DESIGN GUIDELINES FOR SINGLE CARRIAGEWAY NATIONAL ROADS

First Draft

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Planning and Design Cluster

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Design (General):

1 Preamble:

A substantial portion (over 90%) of the National Road Network (SANRAL managed) consists of single carriageway (2, 3 or 4 lane) roads. It is likely that over 50% of these roads will have design standards less than the desired 120km/h, being roads that were previously considered of a lower order and/or were designed and constructed before the 1970's. Substantial lengths of these roads could still satisfy the minimum standards for a 120km/h design speed, while significant portions may not. Upgrading all such portions to 120km/h or even a 100km/h design speed is often found to be impracticable and likely to be unaffordable and not economically justifiable. In addition most of the lower order of the national network carry substantially less traffic than the higher order N routes and is likely to do so for the foreseeable future.

Designers are reminded that "design speed" is a theoretical design parameter and must not be confused with actual operating conditions or even worse, posted speed limit restrictions. Hence, designers must develop appropriate design solutions for such lower order roads which may include widening of paved width or cut faces where sight distance is not optimal, introduction of transition curves and increased super elevation, warning signs and optical devices where current operating conditions fall below the generally perceived desirable safe operating conditions etc..

Designers are encouraged to use sound engineering judgement while ensuring that acceptable operating conditions can be maintained and future upgrading of such facilities can be accomplished in a rational and cost effective manner. Designers and project managers are required to ensure that the distinction between the "design speed" parameter and operating speeds and posted speed limits are adequately explained and addressed in all documentation.

Designers are well advised to consider alignments that will be pleasant to the motorist to drive on. The motoring experience must be enhanced. For this reason this consideration and its application must be discussed in design reports.

2 Classification:

It is a requirement that SANRAL's roads shall be classified in accordance with the DoT's new RIFSA classification available from DoT or DoT website. The majority of SANRAL's network will fall into Class 1. It is intended that such roads shall be upgraded and constructed to the minimum **preferred** National road standards as far as practicable. The remainder of the network will fall into Class 2. It is intended that reduced standards could be tolerated on such roads depending on traffic volumes, now and in the future. However, SANRAL will also as part of its community development programme construct Class 6 and 7 roads from time to time. Typical design details for such roads are included in the SANRAL's typical drawings.

3 Level of Service and Capacity:

Detailed LOS and capacity upgrade requirements must be determined with the Follower Density procedure simulation model. Indicative table of trigger volumes (AADT) for various terrain types and heavy vehicle proportions of the traffic stream are contained in tables 1 and 2. Designers shall take note that the tables are based on using particular peak factors and directional flows. These particular factors are based on research on SANRAL's existing national road network and have a significant impact on the trigger volumes.

4 Typical Road Cross-sections:

4.1 2-lane roads (single carriageway):

(a) Roads with AADT larger than 3000 vehs/day (AADT):

- Shoulders are paved and have a minimum width of 2.5m. Where traffic is to be accommodated during upgrade and rehabilitation work, the paved width should be a minimum of 13.4 m (2x3.7m lane + 2x3.0m paved shoulders).
- Where traffic volumes are less than 2000 vehs/day and likely to remain below 3000 vehs/day for next 10 years a narrower cross section may be considered. However, in all cases toll roads should have paved shoulders of at least 2.5m, distinguishing them from non-toll roads.

(b) Roads with AADT of less than 3000 vehs/day in 10 years:

- Paved shoulder: 800mm (min), 1000mm preferred
- Total shoulder width (including gravel): 2.5m excl. rounding
- Lanes 3.5m (min), 3.7m Preferred
- Paved Width: 8.6 (min) 9.4 Preferred
- Carriageway Width: 12.0 min for existing, 13.4 preferred incl. rounding
- Bridge structures: 12.4m width between barriers (Preferred). Retain existing width if practicable and safe. Each case to be motivated accordingly.
- V-drains to be outside of 12.4m wide carriageway.
- Shoulders to be paved where side drains are installed (Cuts and high fills).

4.2 3-lane roads (single carriageway):

These include sections of higher order 12.4 or 13.4m wide 2-lane roads that have been re-marked to alternate 2 lanes with 1 opposing lane configuration over its entire length, the length of the alternate configurations being 1.2km including tapers leading directly into a similar but opposing section. Research appears to indicate that this configuration could be more dangerous than the conventional 2-lane configuration (although there are also success stories). The substantiation is as follows:

- It has been found that operating conditions LOS/capacity is not substantially improved.

    - Areas of conflict are introduced where there were none previously i.e. at the merge of the 2 lanes
    - Leads to platooning.
    - Leads to excessive speeding in the 2-lane sections. Faster travellers are forced to use a limited opportunity to pass obstructing traffic.
    - Heavy vehicles are more restricted to wheel paths.
    - Additional signs are required and the cost of road marking and maintenance is high.
    - Space to stop on the gravel shoulder is limited.
- This configuration must NOT be implemented over extended sections of single carriageway as a matter of course.
- Designers are required to assess the LOS in detail with the Follower Density software and introduce such configurations only where real benefit can be realised i.e. where reduced sight distance/alignment has reduced capacity and LOS.
- Any 3-lane configuration must be followed by a traditional 2-lane configuration of not less than 400m (i.e. Passing sight distance + barrier restrictions each side) before the following 3-lane configuration is introduced. It is always a requirement that termination of 3 lane configurations shall occur where sight distance is at least 300 m in each direction and preferably greater than the anticipatory sight distance.
- Slow lane drop merge is preferred. Equal merge is also acceptable but recovery area must be provided on the shoulder side and not on the "median" side. Fast lane drop is NOT preferred or recommended.

4.3 4-lane undivided roads:

Design rationale: 4-lane undivided carriageway is generally not preferred. A 4-lane dual carriageway road is normally cheaper to construct and operate. Designers must substantiate where a 4-lane undivided carriageway is proposed for greenfields sections.

4- lane undivided cross section is normally used where:

- o Space is limited
- o For phased upgrading of existing single carriageway facilities. **NOTE: Upgrading of a built carriageway of a dual carriageway facility shall not be considered in this category. Designers are required to substantiate that such designs are the most cost effective alternative.**
    - The cross-section is to be cambered around the centre line of the carriageway.
    - 2.0m wide paved median to make provision for cable barrier is preferred. However, for AADT's of less than 15 000 vehs/day a painted median approximately 800mm wide can be considered.
    - 2.5m wide total shoulder, of which 1.0m minimum should be paved.
    - Minimum 3.5m lane width.

- 21.0m total width (2,5 + 2x3,5 + 2,0 + 2x3,5 + 2,5)
- Shoulders to be paved where side drains are installed (Cuts and high fills).
- 26.0m overpass clear span with mitigating measures at piers.
- Absolute minimum 22.4m horizontal clear width under overhead structures.

5 Intersections:

- Research has indicated that more than 33% of accidents on rural roads occur at at-grade intersections. Designers shall assess the likely requirement in terms of such intersections and the likely upgrades that may be required for at least a 20 year horizon. Such shall provide for:
    - Anticipated/planned linkages between the national road and the supporting provincial or local network
    - Grade separated interchanges
    - Other possible upgrade strategies for at-grade intersection.
    - Removal of undesirable at-grade intersections with new supporting local linkages.
- Where sight distance requirements are not met, such intersections shall be, relocated OR sight distance shall be improved by means of other geometric improvement to acceptable standards.
- Intersections shall be assessed and upgraded as required. Right turn refuge lane and tapers will generally be required where the right turning volume is larger than 30 vehs/day.
- Typical layouts are provided in the SANRAL's typical drawing and the *Geometric Design Guideline*.

6 Warrants for Interchanges:

The need for replacing an at grade intersection (or a number of such intersections) with an interchange shall generally be assessed in terms of the design guidelines and such reference material as the Highway Capacity Manual and AASHTO design code. Designers shall consider that the LOS of a section of highway is often determined by LOS of any at-grade access and not necessarily by the highway section itself. Apart from the undesirable safety aspects of at-grade intersections lower standard grade separated interchanges such as quarter links can provide cost effective solutions.

Bridge structures:

6.1 Aesthetics of Bridges

a. Bridges generally have a life span of anything between 50 and a 100 years and are there for future generations to appreciate or dislike. It is for this reason it is expected that when roads are planned that the aesthetics of bridges receive sufficient attention. Bridge designs that are purely utilitarian and lack visual appeal must be avoided. It is a fallacy to take for granted that such structures are significantly cheaper than aesthetically appealing designs. Attention to aesthetic and practicable detail will result in visually pleasing and functional structures for little, if any, additional cost.

b. Piers that are purely rectangular or square columns should be avoided. In special cases consideration shall be given to special aesthetically pleasing and interesting pier shapes.
c. Jack spans are always preferred for overpass bridges, both for allowing a relatively open and slender structure (more light and less shadows) and shorter and balanced spans, Such structures give a pleasing open effect when approaching the bridge and viewing it in elevation.
d. Pedestrian bridges lend themselves to unusual and very attractive designs at relatively little additional project cost. It is therefore expected of the designer to consider such innovation.
e. Where bridge designs are considered to be particularly esthetically pleasing lighting of such structures and features shall be considered. This is of particular importance in urban areas
f. Bridges that cross large valleys are often very pleasing to view and should be visible to the travelling public. Sometimes a simple solution such as widening of a cut will enable an oblique view of the bridge.
g. One of the biggest aesthetic problems is caused by services attached to bridges in an unplanned way and not hidden from view. To this end when planning bridges and roads sufficient ducts should always be provided for future services. If larger pipes are to cross bridges then these positions must be carefully planned.
h. For some bridges that are iconic in nature and will form landmarks consideration must be given to getting architectural advice. This also may include getting advice on architectural lighting
i. It is simply unacceptable to make statements such as "aesthetics are in the eye of the beholder" and thus try to justify utilitarian and plainly ugly structures. The designer must be proud of the bridge that is created and designers are well advised to consider the acceptability of their designs in consultation with SANRAL.

6.2 Horizontal and vertical clearances between road and structure:

j. Recovery area (horizontal clearance) shall be 7.5m from yellow line or 4.5 m from the shoulder breakpoint whichever is the greater. However for structures with solid abutments with no jack spans the 7,5 m clearance shall be increased to 9,3m and the 4,5m clearance to 6.3 m
k. Under an overpass structure, the clear span must provide for future widening of the carriageway.
l. Vertical clearances shall be as follows:
    i. New bridges (solid or box type of deck soffits) = 5.2 m min measure at any point on the surfaced roadway.
    ii. New bridges (Beam and Slab type decks) = 5.6 m min measured at any point on the surfaced roadway.
    iii. Agriculture (narrow non-vehicular bridges), pedestrian and service overpasses = 5.9 m min. These have generally lightweight decks vulnerable to impact.

iv. Implement/vehicular (single lane) agricultural overpasses will have essentially more robust type of decks and clearance of 5.6 m is allowable. Wider two lane bridges are essentially road bridges and c. i. or c. ii. above will apply.
v. Existing structures (any soffit) = 5.0 m min if structure is not damaged.

6.3 As the structural design (both structurally and functionally) life is normally 100 years for bridges a long-term view should be taken in respect to the length and width of bridges and future clearances that could limit the future development potential of carriageways. It must be noted that some bridge structures (such as some box girder decks) are such that they are generally impossible to widen in the future.

6.4 Bridge designs with jack spans and spill through abutments are preferred and are mandatory at all new interchanges where jack spans should long enough (generally a clear span of 13m or more) to accommodate on or off ramps to allow for possible free flow loops or ramps to be introduced in the future..

6.5 On curved bridges stopping ~~site~~ sight distances that may be affected by bridge parapets or barriers should be carefully assessed.

6.6 The need to provide raised walkways for pedestrians on all urban bridges and where required by local rural communities shall be assessed. Future possible developments shall also be considered.

7 Super Routes:

In essence, super loads can be defined as follows:

> 125 ton GCM or > 35m long or > 6m wide or > 6m high.

Designers shall investigate and report on the likelihood that a particular route could be used as a super route. Additional clearances and design loads may then become applicable

In terms of the TRH11 (Draft Guidelines for granting of exemption permits for the conveyance of Abnormal Loads) accurate calculation of the stresses imposed by an abnormal load is in general required where the gross mass of the vehicle and load exceed 125 000 kg or 18 kN/m² (i.e. for superloads).

The Code of Practice for the design of highway bridges and culverts in South Africa (TMH 7) require that an abnormal design load of 30 kN/m² (NC type loading) be applied in the design of all new bridges and culverts along abnormal load routes.

8 Road Reserves and Land Acquisition:

The minimum road reserve width for single carriageway national roads that are likely to carry less than 8 000 veh/day at the end of a 30 year design period shall generally be a minimum of 50 metres. Designers shall consider future anticipated upgrades and intersection/interchange requirements. SANRAL is obligated to reserve/acquire land that will be required for the national road network now and in the future. This preferred reserve may not always be attainable, practicable or economically justifiable for existing roads. The following alternatives may be considered:

- Retain the existing road reserve if it is at least wider than 30 metres (100 Cape feet) and all upgrades for the next 20 years can be accommodated therein.
- Widen the road reserve where required to accommodate anticipated upgrading including grade separated interchanges and other intersection or structural requirements.

The road reserve width for any other national road shall be a minimum of 80 metres and shall be centred on a road reserve centreline that shall also form the centreline of a dual carriageway highway of which the single carriageway under consideration shall form one of the future dual carriageways.

9 Road Safety Audits:

To be carried out on all projects: Designers to note the following extracts from SANRAL's **ROAD SAFETY MANAGEMENT SYSTEM (RSMS) POLICY AND PROCEDURES:**

"It is important to note that a road safety audit which is done during the design stage of a road is not confused with a road safety investigation which is done on an existing road to identify remedial measures to improve road safety at a hazardous or high risk location"

ROAD SAFETY AUDIT

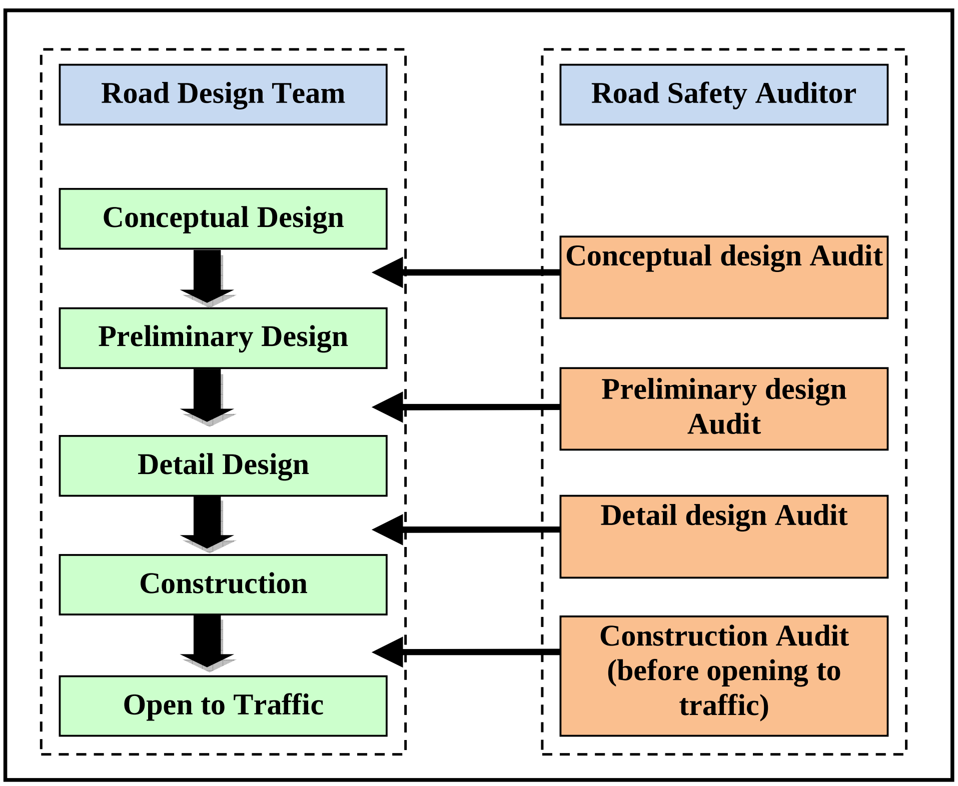

Diagram 1: Road safety audits during the road design stages *(Hirsawa, Asano & SAITO, Proceedings of the Eastern Asia Society for Transportation Studies, Vol. 5, pp. 2018 - 2031, 2005)*

FIGURE 2.1

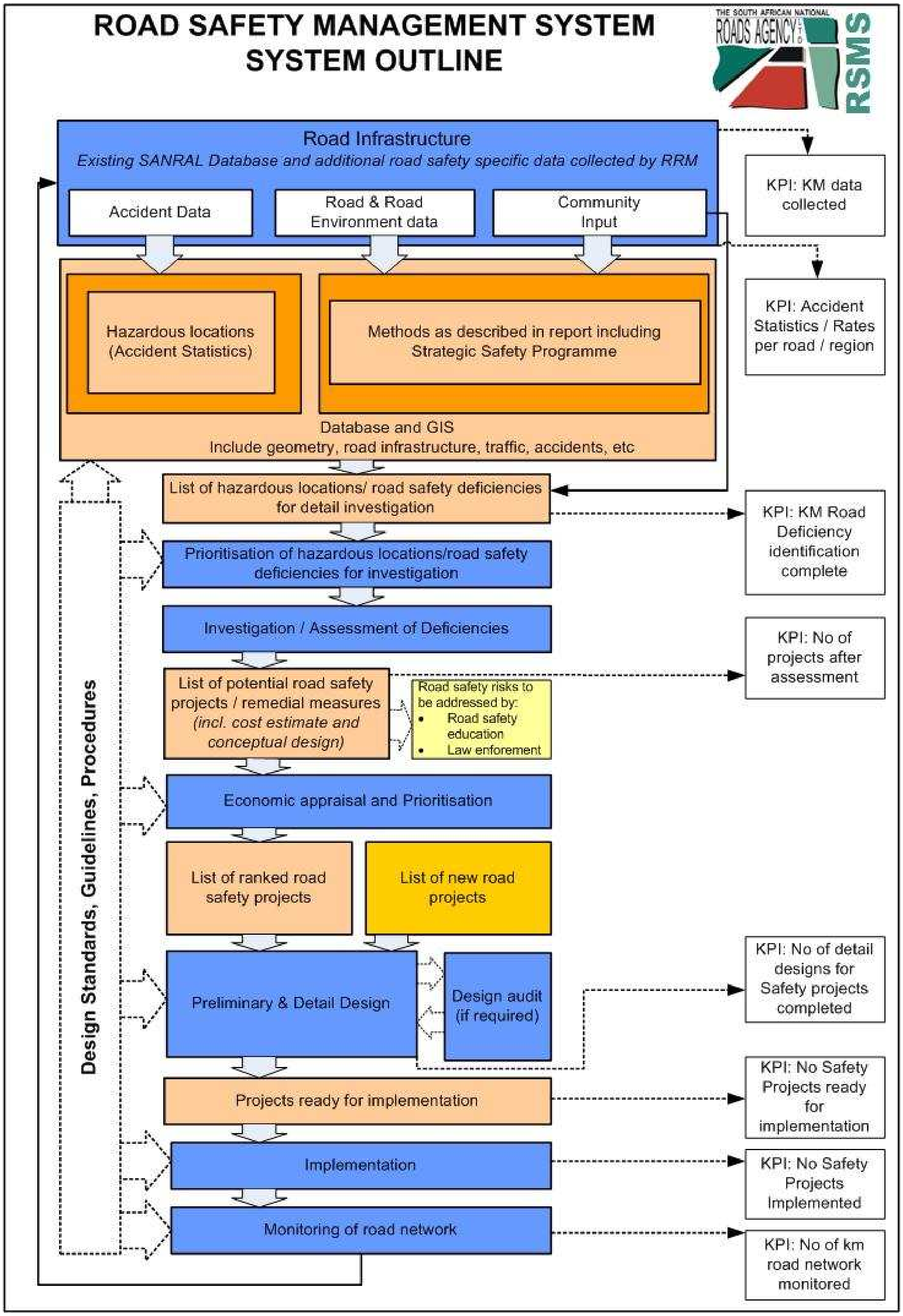
ROAD SAFETY MANAGEMENT SYSTEM
SYSTEM OUTLINE
THE SOUTH AFRICAN NATIONAL ROADS AGENCY LTD
RSMS
Road Infrastructure
Existing SANRAL Database and additional road safety specific data collected by RRM
Accident Data
Road & Road Environment data
Community Input
KPI: KM data collected
KPI: Accident Statistics / Rates per road / region
Hazardous locations (Accident Statistics)
Methods as described in report including Strategic Safety Programme
Database and GIS
Include geometry, road infrastructure, traffic, accidents, etc
List of hazardous locations/ road safety deficiencies for detail investigation
KPI: KM Road Deficiency identification complete
Prioritisation of hazardous locations/road safety deficiencies for investigation
Investigation / Assessment of Deficiencies
KPI: No of projects after assessment
List of potential road safety projects / remedial measures (incl. cost estimate and conceptual design)
Road safety risks to be addressed by:
Road safety education
Law enforement
Economic appraisal and Prioritisation
List of ranked road safety projects
List of new road projects
Preliminary & Detail Design
Design audit (if required)
KPI: No of detail designs for Safety projects completed
Projects ready for implementation
KPI: No Safety Projects ready for implementation
Implementation
KPI: No Safety Projects Implemented
Monitoring of road network
KPI: No of km road network monitored
Design Standards, Guidelines, Procedures

TABLE 1: LIMITING VOLUMES FOR TWO LANE SINGLE CARRIAGEWAY HIGHWAY LINKS OR SEGMENTS WITHOUT CLIMBING LANES; 12,4m WIDTH

LOS	Terrain Classification	AVERAGE ANNUAL DAILY TRAFFIC (AADT) – VEHICLES PER DAY											
		Peak Factor	15,00%								Split	39%	61%
		Proportion Heavy Vehicles of Traffic Stream											
		8%	10%	12%	14%	16%	18%	20%	22%	24%	26%	28%	30%
A	Flat	2,930	2,830	2,740	2,650	2,570	2,500	2,430	2,360	2,290	2,230	2,180	2,120
B		7,030	6,790	6,570	6,370	6,170	5,990	5,820	5,660	5,510	5,360	5,220	5,090
C		9,370	9,060	8,760	8,490	8,230	7,990	7,760	7,550	7,340	7,150	6,970	6,790
D		9,600	9,280	8,980	8,700	8,440	8,190	7,960	7,740	7,530	7,330	7,140	6,960
A	Rolling	1,760	1,700	1,640	1,590	1,540	1,500	1,460	1,420	1,370	1,340	1,310	1,270
B		4,220	4,070	3,940	3,820	3,700	3,590	3,490	3,400	3,310	3,220	3,130	3,050
C		5,620	5,440	5,260	5,090	4,940	4,790	4,660	4,530	4,400	4,290	4,180	4,070
D		5,760	5,570	5,390	5,220	5,060	4,910	4,780	4,640	4,520	4,400	4,280	4,180
A	Mountainous	1,170	1,130	1,100	1,060	1,030	1,000	970	940	920	890	870	850
B		2,810	2,720	2,630	2,550	2,470	2,400	2,330	2,260	2,200	2,140	2,090	2,040
C		3,750	3,620	3,500	3,400	3,290	3,200	3,100	3,020	2,940	2,860	2,790	2,720
D		3,840	3,710	3,590	3,480	3,380	3,280	3,180	3,100	3,010	2,930	2,860	2,780

TABLE 2: LIMITING VOLUMES FOR TWO LANE SINGLE CARRIAGEWAY HIGHWAY LINKS OR SEGMENTS WITHOUT CLIMBING LANES OVER 50% OR MORE OF SEGMENT LENGTH; 13,8m WIDTH or WIDER

LOS	Terrain Classification	AVERAGE ANNUAL DAILY TRAFFIC (AADT) – VEHICLES PER DAY											
		Peak Factor	15,00%	Split								39%	61%
		Proportion Heavy Vehicles of Traffic Stream											
		8%	10%	12%	14%	16%	18%	20%	22%	24%	26%	28%	30%
A	Flat	3,280	3,170	3,070	2,970	2,880	2,800	2,720	2,640	2,570	2,500	2,440	2,380
B		7,870	7,610	7,360	7,130	6,920	6,710	6,520	6,340	6,170	6,010	5,850	5,710
C		10,490	10,140	9,820	9,510	9,220	8,950	8,690	8,450	8,220	8,010	7,800	7,610
D		10,760	10,400	10,060	9,750	9,450	9,170	8,910	8,660	8,430	8,210	8,000	7,800
A	Rolling	1,970	1,900	1,840	1,780	1,730	1,680	1,630	1,580	1,540	1,500	1,460	1,430
B		4,720	4,570	4,420	4,280	4,150	4,030	3,910	3,800	3,700	3,610	3,510	3,430
C		6,290	6,080	5,890	5,710	5,530	5,370	5,210	5,070	4,930	4,810	4,680	4,570
D		6,460	6,240	6,040	5,850	5,670	5,500	5,350	5,200	5,060	4,930	4,800	4,680
A	Mountainous	1,310	1,270	1,230	1,190	1,150	1,120	1,090	1,060	1,030	1,000	980	950
B		3,150	3,040	2,940	2,850	2,770	2,680	2,610	2,540	2,470	2,400	2,340	2,280
C		4,200	4,060	3,930	3,800	3,690	3,580	3,480	3,380	3,290	3,200	3,120	3,040
D		4,300	4,160	4,020	3,900	3,780	3,670	3,560	3,460	3,370	3,280	3,200	3,120