraint Systems. This design should be carried out at DMRB Stage 3.

4.8 Preliminary Considerations of:

Assessment of Potential Departures from Standards

4.8.1 All route options have been designed with a 100Akph design speed and meet the Desirable Minimum geometrical standards as set out in Table 3 of TD9, summarised below:

- Horizontal Curvature m – the Desirable Minimum R with Superelevation of 5% is 720m.
- Vertical Curvature – the Desirable Minimum Crest K Value is 100 and the Absolute Minimum Sag K Value is 26.
- Use of the 2+1 carriageway cross section is at the moment a departure from standard as the standard itself is still in draft form.

Engineering Constraints

4.8.2 The design proposals take into account the following physical constraints;

- Existing Glasgow to Stranraer railway;
- The steep nature of the existing topography;
- Services to the north of Maybole include 11 & 33kV Scottish Power overheads; BT poles and ducts and Scottish Water Mains Distributions pipes up to 250mm diameter;
- National Cycle Route 7 (Carlisle to Inverness) which utilises Gardenrose Path;
- Side road crossings.

Main Aspects of Construction and Maintenance

4.8.3 All options are considered to be very similar in terms of construction and maintenance. The main length of each scheme can be built off-line (that is, with minimal impact to the travelling public). Each involves a new roundabout at both the southern and northern tie-ins. These have been positioned to maximise the amount of construction work that could be carried out off-line, however disruption will be unavoidable and temporary traffic management will be required during construction of these tie-ins.

4.8.4 Furthermore, the options which involve an additional roundabout with the B7023 will cause further disruption during its construction.

4.8.5 The main construction elements will include site clearance, fencing, earthworks, pavement, structures (over/under bridges and culverts) and road-markings. There will be further elements of lighting, traffic signs, safety fencing and landscaping.

4.8.6 Again, the maintenance will be similar for all options. It should be noted that the provision of a bypass in itself means that there is a convenient diversion route available (the existing A77). The options which involve an additional roundabout with the B7023 provide more flexibility for diversion routes when maintaining either the southern or northern length discretely.

4.8.7 The main maintenance elements of the scheme will include earthworks, structures, traffic signs, lighting and pavement.