CHAPTER 4-ROADWAY DESIGN AND TECHNICAL CRITERIA

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CHAPTER 4-ROADWAY DESIGN AND TECHNICAL CRITERIA

4.1 GENERAL

This section sets forth the minimum design, technical criteria and specifications to be used in the preparation of all roadway plans.

4.1.1 Within this chapter of the Roadway Design and Technical Criteria, AASHTO "Green Book" refers to "A Policy on Geometric Design of Highways and Streets" most recent revision, as published by the American Association of State Highway and Transportation Officials.

4.2 ROADWAY DESIGN AND TECHNICAL CRITERIA

Arapahoe County has adopted a Functional Street Classification Plan based on traffic volumes, land use and expected growth. This Functional Street Classification Plan designates streets as local, collector (major and minor) and arterial (major and minor). The following criteria applies to each classification. Standard roadway cross sections are presented in Appendix A.

4.2.1 Planning Principles for Local Circulation Systems.

4.2.1.1 A local circulation system is a traffic management method, implemented to convey vehicular, pedestrian and bicycle traffic through developed areas. Basic considerations in the design of local circulation systems must recognize the following factors:

4.2.1.1.1 Safety – for vehicular, pedestrian and bicycle traffic.

4.2.1.1.2 Efficiency of Service – for all users.

4.2.1.1.3 Livability – especially as affected by traffic elements in the circulation system.

4.2.1.1.4 Economy – These standards take economics into account while providing for the safest roadway progression possible.

4.2.1.2 The following principles are an elaboration on one or more of these four factors. The principles are not intended as absolute criteria, since instances may occur where certain principles conflict. The principles should, therefore, be used as guidelines to proper circulation systems layout.

4.2.1.2.1 **Ensure Vehicular, Pedestrian and Bicycle Access –** The primary function of a local street is to serve the abutting properties. Street widths, placement of sidewalks, patterns of streets and number of intersections are related to the safe and efficient access to abutting lands.

4.2.1.2.2 **Minimize Through Trips –** Through traffic on local and collector streets increases the average speed and volume and thus the accident potential, thereby reducing residential amenities. Through traffic can be discouraged by creating a circuitous route between neighborhoods and higher volume streets and by channeling or controlling median crossings along peripheral routes.

4.2.1.2.3 **Control Access to Arterials –** Local circulation systems and land development patterns should not detract from the efficiency of peripheral arterial facilities. Ideally, land development should occur so that no local streets require direct access to arterial routes. The number of access points between the local circulation system and arterial system should be minimized. Intersections along arterial routes should be properly spaced for

efficient signalization and traffic flow. The streets that do intersect the arterial system will tend to have higher volumes since they are the only exit points.

4.2.1.2.4 **Discourage Speeding –** Residential street should be designed to discourage excessive speed (more than 25 m.p.h.). This can be accomplished through the use of curvilinear alignments and circuitous routes in the street system.

4.2.1.2.5 **Minimize Pedestrian – Vehicular Conflicts –** Pedestrian travel from within the area to points outside should require a minimum number of street crossings. Sometimes this can be achieved through proper design of street patterns, land use arrangements and pedestrian routes. Typical methods include use of cul-de-sacs, loop streets, special pedestrian routes or walkways and the proper placement of high pedestrian traffic generators. In general, while vehicular flow must be outward oriented to the peripheral arterials, pedestrian travel should be inward-oriented to avoid these heavier vehicular flows.

4.2.1.2.6 **Minimize Space Devoted to Street Use –** It is desirable to minimize local street mileage to reduce construction and maintenance costs as well as to permit the most economic land use. Streets should also have an appearance commensurate with their function. They should be in keeping with the residential character.

4.2.1.2.7 **Relate Street to Topography –** Local streets will be more attractive and economical if they are constructed to closely adhere to existing topography. Using the existing topography of the area can enhance the important role that streets play in overall storm drainage system.

4.2.1.2.8 **Layout Street to achieve Optimum Subdivision of Land –** The arrangement of streets should permit economical and practical patterns, shapes and sizes of development parcels. Streets, as a function of land use must not unduly hinder the development of land. Distances between streets, number of streets, and related elements all have a bearing on the efficiency of a subdivision. Access to adjoining properties should also be encouraged.

4.2.3 Urban Local

A local street is a general term denoting a residential roadway designed or operating with the following characteristics, No commercial property shall be permitted access to a local roadway:

A. POSTED SPEED LIMIT – 25 mph maximum per AASHTO "Green Book". Posted or Prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. TRAFFIC VOLUMES – Less than 1,500 vehicles per day for residential roadways with backing driveway access. Less than 2,500 vehicles per day for residential roadways with non-backing driveway access.

C. LIMITED CONTINUITY

D. SAFETY – Designed for the safety of pedestrians and bicyclists, and the ease of access to adjacent parcels of land.

E. TRAFFIC CONTROL – Stop signs, yield signs, or right-of-way rules for uncontrolled intersections.

F. FUNCTION – Local streets provide direct access to adjacent property. Traffic carried by local streets should have an origin or a destination within the neighborhood. Utility line easements should be available.

G. RIGHT-OF-WAY – In single-family residential areas with monolithic rollover curb, gutter and sidewalk: 50 feet minimum. In single-family residential with 5-foot detached sidewalk: 60 feet minimum. In multiple-family residential areas: 60 feet minimum.

H. NUMBER OF MOVING LANES – Two.

I. ACCESS CONDITIONS – Intersections at grade with direct access to abutting property permitted.

J. PLANNING CHARACTERISTICS – Local streets should be designed to discourage through traffic from moving through the neighborhood. Local streets should not intersect major collectors or arterial streets. Single-Family Residential Local Roadways shall have either monolithic rollover curb, gutter and sidewalk or 5-foot detached sidewalk. Multi-family Residential Local Roadways shall have 5-foot detached sidewalk.

1. See section 11.2 for intersection spacing criteria.

K. TYPE OF CURB AND GUTTER – vertical, Hollywood type and high-speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) are permissible with attached sidewalk.

L. CUL-DE-SACS and KNUCKLES – Cul-de-sacs shall have a minimum flowline radius of thirty-eight (38) feet, Knuckles shall have a minimum flowline radius of forty-five (45) feet (see detail SP-24). Cul-de-sacs may have a maximum length of 500 feet or a maximum of 15 dwelling units whichever is most restrictive. Extended lengths and/or increased number of dwelling units may be permitted only with written approval from the affected Fire Protection District and approval by the Board of County Commissioners.

M. ROADWAY WIDTHS:
1. Single-family residential: 30’ paved width plus 2-2’ gutter pans (34’ flowline – flowline).
2. Multiple-family residential: 40’ paved width plus 2-2’ gutter pans (44’flowline – flowline).

N. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL): See Table 4.2.

O. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – (Reverse Curves Permissible) Minimum Tangent Length on Local Roadways shall be at least 25 feet.

P. MINIMUM LENGTH OF VERTICAL CURVES: See Table 4.6.

Q. STREET GRADES: A minimum longitudinal flowline grade of 1.0% shall be required on all Local streets except at curb returns, knuckles, and bubbles where the minimum flowline grade shall be 1.0%. Maximum grade shall be 7%. See table 4.1, table 4.6 and Section 4.4.2 (inlets).

R. CURB RADII – See table 4.3.

S. Maximum Tangent Length – ¼ Mile.

4.2.3 Collector

Minor Collector

A minor collector is a general term denoting a roadway designed or operating with the following characteristics:

A. POSTED SPEED LIMIT – Between 25 and 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. TRAFFIC VOLUMES – Generally less than 7,000 vehicles per day.

C. CONTINUOUS – For less than 2 miles.

D. TRAFFIC VOLUMES – Designed to handle traffic volumes loading from and onto local, other collector, and arterial roadways.

E. TRAFFIC CONTROL – on minor collectors provided by stop signs.

F. DRIVEWAYS – No back out drives permitted.

G. FUNCTION – Collector streets collect and distribute traffic between arterial and local streets and serve as main connectors within communities, linking one neighborhood with another. Traffic carried by minor collector streets should have an origin or a destination within the community. Utility easements should be available.

H. RIGHT-OF-WAY WIDTH – 76 feet minimum.

I. NUMBER OF MOVING LANES – Two.

J. ACCESS CONDITIONS – Intersections at grade with direct access to abutting property permitted.

K. TRAFFIC CHARACTERISTICS – Regulation of traffic accomplished through the use of stop signs and channelization. Traffic signals normally used only at intersections with major collectors and arterial streets.

L. PLANNING CHARACTERISTICS –Minor Collector streets should have continuity throughout a neighborhood but need not extend beyond the neighborhood. Intersections with minor collectors, major collectors and arterial streets should be at least one-quarter mile apart. Detached sidewalks are required with a 7 foot landscaped area separating the sidewalk and roadway.

M. TYPE OF CURB AND GUTTER – Vertical or high speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) permitted, detached sidewalk required.

N. STREET WIDTHS – 46’ paved with plus 2-2’ gutter pans (50’ flowline – flowline).

O. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL): See Table 4.2.

P. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – (Reverse curves permissible) Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.3.

Q. MINIMUM LENGTH OF VERTICAL CURVES – See Table 4.6.

R. STREET GRADES – Minimum grade 1% - Maximum grade 6%.

S. CURB RADII – See Table 4.3.

4.2.3.2 Major Collector

A major collector is a general term denoting a roadway designed or operating with the following characteristics:

A. POSTED SPEED LIMIT – Between 30 and 45 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. TRAFFIC VOLUMES – Generally between 7,000 and 12,000 vehicles per day when the land, which the collector serves, is fully developed.

C. CONTINUOUS – For 2 or more miles.

D. TRAFFIC VOLUMES – Designed to handle traffic volumes loading from and onto local, other collector and arterial roadways.

E. TRAFFIC CONTROL – Provided by traffic signals

F. DRIVEWAYS – No back-out drives permitted

G. FUNCTIONS – Major collector streets permit relatively unimpeded traffic movement and are intended for use on those routes where four (4) moving lanes are required but where a larger classified street is not warranted.

H. RIGHT-OF-WAY – 88 feet.

I. NUMBER OF MOVING LANES – four.

J. ACCESS CONDITION:
1. Intersection at grade.
2. Intersection with other streets will not be restricted.
3. Access from street of lower classification will be permitted but in all cases will be controlled by traffic-control devices when warrants are met.
4. Normally, all abutting property will be allowed access to the streets and will face the street but perhaps with increased setback requirements.

K. TRAFFIC CHARACTERISTICS
1. Regulation of traffic accomplished by signs and channelization.
2. Traffic signals will normally be located only at intersection with streets of equal or higher classification.
3. Parking shall be prohibited.

L. PLANNING CHARACTERISTICS
1. Major collector streets should be employed where traffic demands are high and right-of-way acquisition costs are not prohibitive.
2. Detached sidewalk required except at intersections. See Roadway Cross Section for Major Collector at Intersection in the appendix.
3. Design elements (Trees, open space, etc.) are recommended.

M. TYPE OF CURB AND GUTTER – Vertical or High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards), detached sidewalk required except at intersections where attached walk is permitted. High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) Curb is required for all roadways with a posted speed of 45 miles per hour and above.

N. STREET WIDTHS – There are two types of Major Collectors one at intersections and one when between intersections. The street widths are as follows for each options:
1. At Intersections – 4-12' travel lanes; 1-14 center median; 2-2' gutter pans; 2-5' bike lanes (76' flowline – flowline).
2. Between Intersections – 4-12' travel lanes, 2-2'gutter pans and 2-5' bike lanes (62' flowline – flowline).

O. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

P. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1

Q. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

R. STREET GRADES – Minimum grade 1% maximum grade 6%.

S. CURB RADII – See Table 4.3.

4.2.4 Arterial

4.2.4.1 Minor Arterial

An arterial street is a general term denoting a roadway designed or operating with the following characteristics:

A. POSTED SPEED LIMIT – Greater than or equal to 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 4-lane minimum width, plus additional auxiliary lanes.

C. TRAFFIC VOLUMES – 12,000 TO 20,000 vehicles per day expected traffic volume when the land, which the arterial serves, is fully developed.

D. ACCESS – Limited access to adjacent parcels of land.

E. CONTINUITY – Several miles, generally connecting with intercity routes.

F. TRAFFIC CONTROL – On arterial provided by traffic signals.

G. FUNCTION – Arterial routes permit relatively unimpeded traffic movement and are intended for use on these routes where four moving lanes and one left-turn lane are required but where a major arterial cross section would not be warranted.

H. RIGHT-OF-WAY WIDTH – 114 feet minimum.

I. NUMBER OF MOVING LANES – Four.

J. ACCESS CONDITIONS – Intersection at grade. Intersection with other streets will not be restricted. Access from street of lower classification will be permitted but in all cases will be controlled by traffic control devices. Normally, all abutting property will be allowed access to the street if no other access is available and will face the street but perhaps with increased setback requirements.

K. TRAFFIC CHARACTERISTICS – Regulation of traffic accomplished by signs and channelization. Traffic signals will normally be located only at intersections with streets of equal or higher classification. Parking shall be prohibited.

L. PLANNING CHARACTERISTICS – Arterial should be spaced from ½ to 1 mile apart and should, where possible, be continuous. Arterial should act as boundaries between neighborhood areas. Arterial cross section should be employed where traffic demands are high and right-of-way acquisition costs are not prohibitive. Detached sidewalk required. Separate major land uses.

M. TYPE OF CURB AND GUTTER – Vertical or High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards), detached 8' sidewalk required. High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) Curb is required for all roadways with a posted speed of 45 miles per hour and above.

N. STREET WIDTHS – 4-12' travel lanes; 1-16' left turn lane/striped median; 2-2' gutter pans 2-5' bike lanes plus acceleration/deceleration lanes at intersections (78' flowline – flowline).

O. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

P. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

Q. MINIMUM LENGTH OF VERTICAL CURVES – See Table 4.6.

R. STREET GRADES – Minimum grade 1% maximum grade 6%.

S. CURB RADII- See Table 4.3.

4.2.4.2 Major Arterial (4 Lane)

A. POSTED SPEED LIMIT – Greater than or equal to 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 4-lane minimum width, plus additional turn lanes.

C. TRAFFIC VOLUMES – 12,000 to 30,000 vehicles per day expected traffic volume when the land, which the arterial serves, is fully developed.

D. ACCESS – Limited access to adjacent parcels of land.

E. CONTINUITY – Several miles, generally connecting with intercity routes.

F. TRAFFIC CONTROL – On arterial provided by traffic signals.

G. FUNCTION – Major arterial streets permit rapid and relatively unimpeded traffic movement through the county, connecting major land use elements as well as communities with one another.

H. RIGHT-OF-WAY WIDTH –114' minimum.

I. NUMBER OF MOVING LANES – Four.

J. ACCESS CONDITIONS – Intersections will generally be at grade. Intersections will normally be located at one-quarter mile intervals. Traffic control devices shall control access from collector and arterial streets. Normally, abutting properties and local streets will not be allowed direct access to the street. Abutting properties should not face on the roadway unless separated from it by a frontage road.

K. TRAFFIC CHARACTERISTICS – Movement of traffic will be controlled by signals and channelization. Parking shall be prohibited. Roadway should have a median strip between them.

L. PLANNING CHARACTERISTICS – Major arterial streets should be spaced approximately one mile apart and should traverse the entire city and/or county. Major arterial streets should not bisect neighborhoods but should act as boundaries between them. Detached sidewalk required.

M. TYPE OF CURB AND GUTTER – Vertical or High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards), detached 8' sidewalk required. High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) Curb is required for all roadways with a posted speed of 45 miles per hour and above.

N. STREET WIDTHS – 4-12' travel lanes; 14' medians; 2-1' median gutter pans, 2-2' gutter pans 2-5' bike lanes plus necessary left turn and acceleration/deceleration lanes and 4' median at intersections (78' flowline – flowline).

O. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

P. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

Q. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

R. STREET GRADES – Minimum grade 1% maximum grade 6%.

S. CURB RADII – See Table 4.3.

4.2.4.3 Major Arterial (6 Lane)

A. POSTED SPEED LIMIT – Greater than or equal to 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 6-lane minimum width, plus additional turn lanes.

C. TRAFFIC VOLUMES – 12,000 to 45,000 vehicles per day expected traffic volume when the land, which the arterial serves, is fully developed.

D. ACCESS – Limited access to adjacent parcels of land.

E. CONTINUITY – Several miles, generally connecting with intercity routes.

F. TRAFFIC CONTROL – On arterial provided by traffic signals.

G. FUNCTION – Major arterial streets permit rapid and relatively unimpeded traffic movement throughout the county, connecting major land use elements as well as communities with one another.

H. RIGHT-OF-WAY WIDTH – 144' minimum.

I. NUMBER OF MOVING LANES – Six.

J. ACCESS CONDITIONS – Intersections will generally be at grade. Intersections will normally be located at one-quarter mile intervals. Access from collector and arterial streets shall be controlled by traffic control devices. Normally, abutting properties and local streets will not be allowed direct access to the street. Abutting properties should not face on the roadway unless separated from it by a frontage road.

K. TRAFFIC CHARACTERISTICS – Movement of traffic will be controlled by signals and channelization. Parking shall be prohibited. Roadways should have a median strip between them.

L. PLANNING CHARACTERISTICS – Major arterial streets should be spaced approximately one mile apart and should traverse the entire city and/or county. Major arterial streets should not bisect neighborhoods but should act as boundaries between them. Detached sidewalk required.

M. TYPE OF CURB AND GUTTER – Vertical or High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards), detached 10' sidewalk required. High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) Curb is required for all roadways with a posted speed of 45 miles per hour and above.

N. STREET WIDTHS – 6-12' travel lanes; 26' medians; 2-1' median gutter pans, 2-2' gutter pans, plus necessary left turn and acceleration/deceleration lanes and 4' minimum median at intersections (104' flowline – flowline).

O. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

P. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

Q. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

R. STREET GRADES – Minimum grade 1% maximum grade 6%.

S. CURB RADII – See Table 4.3.

4.2.4.4 Urban Expressway (8 Lanes)

A. POSTED SPEED LIMIT – Greater than or equal to 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 8-lane minimum width, plus additional turn lanes.

C. TRAFFIC VOLUMES – 45,000 vehicles per day expected minimum traffic volume when the land, which the expressway serves, is fully developed.

D. ACCESS – Limited access to adjacent parcels of land.

E. CONTINUITY – Several miles, generally connecting with intercity routes.

F. TRAFFIC CONTROL – On expressway provided traffic signals.

G. FUNCTION – Expressway streets permit rapid and relatively unimpeded traffic movement throughout the county, connecting major land use elements as well as communities with one another.

H. RIGHT-OF-WAY WIDTH – 168' minimum.

I. NUMBER OF MOVING LANES – Eight.

J. ACCESS CONDITIONS –ACCESS CONDITIONS – Intersections will either be at grade or grade-separated dependant on traffic volumes. Intersections will normally be located at one-mile intervals. Access from arterial streets shall be controlled by traffic control devices or grade separated interchanges. Abutting properties should not face on the roadway unless separated from it by a frontage road.

K. TRAFFIC CHARACTERISTICS – Movement of traffic will be controlled by signals and channelization. Parking shall be prohibited. Roadways should have a median strip between them.

L. PLANNING CHARACTERISTICS – Expressway streets should only be utilized when traffic projections provide necessity and should traverse the entire city and/or county. Expressway streets should not bisect neighborhoods and should only be accessed by Arterial roadways. Detached sidewalk required.

M. TYPE OF CURB AND GUTTER – High speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards), detached 10' sidewalk required.

N. STREET WIDTHS – 8-12' travel lanes; 26' raised median; 2-1 median gutter pans, 2-2' gutter pans plus necessary left turn and acceleration/deceleration lanes and 4' minimum median at intersections (128' flowline – flowline).

O. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

P. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

Q. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

R. STREET GRADES – Minimum grade 1% maximum grade 6%.

S. CURB RADII – See Table 4.3.

4.2.5 Freeways

Freeways are designed and built to provide inter-city, inter-county, and/or interstate traffic flow. They are controlled access roadways. All Freeway and Interstate Improvements are under the jurisdictional authority of the State of Colorado. Proposed Improvements shall not be approved by Arapahoe County.

A. FUNCTION – Freeways permit rapid and unimpeded movement of traffic through and around the County.

B. RIGHT-OF-WAY WIDTH – 300 feet minimum.

C. NUMBER OF MOVING LANES – Four to ten.

D. ACCESS CONDITIONS – Access will be completely controlled. No intersections at grade will be permitted.

E. TRAFFIC CHARACTERISTICS – No traffic signals. Parking prohibited. Roadways will be divided.

F. PLANNING CHARACTERISTICS –Freeways should connect with main highways approaching and leaving the county from all directions. Freeways should be so aligned as to serve the major traffic generators within the county. (Major business district, major industrial areas, regional shopping centers, etc.) Freeways should not bisect neighborhoods or communities but should act as boundaries between them.

G. DESIGN CRITERIA – To be developed on a case-by-case basis but generally conforming to CDOT standards and criteria.

4.2.6 Rural Primary (4-Lane)

A. POSTED SPEED LIMIT – Greater than or equal to 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 2-lane minimum width with expansion capability to 4-lanes, plus additional turn lanes.

C. TRAFFIC VOLUMES – Generally between 10,000 and 20,000 vehicles per day when the land in which the roadway serves is being fully developed.

D. ACCESS- Limited access to adjacent parcels of land.

E. CONTINUITY – Several miles, generally connecting rural towns.

F. TRAFFIC CONTROL – On Rural Primary provided by traffic signals and/or signs.

G. FUNCTION – Rural Primary Roads permit relatively unimpeded traffic movement throughout the rural portion of the County.

H. RIGHT-OF-WAY WIDTH – 114' minimum.

I. NUMBER OF MOVING LANES- four.

J. ACCESS CONDITIONS – Intersections will generally be at grade. Intersections will normally be located at one-quarter mile intervals. Abutting properties, collector and local streets shall normally be allowed acceptable access to the street.

K. TRAFFIC CHARACTERISTICS – Movement of traffic will be controlled by signals and channelization. Parking shall be prohibited.

L. PLANNING CHARACTERISTICS – Rural Primary Roads should be utilized along section lines and where traffic projections warrant the additional lanage and right-of-way.

M. STREET WIDTHS – 4-12' travel lanes; 2-6' shoulders plus necessary left turn and acceleration/deceleration lanes and variable width drainage ditch area (60' Edge of Shoulder – Edge of Shoulder).

N. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

O. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES- Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

P. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

Q. STREET GRADES – Minimum grade 1% maximum grade 6%.

R. CURB RADII – See Table 4.3.

4.2.7 Rural Secondary (2-Lane)

A. POSTED SPEED LIMIT – Greater than or equal to 35 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 2-lane width, plus additional turn lanes.

C. TRAFFIC VOLUMES – Generally between 7,000 and 10,000 vehicles per day when the land in which the roadway serves is fully developed.

D. ACCESS – Direct access to adjacent parcels of land.

E. CONTINUITY – Generally less than 2 miles, generally connecting Rural Primary Roads.

F. TRAFFIC CONTROL – On Rural Secondary provided by traffic control signs.

G. FUNCTION – Rural Secondary Roads collect and distribute traffic between Rural Primary Roads and Rural Local Roads.

H. RIGHT-OF-WAY WIDTH – 60' minimum (Must be wide enough to accommodate roadside drainage requirements).

I. NUMBER OF MOVING LANES – two.

J. ACCESS CONDITIONS – Intersections will generally be at grade. Abutting properties and rural local streets will normally be allowed acceptable access to the street.

K. TRAFFIC CHARACTERISTICS – Movement of traffic will be controlled by signage. Parking shall be prohibited.

L. PLANNING CHARACTERISTICS – Rural Secondary Roads should be utilized as collector roadways for distribution of Rural Primary Road traffic.

M. STREET WIDTHS – 2-14' travel lanes; 2-6' shoulders plus necessary left turn and acceleration/deceleration lanes and variable width drainage ditch area (40' Edge of Shoulder – Edge of Shoulder).

N. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

O. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES – Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

P. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

Q. STREET GRADES – Minimum grade 1% maximum grade 6%.

R. CURB RADII – See Table 4.3.

4.2.8 Rural Local (2-Lane)

A. POSTED SPEED LIMIT – Greater than or equal to 25 mph. Posted or prima facie speeds for the various street classifications are normally 5-10 miles per hour less than the design speed of that street.

B. WIDTH – 2-lane width, plus additional turn lanes.

C. TRAFFIC VOLUMES – Generally less than 1,500 vehicles per day when the land in which the roadway serves is fully developed.

D. ACCESS – Direct access to adjacent parcels of land.

E. LIMITED CONTINUITY.

F. TRAFFIC CONTROL – On Rural Local provided by traffic signs.

G. FUNCTION – Traffic carried by Rural Local Streets should have an origin or destination within the neighborhood.

H. RIGHT-OF-WAY WIDTH – 50' minimum (Must be wide enough to accommodate roadside drainage requirements).

I. NUMBER OF MOVING LANES – two.

J. ACCESS CONDITIONS – Intersections will generally be at grade. Abutting properties shall normally be allowed acceptable access to the street.

K. TRAFFIC CHARACTERISTICS – Movement of traffic will be controlled by traffic control signs. Parking shall be prohibited.

L. PLANNING CHARACTERISTICS – Rural Local Roads should be designed to discourage through traffic. Access to rural primary roads is discouraged.

M. STREET WIDTHS – 2-14' travel lanes; 2-6' shoulders plus necessary left turn and acceleration/deceleration lanes and variable width drainage ditch area (40' flowline – flowline).

N. MINIMUM RADIUS OF CURVATURE ON CENTER LINE (HORIZONTAL); See Table 4.2.

O. MINIMUM LENGTH OF TANGENTS BETWEEN CURVES- Minimum Tangent length shall be equal to or greater than the sum of the Superelevation Runoff Length and the Tangent Runout Length. See Section 4.5.5.1.

P. MINIMUM LENGTH OF VERTICAL CURVES. See Table 4.6.

Q. STREET GRADES – Minimum grade 1% maximum grade 6%.

R. CURB RADII – See Table 4.3.

4.2.9 Roadway Specifications

Table 4.1 shows a summary of the minimum roadway construction requirements and other related information.

Table 4.1 ROADWAY CONSTRUCTION STANDARDS

	LOCAL	COLLECTOR		ARTERIAL			URBAN EXPRESSWAY
		MINOR	MAJOR	MINOR	MAJOR 4-LANE	MAJOR 6-LANE	
DESIGN SPEED	30-35	30-35	40	45	55	55	55
DRIVING LANES	2	2	4	4	4	6	8
MINIMUM R.O.W.	50'	76'	88'	114'	114'	144'	168'
ROADWAY WIDTH AND COMPOSITION OF CROSS SECTION AT INTERSECTION	34' 30' PAVED WIDTH 2-2' GUTTER PANS	50' 46' Paved 2-2' gutter pans	62' 58' paved 2-2' gutter pans	78' 74' paved 2-2' gutter pans	78' 74' paved 2-2' gutter pans	104' 100' paved 2-2' gutter pans	128' 124' paved 2-2' gutter pans
ROADWAY WIDTH AND COMPOSITION OF CROSS SECTION NOT AT INTERSECTION	SAME	SAME	76' 72' paved 2-2' gutter pans	SAME	SAME	SAME	
SIDEWALK, CURB GUTTER	COMBINATION, VERTICAL OR HIGH SPEED TYPE 2	VERTICAL OR HIGH SPEED TYPE 2 DETACHED 6' WALK	VERTICAL OR HIGH SPEED TYPE 2 DETACHED 6' WALK	VERTICAL OR HIGH SPEED TYPE 2 DETACHED 8' WALK	VERTICAL OR HIGH SPEED TYPE 2 DETACHED 8' WALK	VERTICAL OR HIGH SPEED TYPE 2 DETACHED 10' WALK	VERTICAL OR HIGH SPEED TYPE 2 DETACHED 10' WALK
CURB RETURN MINIMUM RADII							
-INTERSECT ARTERIAL	-	40'	40'	50'	50'	50'	50'
-INTERSECT COLLECTOR	30'	40'	40'	40'	40'	40'	-
-INTERSECT LOCAL	20'	30'	-	-	-	-	-
MINIMUM RADIUS AT CURVE AT CENTERLINE PER AASHTO	100-300'	300-475	700	900	Super Elevation is required see section 4.5.5		
MIN TANGENT LENGTH BETWEEN REVERSE CURVES	Min. 25 Equals the Super Elevation Runoff Length + Tangent Runout Length	Min. 90-105	Min. 120	Min. 132	Equals the Super Elevation Runoff Length + Tangent Runout Length		
MAXIMUM GRADE OF INTERSECTION							
-INTERSECT ARTERIAL	-	1%-3%	1%-3%	1%-2%	1%-2%	1-2%	1-2%
-INTERSECT COLLECTOR	1%-4%	1%-3%	1%-3%	1%-3%	1%-3%	1%-3%	-
-INTERSECT LOCAL	1%-4%	1%-4%	1%-4%	-	-	-	-
MIN-MAX STREET GRADIENT	1%-7%	1%-6%	1%-6%	1%-6%	1%-6%	1%-6%	1%-5%
VERTICAL ALIGNMENT CONTROL	See Table 4.6						
MINIMUM PAVEMENT SECTION	See Table 5.4						

TABLE 4.1 ROADWAY CONSTRUCTION STANDARDS CONT.			
	RURAL LOCAL	RURAL COLLECTOR	
		SECONDARY	PRIMARY
DESIGN SPEED	35	50	60
DRIVING LANES	2	2	4
MINIMUM R.O.W.	50'	60'	114'
ROADWAY WIDTH AND COMPOSITION OF CROSS SECTION AT INTERSECTION	40' 28' Paved 2-6' Gravel Shoulders	40' 28' Paved 2-6' Gravel Shoulders	60' 48' paved 2-6' Gravel Shoulders
ROADWAY WIDTH AND COMPOSITION OF CROSS SECTION NOT AT INTERSECTION	SAME	SAME	SAME
SIDEWALK, CURB GUTTER	Normally no Curb & Gutter or Sidewalk	Normally no Curb & Gutter or Sidewalk	Normally no Curb & Gutter or Sidewalk
CURB RETURN MINIMUM RADII -INTERSECT ARTERIAL -INTERSECT COLLECTOR -INTERSECT LOCAL	EOA Return same as Table 4.1	EOA Return same as Table 4.2	EOA Return same as Table 4.3
MINIMUM RADIUS AT CURVE AT CENTERLINE PER AASHTO	100-300'	See Table 4.2	See Table 4.2
MIN TANGENT LENGTH BETWEEN REVERSE CURVES	25	90-105	120
MAXIMUM GRADE OF INTERSECTION -INTERSECT ARTERIAL -INTERSECT COLLECTOR -INTERSECT LOCAL	1-3% desirable		
MIN-MAX STREET GRADIENT	1%-7%	1%-6% 7% in Mountainous Terrain	1%-6% 7% in Mountainous Terrain
VERTICAL ALIGNMENT CONTROL	See Table 4.6	See Table 4.6	See Table 4.6
MINIMUM PAVEMENT SECTION	As Defined by Pavement Design Report	As Defined by Pavement Design Report	As Defined by Pavement Design Report

4.3 SIDEWALKS, CURB/GUTTER, AND DRIVEWAYS

4.3.1 Roadway typical sections shall be as specified by these Standards**.** Details are located in Appendix A of these Standards.

4.3.2 Sidewalks or bicycle paths shall be constructed on both sides of all urban roadways unless specifically deleted by action of the Board of County Commissioners.

4.3.3 All sidewalks used in conjunction with vertical or high-speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) curb and gutter shall have a minimum width of five feet.

4.3.4 Combination curb, gutter and walk is approved for use on local roadways only. Vertical or high-speed Type 2 (Sections IM and IIM as defined by CDOT M & S Standards) curb, gutter and detached walk shall be used on all other roadways.

4.3.5 State law requires that handicap ramps be installed at all intersections and at certain mid-block locations for all new construction or reconstruction of curb and sidewalks. (CRS 42-2-107 {2}. Handicap ramps shall be constructed in accordance with the Arapahoe County Standards Details found in Appendix A of these Standards or the Americans with Disabilities Act Standards (most recent revision) whichever is more restrictive. Handicap ramps may be shown at all curb returns or called out by a general note on the development plans, but must be shown (located) at all "T" intersections. Whenever referencing a handicap ramp call out the specific Arapahoe County Standard Detail to be used to construct that ramp.

4.3.6 Curb cuts are allowed for commercial/industrial or high volume residential driveways. In general, when the number of parking spaces serviced by the driveway exceeds ten (10), radius returns are required (See Table 4.3 for flowline radius).

4.3.7 Where curb cuts are allowed based on traffic considerations, concentrated storm water runoff must not be discharged across the sidewalk. The Design Engineer is responsible for determining acceptable alternatives to convey flows. Sidewalk Chases will be strongly discouraged in new developments and will only be permitted as a Final Alternative. (See Section 4.4.6). If this is not possible due to grading restraints, radius returns and a crosspan must be used.

4.3.8 Curb cuts and driveways shall be constructed in accordance with the Arapahoe County Standard Detail Sp. 6 found in Appendix A of these Standards.

4.4 DRAINAGE

The minor and major storm drainage systems are designed in accordance with the Arapahoe County Storm Drainage Criteria Manual. Because safe and efficient conveyance of traffic is the primary function of roadways, the storm drainage function of the roadway (such as allowable gutter capacity and street overtopping) will be designed to the limits set forth in the Manual. In the case of conflict caused by requirements of the Manual, drainage requirements shall govern.

4.4.1 Crosspans

Crosspans shall be constructed in accordance with the Arapahoe County Standard Details (SP-7, in Appendix A). Crosspans are not permitted across collector or arterial roadways, nor are they allowed on roadways with storm sewer systems. Crosspans shall be a minimum of 8-feet wide, additional width may be required to accommodate drainage flows.

Double crosspans (crosspan on both sides of major roadway running parallel to one another) may be used parallel to collector or arterial roadways to convey storm runoff across residential roadways. The use of double crosspans elsewhere, or the use of any crosspan on roadways where

the vertical grade exceeds four and one-half (4.5) percent at the crosspan will be considered only after all other alternatives have been exhausted.

4.4.2 Inlets

Inlets shall be located to intercept the curb flow at the point curb flow capacity is exceeded by the storm runoff. Refer to Chapter 9 in the Manual for curb capacity. Inlets shall also be installed to intercept cross-pavement flows at points of transition in superelevation. Due to the presence of handicap ramps, inlets are not allowed in the curb return, but will be located at the tangent points of the curb returns.

4.4.3 Cross Slope

Except at intersections, or where superelevation is required, roadways shall be level from top of curb to top of curb (or flowline to flowline) and shall have a two (2) percent crown. At or within 150' of an intersection, the maximum elevation difference between flowlines is that dictated by the allowable intersection grade (Figure 4.3) and the actual distance between flowlines.

4.4.3.1 Parabolic or curved crowns are not allowed. In no case shall the pavement cross slope at warped intersections exceed the grade of the through street.

4.4.3.2 The rate of change in pavement cross slope, when warping side streets at intersections, shall not exceed one (1) percent every twenty-five (25) feet horizontally on a local roadway, one (1) percent every thirty-seven and one-half (37.5) feet horizontally on a collector roadway, or one (1) percent every fifty-six and one-half (56.5) feet horizontally on arterial roadways. See Section 4.6.6 of these standards.

4.4.4 Temporary Erosion Control

Temporary erosion control is required along and at the ends of all roadways that are not completed due to project phasing, subdivision boundaries, etc., in accordance with the Manual, Chapter 14, the Arapahoe County Grading, Erosion and Sediment Control (GESC) Manual and other approved Public Works and Development Administrative Procedures.

4.4.5 Permanent Erosion Control

Permanent Erosion Control is required for all new site development as well as redevelopment. All Permanent Erosion Control measures shall be performed in accordance with the Manual and the Arapahoe County Grading, Erosion and Sediment Control Manual (GESC).

4.4.6 Sidewalk Chases

Where curb cuts are allowed based on traffic considerations, concentrated storm water runoff must not be discharged across the sidewalk. The Design Engineer is responsible for determining acceptable alternatives to convey flows. Sidewalk Chases will be strongly discouraged in new developments and will only be permitted as a Final Alternative through the variance process (See Section 3.2). If this is not possible due to grading restraints, radius returns and a crosspan must be used. In the event a chase section is approved, the chase sections shall not be located within the curb cut or driveway. A hydraulic design shall be in required in accordance with the Manual. Approved Sidewalk chase sections are to be constructed in accordance with the Arapahoe County Standard Details found in Appendix A of these Standards.

4.5 HORIZONTAL ALIGNMENT

4.5.1 Horizontal Curves
See Table 4.2 below.

HORIZONTAL CURVES
TABLE 4.2

DESIGN SPEED (MPH)	AVERAGE RUNNING SPEED (MPH)	MAXIMUM DEGREE OF CURVATURE	MINIMUM CURVE RADIUS (FT) ROUNDED
15	15	114.60	50
20	20	63.66	90
25	24	32.74	175
30	28	20.83	275
35	32	12.73	450
40	36	9.54	600
45	40	6.74*	850*
50	44	4.77*	1200*
55	48	3.64*	1575*

* **Superelevation required at design speed 45 mph and up**
* **All design calculations for superelevation shall be submitted along with plan and profile**

4.5.2 Curb Return Radius
Minimum return radius shall be shown in Table 4.3 below.

TABLE 4.3
CURB RETURN RADII
AT 90º INTERSECTIONS
(MEASURED ALONG FLOWLINE)

THROUGH STREET	INTERSECTING STREETS		
	ARTERIAL	COLLECTOR	LOCAL SERVICE
ARTERIAL	50’	40’	NOT PERMITTED
COLLECTOR	40’	40’	*30’
LOCAL SERVICE	NOT PERMITTED	30’	*20’
* NO PARKING IS ALLOWED WITHIN 30-FEET OF PCR ON APPROACHES TO ALL CONTROLLED INTERSECTIONS. ALL OTHER APPROACHES AND DEPARTURES SHALL HAVE NO PARKING OR DRIVEWAY ACCESS WITHIN 20-FEET OF THE PCR,			

4.5.3 Design Speed
Horizontal alignment design speed shall be consistent with the requirement for vertical alignment design speed. If no superelevation is required and a normal crown section exists, the horizontal curve data, up to 40 mph, as shown in Table 4.2 shall be considered.

4.5.4 Barricades
Whenever roadways terminate due to project phasing, subdivision boundaries, etc., barricades are required. Design and construction shall comply with the requirements of the Manual of Uniform

Traffic Control Devices most recent edition. Details shall be shown on the construction drawings, and installation shall be provided by the developer.

4.5.5 Superelevation

Superelevation is required for curves on all roadway classifications of arterial designation or higher and for selected collector roadways that will require superelevation to function properly. Horizontal curve radius and superelevation shall be in accordance with the requirements detailed within this manual and the recommendations of all supporting references.

The use of Superelevation shall be avoided on all roadways with a design speed of 40 mph or less. If superelevation cannot be avoided on a roadway with a design speed of 40 mph or less all design criteria within these standards and recommendations of the AASHTO "Green Book" shall apply.

The use of Superelevation on County roadways with a design speed greater than 40 mph shall be designed in conformance with these standards and recommendations of the AASHTO "Green Book" shall apply.

The following procedure is an outline for the correct application of superelevation on roadways within Arapahoe County.

4.5.5.1 Definitions Regarding Superelevation

Superelevation Runoff – That length of roadway needed to accomplish the change in cross slope from a section with the adverse crown removed (flat) to the fully superelevated section, or vice versa.

Transition Points – Beginning or ending of tangent runout, superelevation runoff of full superelevation.

Tangent Runout – That length of roadway needed to accomplish the change in cross slope from a normal (2.0%) crown section with the adverse crown removed (flat), or vice versa.

4.5.5.2 General

One of the most important factors to consider in highway safety is the centrifugal force generated when a vehicle traverses a curve. Centrifugal force increases as the velocity of the vehicle and/or the degree of curvature increases.

In order to overcome the effects of centrifugal force, all curves must be superelevated. It is impossible to balance centrifugal force by superelevation alone, because for any given curve radius a certain superelevation rate is exactly correct for only one driving speed. At all other speeds there will be a side thrust either outward or inward, relative to the curve, which must be offset by side friction.

From the Law of Mechanics the basic formula that governs vehicular operation on a curve is:

$$\frac{0.01e+f}{1+0.01ef}=\frac{V^2}{gR}=\frac{0.067V^2}{R}=\frac{V^2}{15R}$$

e = Rate of Superelevation
f = Side Friction Factor
V = *Velocity in MPH*
R = Horizontal Curve Radius
g = Gravity

The Standard Equation used to determine Side Friction Factors is:

$$f = \frac{V^2}{15R} - 0.01e$$

The following table lists the acceptable friction factors on Low Speed Urban Roadways for superelevation design:

Design Speed	Friction Factor
15	.33
20	.30
25	.25
30	.22
35	.19
40	.18
45	.16

The following Table lists the acceptable friction factors for High Speed Urban Roadways for Superelevation Design:

Design Speed	Friction Factor
40	.15
50	.14
60	.12
70	.10
80	.08

The minimum radius for a given speed, rate of superelevation and side friction factor is:

$$R_{\min} = \frac{V^2}{15(f + 0.01e)}$$

4.5.5.3 Standards for Superelevation on State Roadways

CDOT'S M & S ("M" Standards) on Superelevation shall be used to determine the required rate of Superelevation for all state jurisdictional roadways.

The Division "M" Standards include tables that detail the required rate of Superelevation for various degrees of curvature along the horizontal curve. The applicable tables within the Division "M" Standards are as follows:

1. Table M-203-10 – Crowned Highways
2. Table M-203-11 – Divided Highways Shoulder Pivot
3. Table M-203-12 – Streets
4. Table M-203-13 – Divided Highways Center Pivot

Maximum superelevation rates of 0.04 to 0.06 foot per foot are commonly used on major streets. On freeways and expressways, maximum rates of 0.08 to 0.10 apply. The lower value should be used where snow and ice are significant factors, particularly on facilities with numerous bridges. In suburban areas, rural design criteria may be considered for freeways and other arterial on new location. Maximum superelevation rates of 0.08 to

0.10 are applicable for rural areas where there are no climatic problems, although future operational changes caused by increased urbanization should be considered.

4.5.5.4 Standards for Superelevation on County Roadways

When necessary the AASHTO "Green Book" design recommendations on superelevation shall be used to determine the required rate of superelevation for all roadways within Arapahoe County Jurisdiction that require superelevation. Superelevation shall be used for all curves on roadways of arterial designation or higher and for selected collector roadways that have no other options. It is strongly discouraged to have superelevation on local roadways.

Maximum superelevation rates of 0.04 to 0.06 foot per foot are commonly used on Arterial and Collector roadways, respectively, when superelevation is necessary. On local roadways superelevation should always be avoided, in the event superelevation is deemed necessary on a local roadway maximum rates of 0.04 to 0.06 shall apply. The lower value should be used where snow and ice are significant factors, particularly on facilities with numerous bridges.

Superelevation Runoff and Tangent Runout distances shall be measured from the point of curvature heading into the curve and from the point of tangency coming out of the curve. The roadway shall be at 85% of desired superelevation prior to entering the curve and must not begin transitioning back to a normal crown section until out of the curve.

The standard calculation is used to create AASHTO "Green Book" Exhibit 3-29 from the AASHTO "Green Book" 2001 to determine the Super Elevation Runoff Length for high-speed roadways:

$$L_r = \frac{(wn_1) * e_d}{\Delta}(b_w)$$

L_r = Minimum Length of Superelevation Runoff
Δ = Maximum relative gradient
n_1 = number of lanes rotated
b_w = adjustment factor for number of lanes rotated
w = width of one lane of traffic
e_d = design superelevation rate

The standard calculation is used to create AASHTO "Green Book" Exhibit 3-29 from the AASHTO "Green Book" 2001 to determine the Super Elevation Runoff Length for low-speed roadways:

$$L_r = \frac{47.2 f V^2}{C}$$

L_r = Minimum Length of Superelevation Runoff
C = Rate of change of friction factor
f = friction factor
V_d = Design Speed

The standard calculation is used to create AASHTO "Green Book" Exhibit 3-29 from the AASHTO "Green Book" 2001 to determine the Tangent Runout Length for both high-speed and low-speed roadways:

$$L_t = \frac{e_{nc}}{e_d}(L_r)$$

e_{nc} = normal cross slope (usually 2%)
e_d = design superelevation rate
L_r = Minimum Length of Superelevation Runoff
L_t = Tangent Runout Length

4.5.5.4 Urban Street Conditions

Every effort should be made to maintain standard rates of superelevation. However, in urban areas, street intersections, established street grades, curbs and drainage conditions may require a reduction in the rate of superelevation, or different rates for each half of the roadbed. In warping areas for drainage, adverse superelevation should be avoided.

4.5.5.5 Effect of Grade

Drivers tend to travel somewhat faster in the downgrade than in the upgrade direction. This should be recognized in the designs for divided highways and ramps on steep grades.

Where practical, the designer should use a higher design speed for the downgrade and a lower design speed for the upgrade. The variation of design speed will depend upon the rate and length of grade and the degree of curvature compared with other curves on the highway section.

4.5.6 Spiral Curves

Spiral curves shall be used only on arterial roadways within Arapahoe County (State Highways excluded) and only upon written approval of the Director, Public Works and Development. With approval from the Director, spiral curves shall be designed in accordance with the AASHTO "Green Book" (Chapter 4 in AASHTO "Green Book" 2001).

4.5.7 Railroad Crossings

The Arapahoe County Engineering Division strongly discourages at-grade railroad crossings. All railroad crossings should be designed as grade separated structures and will only be permitted at-grade in extreme circumstances.

All railroad crossings shall be designed in accordance with AASHTO "Green Book" and must be approved by the affected railroad company.

4.5.8 Cul-de-sacs

The following criteria shall be used for cul-de-sac horizontal geometry.

1.	Minimum property line radius	45'
2.	Minimum Flowline radius	38'
3.	Maximum length of cul-de-sac measured along & between the radius point, and the ROW line of the abutting street	500' length or a maximum of 15 residential dwelling units, whichever is greater.

Longer distances and/or increased number of dwelling units may be permitted with approval from the affected Fire Protection District and the Board of County Commissioners.

4.5.9 Sight Distances

4.5.9.1 General

The major considerations in alignment design are safety, grade, profile, road area, design speed, sight distance, topography, drainage, and performance of heavy-duty vehicles. Alignment should provide for safe and continuous operation at a uniform design speed. Road layout shall bear a logical relationship to existing or platted roads in adjacent properties.

4.5.9.2 Horizontal Alignment

a. Sight Distance. Horizontal alignment must provide at least the minimum stopping distance for the design speed at all points. This includes visibility at intersections as well as around curves and roadside encroachments.

b. Stopping Site Distance. The minimum stopping sight distance is the distance required by the driver of a vehicle traveling at the design speed to bring the vehicle to a stop after an object on the road becomes visible. Stopping sight distance is calculated in accordance with the AASHTO "Green Book", Latest Edition (see Exhibit 3-57, page 229-230 in AASHTO "Green Book" 2001). Object height is 6" above road surface and viewer's height is 3.50 feet above road surface.

Where an object off the pavement restricts sight distance, the minimum radius of curvature is determined by the stopping sight distance. In no case shall the stopping sight distance be less than as specified in Table 4.4. A likely obstruction may be a bridge abutment or line of column, wall, cut sideslope, or a side or corner of a building. The sight distance design procedure shall assume a 6'–0" fence (as measured from actual finished grade) exists at all property lines except in the sight-distance triangles required at all intersections.

The lateral clearance, inner edge of pavement to sight obstructions, for various radii of inner edge of pavement and design speeds, is shown graphically in AASHTO "Green Book" Exhibit 3-57. The position of the driver's eye and the object sighted are assumed to be 6' from the inner edge of pavement, with the sight distance being measured along this arc.

TABLE 4.4
STOPPING AND PASSING SIGHT DISTANCE

DESIGN SPEED (MPH)	STOPPING SIGHT DISTANCE	PASSING SIGHT DISTANCE
15	80	500
20	115	710
25	155	900
30	200	1090
35	250	1280
40	305	1470
45	360	1625
50	425	1835
55	495	1985
From AASHTO "Green Book" Exhibit 3-1 and Exhibit 3-7		

c. Passing Sight Distance. Passing sight distance is the minimum sight distance that must be available to enable the driver of one vehicle to pass another safely and comfortably without interfering with oncoming traffic traveling at the design speed. Two-lane roads should provide adequate passing zones. Required passing sight distance for given design speeds are given in Table 4.4.

d. Coefficient of Friction. The coefficient of friction (f) shall conform to the values shown in Table 4.5 for snowpacked conditions rather than as shown in Exhibit 3-13 of the AASHTO "Green Book", page 144.

TABLE 4.5
COEFFICIENT OF FRICTION
DESIGN CRITERIA FOR SNOWPACKED

DESIGN SPEED	*f*
30-40	0.24
40-50	0.22
50-60	0.21
60-70	0.20

4.5.9.3 Intersection Sight Distance

4.5.9.3.1 Sight Triangle – There shall be an unobstructed site distance along both approaches of both sides at an intersection and across their included corners for distances sufficient to allow the operators of vehicles, approaching simultaneously, to see each other in time to prevent collisions at the intersection. The sight triangle relationship developed for use in Arapahoe County is based upon the dimensions shown in detail SP-26 in Appendix A.

Any object within the sight triangle more than thirty-six (36) inches above the elevation of the adjacent roadway shall constitute a sight obstruction, and shall be removed or lowered. Such objects include: buildings, cut slopes, hedges, trees, bushes, utility cabinets or tall crops. This design criteria also requires the elimination of parking within the sight triangle and applies whether the intersecting roads are level or on grades.

4.5.9.3.2 **Departure Sight Distance** – The clear sight line for viewing traffic approaching from both the left and the right shall use the minimum intersection sight distance detailed in this manual.

4.5.9.3.2.1 The clear sight distance for viewing traffic approaching from the left (See AASHTO "Green Book" Exhibit 9-50) shall utilize Exhibit 9-55 from the AASHTO "Green Book" to determine the distance required for leg B of the Departure Sight Triangle. Leg A for a two-lane road shall always be ½ of the lane width + 14.5 feet. The distance for Leg A and Exhibit 9-55 will vary based on the width of the roadway.

4.5.9.3.2.2 The clear sight distance for viewing traffic approaching from the right (see AASHTO "Green Book" Exhibit 9-50) shall utilize Exhibit 9-58 from the AASHTO "Green Book" to determine the distance required for a leg B of the Departure Sight Triangle. Leg A for a two-lane roadway shall always be 1 lane + ½ of a lane width + 14.5 feet. The distance for leg A and the distances shown in AASHTO "Green Book" Exhibit 9-58 will vary based on the width of the roadway.

4.5.9.3.2.3 The impacts of median height and landscaping on departure sight distance shall also be evaluated. The evaluation of the distance shall also be evaluated. The evaluation of the sight distance shall take into account both when the trees are newly planted and once mature.

4.5.9.4 Vertical Alignment

Both the horizontal and vertical sight distance should be checked to insure that the sight distance along the major highway is sufficient to allow a vehicle to cross or turn left, whichever is required.

a. By determining graphically the sight distances on the plans and recording them at frequent intervals, the designer can appraise the overall layout and affect a more balanced design by minor adjustments in the plan or profile. Methods for scaling sight distances are demonstrated in AASHTO "Green Book" Exhibit 3-8. The exhibit also shows a typical sight distance record that would be shown on the final plans.

   Because the view of the roadway ahead may change rapidly in a short distance, it is desirable to measure and record sight distance for both directions of travel at each station. Both horizontal and vertical sight distances should be measured and the shorter lengths recorded. In the case of two-lane streets, passing sight distance in addition to stopping sight distance should be measured and recorded.

b. Horizontal sight distance on the inside of a curve is limited by obstructions such as buildings, hedges, wooded areas, high ground, or other topographical features. These generally are plotted on the plans. Horizontal sight is measured with a straightedge, as indicated at the upper left in AASHTO "Green Book" Exhibit 3-8. The cut slope obstruction is shown on the worksheets by a line representing the proposed excavation slope at a point 2.0' (average of 3.50 and 0.5') above the road surface for stopping sight distance and at a point about 3.75' above the road surface for passing sight distance. The position of this line

with respect to the centerline may be scaled from the plotted roadway cross sections. The topping sight distance should be measured between points on the one traffic lane, and passing sight distance from the middle of one lane to the middle of the other lane as outlined in AASHTO "Green Book" Exhibits 3-57a and 3-57b.

c. Vertical sight distance may be scaled from a plotted profile by the method illustrated at the right center of AASHTO "Green Book" Exhibit 3-8. A transparent strip with parallel edges 3.5 feet apart and with a scratched line 2.00' from the upper edge, in accordance with the vertical scale, is a useful tool. The lower edge of the strip is placed on the station from which the vertical sight distance is desired, and the strip is pivoted about this point until the upper edge is tangent to the profile. The distance between the initial station and the station on the profile intersected by the 2.00' line is the stopping sight distance. The distance between the initial station and the station on the profile intersected by the lower edge of the strip is the passing sight distance.

d. A simple sight distance record is shown in the lower part of AASHTO "Green Book" Exhibit 3-8. Sight distances in both directions are indicated by arrows and figures at each station on the plan and profile sheet of the proposed highway. To avoid the extra work of measuring unusually long sight distances that may occasionally be found, a selected maximum value may be recorded. In the example shown, all sight distances of more than 3,000' are recorded as 3,000+, and where this occurs for several consecutive stations, the intermediate values are omitted. Sight distances less than 1,000' may be scaled to the nearest 50' and those greater than 1,000' to the nearest 100'.

e. The methodology of graphically determining sight distances may well require longer stopping sight distances than noted in Table 4.4 or AASHTO "Green Book" Exhibits 3-57a and 3-57b. However, in urban design, the combination of horizontal curves, vertical curves and intersections occurring at the same time is very real. The graphic solution then is a simple means to determine the controlling sight distances.

4.6 VERTICAL ALIGNMENT

Design controls for vertical alignment are shown on Table 4.6 below.

TABLE 4.6
VERTICAL ALIGNMENT CONTROLS

DESCRIPTION	DESIGN SPEED*	MAXIMUM GRADE**	K VALUE CREST***	K VALUE SAG***	V.C.L. MIN. CREST	V.C.L. MIN. SAG
LOCAL	35	7	35-50	40-50	50	50
MINOR COLLECTOR	35	6	35-50	40-50	50	50
MAJOR COLLECTOR	40	6	55-65	65-80	50	50
MINOR ARTERIAL	45	6	65-85	80-95	70	80
MAJOR ARTERIAL	55	6	115-190	115-140	110	90
EXPRESSWAY	60	5	155-300	140-155	150	100
FREEWAY	60	5	155-300	140-155	150	100

* The design speed is a minimum of five (5) mph over the posted speed for each classification.

** The maximum grades indicated should only be used in extreme topographic conditions. The designer should strive to minimize the use of these grades for considerable lengths and on north facing slopes.

***K values exceeding 125 on curbed streets should be checked for drainage. Multiple inlets may be required within long sag vertical curves where the longitudinal slope is less then 0.4%.

4.6.1 Permissible Roadway Grades

The minimum allowable grade for roadways or alleys is one (1) percent. The minimum allowable grade for knuckles and cul-de-sacs is one (1) percent. The **maximum** allowable grade for any roadway is shown in Table 4.6 of these Standards. In areas where a one percent slope is difficult to obtain a variance to this criteria may be granted if deemed appropriate by Staff.

4.6.2 Permissible Intersection Grades (Public Right-of-Way)

The maximum permissible centerline grade at intersections will be four (4) percent for local roadways intersecting any roadway, three (3) percent for collector/collector or collector/arterial intersections and two (2) percent for all arterial/arterial intersections. These grades are maximum instantaneous flowline grades for the stated distances (each side of street) of the minor (intersecting) street (See Detail SP-25 in Appendix A). Desirable intersection grades should be in the range of one (1) to three (3) percent for all intersecting streets with the limit of two (2) percent for arterial.

Then, intersection grade of the major (through) street at the intersection may be dictated by design considerations for that street. However, if the major street intersection grade exceeds 3% the type of access and access control will be dictated by Arapahoe County.

4.6.3 Changing Grades

The use of grade breaks in lieu of vertical curves is discouraged. However, if a grade break is necessary and the algebraic difference in grade (A from the equation K=L/A) does not exceed eight tenths (0.008 ft./ft.) of a percent along the roadway, the grade break will be permitted.

The maximum grade break allowed at the point of tangency at a curb return for local and collector roads shall be two (2) percent and for arterial roadways a maximum of one (1) percent.

4.6.4 Cross Fall

Except at intersections, or where superelevation is required, roadways shall be level from top of curb to top of curb (or flowline to flowline). The distance from intersections with which cross fall will be permitted shall be determined by criteria in Section 4.4.3, Cross-Slope.

4.6.5 Vertical Curves

When the algebraic difference in grade (A) is at or exceeds eight-tenths (0.008) ft/ft) of a percent, a vertical curve shall be used. Design criteria for vertical curves is found in Table 4.6 of these standards. The minimum gradient into and out of a sag (sump) vertical curve is 1 percent (0.01 ft/ft). Minimum length of a vertical curve is shown in Table 4.6 of these standards. All vertical curves shall be labeled, in the profile, with length of curve (L) and K (=L/A) values.

4.6.6 Intersections

In addition, the following criteria shall apply at intersections.

4.6.6.1 The grade of the "through" street shall take precedence at intersections. At intersections of roadways with the same classification, the more important roadway, as determined by the Arapahoe County Engineering Division, shall have this precedence. The design should warp side streets to match through streets with as short a transition as possible. See below.

4.6.6.2 The key criteria for determining the elevation of the curb return on the side street and the amount of warp needed on a side street transitioning to a through street are:

A. Permissible grade in the stop/start lane. (See Section 4.6.2 of these Standards).

B. Pavement cross slope at the P.C.R.'s on the side street and permissible warp in pavement cross slope. (See Section 4.4.3 of these Standards).

C. Normal vertical curve criteria. (See Section 4.6.5 of these Standards).

D. Vertical controls within the curb return itself. (See Section 4.6.8 of these Standards).

4.6.6.3 The elevation at the PCR of the curb return on the through street is always set by the grade of the through street in conjunction with normal pavement cross slope allowances.

4.6.6.4 Carrying the crown at a side street into the through street is permitted only when drainage considerations warrant such a design. Refer to Section 4.4.3.2 for street cross slope allowances.

4.6.6.5 Dipping the flowline to the extent that the lip of gutter is dipped is not permitted, except as specified by Arapahoe County Standards Details concerning curb opening inlets. Tipping an inlet for the benefit of drainage is also not permitted.

4.6.6.6 A more detailed review shall be performed for arterial-arterial intersections to maximize drivability. Few arterial intersections will have a uniform 2% cross slope, the majority of them having one or more sides warped. (See Sections 4.4.3 and 4.6.6 of these standards for rates of pavement warp allowed). A Plan View drawing of all arterial/arterial intersections will be required showing spot elevations on a 10-foot by 10-foot grid.

4.6.6.7 Whenever possible, intersections shall be made at right angles or radial to a curve. No intersecting angle of less than seventy-five (75) degrees will be allowed.

4.6.7 Curb Returns

Minimum fall around curb returns for flow along the curb line shall be as follows:

CURB RETURNS
TABLE 4.7

RADIUS	MINIMUM FALL
20	0.40'
25	0.50'
30	0.60'
35	0.70'
40	0.80'
50	1.00'
All Others	1.27% around the Curb Return or from the High/Low Point to the PCR

4.6.8 Curb Return Profiles

Curb return profiles are required for all curb return radii equal to or greater than twenty-five (25') feet within the public right-of-way. A midpoint elevation along the arc length of the curb return shall be shown for all curb return radii. Curb return design shall be set in accordance with the

following design procedure. Curb Return Profiles shall be extended 100-feet in each direction to ensure adequate design with impacted roadways. General standards for flowline control and profiles within the curb returns shall be as follows:

4.6.8.1 The point of tangency at each curb return shall be determined by the projected tangent grade beginning at the point of intersections (PI) of the flowlines.

4.6.8.2 The arc length and external distance of the curb return shall be computed and indicated on the drawing.

4.6.8.3 Show the corresponding flowline (or top of curb) grade for 100-feet on each roadway beyond the PCR.

4.6.8.4 Design the flowline of the curb return such that a maximum cross slope between the midpoint of the curve and the PI (tangent intersect) does not exceed +5 percent. Grade breaks are the PCR's will not exceed two (2) percent for local and collector streets and one (1) percent for arterial. The flowline design of the curb return will be accomplished within the return without affecting street grades beyond the PCR. Maximum vertical curves will equal the arc length of the curb return. The elevation and location of the high or low point within the return, if applicable, is to be called out in the profile.

4.6.8.5 Scale for the curb return profile shall match the plan and profile scale the curb return is shown on. The scale shall not exceed 1" = 50' horizontally and 1" = 5' vertically.

4.6.9 Connection With Existing Roadways

4.6.9.1 Connection with existing roadways shall be smooth transitions conforming to normal vertical curve criteria (see Section 4.6 of these Standards) if the algebraic difference in grade (A) between the existing and proposed grade exceeds eight tenths (0.008 ft/ft) of a percent. When a vertical curve is used to make this transition, it shall be fully accomplished prior to the connection with the existing improvement, and also comply with the grade requirements at intersection approaches.

4.6.9.2 Existing grade shall be shown for at least three-hundred (300) feet with field verified as-builts showing stations and elevations at twenty-five (25) foot intervals. In the case of connection with an existing intersection, these as-builts are to be shown within a three-hundred (300) foot radius of the intersection. This information will be included in the plan and profile that shows that proposed roadway.

4.6.9.3 Previously approved designs are not acceptable means of establishing existing grades. However, they are to be referenced on the construction plans, where they occur.

4.6.9.4 The basis of the as-built elevations shall be the same as the design elevation (both flowline or both top of curb, etc.) when possible.

4.7 ROADSIDE DESIGN CRITERIA

4.7.1 Recovery Zones

Recovery Zone is the area adjacent to a roadway that is needed to recover a vehicle when it leaves the roadway. This area must meet certain slope requirements and be clear from any obstructions or additional safety measures may be required. On foreslopes (also called fillslopes) a slope of 4:1 or flatter is considered recoverable. Non-recoverable foreslopes (slopes ranging from 3:1 to 4:1) shall be designed in accordance with the AASHTO Roadside Design Guide. Critical foreslopes (slopes steeper than 3:1) shall require guardrail or other form of roadside barrier if closer to the traveled roadway than the recommended clear zone distance (see Section 4.7.2).

4.7.2 Clear Zones

Clear Zones are the distance necessary to meet the recovery zone slope requirements for safe recovery of a motor vehicle in the event it leaves the roadway. Acceptable clear zone distance shall be determined utilizing the latest version of the AASHTO Roadside Design Guide (See Figures 3.1a and 3.1b from the 2001 AASHTO Roadside Design Guide) for determining clear zone distance for slopes of 4:1 or flatter.

4.7.3 Obstructions

Roadside obstructions include both non-traversable terrain and fixed objects (inlets, trees, buildings, pedestrians, etc.). Roadside obstructions within the clear zone are strongly discouraged. In the event that obstructions do exist within the clear zone, Roadside Barrier Warrants shall be checked to determine if a roadside barrier is necessary. In the event warrants are met the applicant shall be responsible for providing an acceptable type of roadside barrier.

4.7.4 Guard Rail Requirements

Guard Rail Requirements shall meet or exceed the minimum standards set for in the AASHTO Roadside Design Guide, Chapters 3, 5 and 10. Guard Rail options may also be selected using the CDOT M & S Standards.

4.8 OFFSITE DESIGN

The design grade, and existing ground at that design grade, of all roadways that dead end due to project phasing, subdivision boundaries, etc., shall be continued, in the same plan and profile as the proposed design, for at lease five hundred (500) feet or to its intersection with an arterial roadway as determined by County Engineering Division Staff. This limit shall be extended to one thousand (1,000) feet when arterial roadways are being designed.

4.8.1 If the offsite roadway, adjacent to the proposed development is not fully improved, the developer is responsible for the design and construction of a transition for the safe conveyance of traffic from his improved section to the existing roadway. The following ratios shall be applied to the taper of lane change necessary for this transition:

Redirect Taper Ratios

Posted Speed Limit	30 or less	35	40	45	50	55	60	65	70
Taper Ratio	15:1	20:1	30:1	45:1	50:1	55:1	60:1	65:1	70:1

4.8.2 The County Engineering Division Staff should be contacted to establish unusual criteria. This contact is the responsibility of the applicant.

4.9 ACCELERATION AND DECELERATION LANES

The design of the collector and arterial street systems depends upon the proper control of access to developments. The location and design of access points must minimize traffic hazards and interference to through traffic movements. To ensure proper access control, the following standards for deceleration lanes have been established. The need for deceleration lanes is established by the approved Traffic Impact Study for the Final Plat or Final Development Plan.

4.9.1 Requests for exemption from the requirements for acceleration and deceleration lanes shall be based upon a traffic engineering study that presents trip generation data for the proposed development in terms of impacts upon through traffic flows. Such requests shall be reviewed by the Traffic Engineer and may be approved, except if any of the following conditions exist during the long range traffic planning horizon:

4.9.1.1 For exemption of a right turn Deceleration Lane the traffic volume in the travel lane must fall below 150 vph (vehicles per hour) during both A.M. and P.M. peak hour.

4.9.1.2 For exemption of a left turn deceleration lane the opposing traffic volume must fall below 100 vph during both the A.M. and P.M. peak hour.

4.9.1.3 For exemption of a right turn acceleration lane the traffic volume in the travel lane must fall below 120 vph during both the A.M. and P.M. peak hour.

4.9.1.4 For exemption of a left turn acceleration lane the traffic volume in the inside travel lane must fall below 120 vph during both the A.M. and P.M. peak hour.

4.9.1.5 Other unique condition determined by the review engineer that warrants special design consideration.

4.9.2 Acceleration and deceleration lanes may be required along segments of collector streets if the proposed development constitutes a potential for creating a traffic hazard or unnecessarily impedes through traffic movements. In the event that acceleration or deceleration lanes are required for a collector roadway, the designing engineer shall conform to all of the acceleration and/or deceleration lane design standards detailed in the latest edition of the AASHTO "Green Book".

4.9.3 Acceleration and deceleration lanes shall have a minimum paved width of eleven feet (11') unless otherwise approved at a lesser width by the Director, PWD.

4.9.4 The design minimums for acceleration and deceleration lanes on Arterial roadways was determined using the minimum standards set forth in the "State of Colorado State Highway Access Code Volume 2". The following tables detail the requirements for the determination of Roadway Classification, Acceleration and Deceleration Lengths, Taper Lengths, Storage Lengths and when each of the criteria should be accounted for in design.

4.9.5 The access classification should be determined by utilizing the Arapahoe County Transportation Plan roadway designations and then determining the corresponding access classifications. The table below lists the Access Classification for Arterial and Expressways:

ACCESS CLASSIFICATION
TABLE 4.10
FOR ARTERIALS AND EXPRESSWAYS

ROADWAY TYPE	ACCESS CLASSIFICATION
MINOR COLLECTOR	NR-C
MAJOR COLLECTOR	NR-C
MINOR ARTERIAL	NR-B
MAJOR ARTERIAL	NR-B
URBAN EXPRESSWAY	NR-A

FROM THIS STATE OF COLORADO STATE HIGHWAY ACCESS CODE VOLUME 2, CODE OF COLORADO REGULATIONS 601-1

4.9.6 The Components of Speed Change Lanes vary based on the roadway access classification. The table below lists the components for speed change lanes for each access classification:

COMPONENTS OF SPEED CHANGE LANES LENGTH
TABLE 4.11
FOR ARTERIALS AND EXPRESSWAYS

ACCESS CLASSIFICATION	LEFT TURN DECELERATION	RIGHT TURN DECELERATION	ACCELERATION
NR-B	TAPER + STORAGE	TAPER + STORAGE	ACCEL. LENGTH
NR-C	TAPER + STORAGE	TAPER + STORAGE	ACCEL. LENGTH
NR-A	DECEL LENGTH + STORAGE	DECEL LENGTH	ACCEL. LENGTH

FROM THE STATE OF COLORADO STATE HIGHWAY ACCESS CODE VOLUME 2, CODE OF COLORADO REGULATIONS 601-1

4.9.7 The minimum Acceleration and Deceleration Lengths for Arterials and Expressways are detailed in the following table:

ACCELERATION AND DECELERATION LENGTHS
TABLE 4.12
FOR ARTERIALS AND EXPRESSWAYS

DESIGN SPEED (MPH)	MIN. LENGTH (FEET) ACCEL.	MIN LENGTH (FEET) DECEL.
30	**190**	**250**
35	**270**	**310**
40	**380**	**370**
45	**550**	**435**
50	**760**	**500**
55	**960**	**600**

4.9.8 The minimum storage length required based on turning vehicles per hour is detailed in the following table:

ACCELERATION AND DECELERATION STORAGE LENGTH
TABLE 4.13
FOR ARTERIALS AND EXPRESSWAYS

VEHICLES PER HOUR	BELOW 30 VPH	30 VPH	60 VPH	100 VPH	200 VPH	300 VPH
REQUIRED LANE LENGTH	25’	40’	50’	100’	200’	300’

4.9.9 The lead-in taper length for the deceleration lane shall be based upon the posted speed limit along the street, except that a minimum of one hundred sixty (160') shall be required. The following table details the taper ratios for each possible posted speed limit:

DECELERATION TAPER LENGTH
TABLE 4.14
FOR ARTERIALS AND EXPRESSWAYS

POSTED SPEED (MPH)	TAPER RATIO
30	8:1
35	10:1
40	12:1
45	13.5:1
50	15:1
55	18.5:1
60	25:1
65	25:1

4.9.10 Deceleration lanes shall be provided for all exclusive right-turn access points: i.e., right-in/right-out driveways.

4.9.11 The deceleration lane and the associated signage and pavement marking shall be installed, as per the requirements established by the Traffic Engineer, prior to the issuance of any Certificate of Occupancy within the development.

4.10 BUS PULLOUT LANES

If recommended by the Regional Transportation District, bus pullout lanes shall be designed and construction by the adjacent subdivider.

4.10.1 The design of the pullout lanes will be governed by dimensions shown in Table 4.15 and shall be reviewed and approved according to procedures set forth in these Design Standards. Bus pullout lanes shall be constructed using Portland Cement Concrete using the methodologies described in the MGPEC Pavement Design Standards and Construction Specifications.

BUS PULLOUT LANES
TABLE 4.15

POSTED SPEED (MPH)	LEAD-IN LENGTH	LEAD-OUT LENGTH
30	60'	60'
40	100'	70'
45	150'	80'
50	200'	90'
55	250'	100'

4.10.2 The Pavement Design Soils Report (see Chapter 5) shall consider the requirements of the pullout lane separately from the adjacent roadway.

4.10.3 Bus pullouts shall be construction with no less than 50 feet between an intersection curb return curve (PC) and the beginning of the lead-in taper.

4.11 PRIVATE ROAD CRITERIA

The following minimum requirements shall apply to all applications for private roadways.

4.11.1 Definition

Private Road is defined as any roadway, serving two or more residential lots, which will not be maintained by Arapahoe County.

4.11.2 County Policy

Arapahoe County will only consider assuming ownership and maintenance of any private road if the roadway in question was designed by a registered Professional Engineer in the State of Colorado and the roadway meets all applicable Standards for Public Roadways including paving requirements.

4.11.3 Use, Placement and Maintenance

4.11.3.1 Use of a Private Roadway

Private Roadway use in subdivision design may be appropriate if all of the following are present:

- Common Ownership of the Private Roadway can be established and the roadway serves as access only to those within the common ownership.
- Financial Participation from a common ownership can be demonstrated to provide perpetual maintenance of the Private Roadway.
- The roadway does not interrupt or prelude continuity of present or planned Public Roadway connections.
- The Roadway carries less than 1,500 vehicles per day with direct backing access or 2,500 vehicles per day without direct backing access.

4.11.3.2 Placement

Private Roadways shall be placed in a tract of common ownership (typically a Homeowner's Association for residential property). The roadway tract must contain all appurtenances to the private roadway, including but not limited to; curb, gutter, sidewalk, and associated drainage facilities. Requests for placing detached sidewalk in an easement instead of a tract will be considered on a case-by-case basis.

4.11.3.3 Maintenance

The roadway tract owner must demonstrate that perpetual maintenance of the private roadway can be provided for by implementation of a viable maintenance plan (as described in 4.11.4.3).

4.11.4 Submittal Requirements

4.11.4.1 Pavement Design

4.11.4.1.1 Private Roadway shall be paved with materials and methods consistent with the Arapahoe County Land Development Code and the Standards for Paving Public Roads detailed in this manual.

4.11.4.1.2 Private Roadway applications shall include a pavement design in conformance with the Pavement Design and Technical Criteria (see Chapter 5).

4.11.4.2 Cost Estimate

4.11.4.2.1 Private Roadways, sidewalks, and roadway appurtenances costs shall be included as a necessary improvement within the Subdivision Improvement Agreement (SIA) and subject to collateral in a form accepted by the County.

4.11.4.3 Maintenance Plan/Life Cycle Cost Analysis

4.11.4.3.1 Proposals for Private Roadways shall include a plan for perpetual maintenance of the roadway. This plan shall be prepared and certified by a Colorado Licensed Professional Engineer, and shall contain:

A) A life cycle cost analysis with a minimum design life of 20-years and utilizing a 4% rate to account for annual inflation and construction cost increases.
B) Estimated current costs of proposed roadway, curb, gutter and sidewalk construction (installed).
C) Schedule and cost of major maintenance events as chip or fog sealing, resurfacing, etc.
D) Cost of annual and routine maintenance such as crack sealing, pothole repair, etc.
E) Projected future value cost of replacement at the end of the design life.
F) If restricted parking sections are proposed, include a plan for no parking enforcement and an estimate for annual enforcement costs.
G) Identify the proposed method of implementation of a funding mechanism for plan (i.e. HOA fees, fees with property sales deposited to escrow, district formation and taxation, etc.).
H) If fees are the selected funding mechanism in G) above, provide an estimated monthly cost, per developed unit, calculated to demonstrate adequate funding to provide perpetual maintenance of the roadway. If district formation is selected, provide a copy of the district service plan and letter of intent to form said district.
I) Certification and statement by a Colorado Licensed Professional Civil Engineer indicating that the report was prepared by, or under direct supervision of said licensed professional.
J) Certification and Statement of owner of intent to implement the plan as a mechanism for perpetual maintenance of roadway.

4.11.4.3.2 Construction Plans

4.11.4.3.2.1 Construction Plans shall be submitted in conformance with Chapter 4 of these Standards.

4.11.4.3.3 Intersections

4.11.4.3.3.1 Private intersections with other private roads may require an increase in the roadway pavement width at the approach to accommodate storage, additional laneage and provide for proper roadway alignment.

4.11.4.3.3.2 Private intersections with public roads: Private roads shall meet all public roadway standards at the intersection. Transitions of pavement width and transition distance will be reviewed on a case-by-case basis.

4.11.4.4 Private Roadway Attributes – Urban Areas

4.11.4.4.1 Pavement widths will vary with the amount of on-street parking proposed. Intersections, drainage crossings or special conditions may require additional pavement width, as determined on a case-by-case basis.

4.11.4.4.1.1 No on-street parking

- Option is not allowed.

4.11.4.4.1.2 Parking One Side (See Appendix for cross section)

- A 26-foot minimum paved section (two 10-foot drive lanes plus 6-foot parking lane).
- Approval of the local fire jurisdiction.
- Posting of one side roadway "NO PARKING".
- Enforcement of "NO PARKING" areas by tract owner, by development plan notes, HOA Covenants, etc.
- On-street Parking shall be adjacent to sidewalk.

4.11.4.4.1.3 Parking Both Sides (See Appendix for cross section)

- A minimum 30-foot paved section (equivalent to Public Local Roadway Section).

4.11.4.5 Private Roadway Attributes – Rural Areas (See Appendix for cross section)

- A 20-foot minimum paved section (two 10-foot driving lanes).
- Approval of the local fire district.
- Posting of Roadway "NO PARKING".
- Enforcement of "NO PARKING" by tract owner, development plans, HOA covenants, etc.
- Curb and gutter not required if determined a rural area by County Staff.
- A 6-foot gravel shoulder on each side of roadway, consisting of a minimum 6-inch deep aggregate base course.
- A roadside ditch of sufficient drainage capacity (4:1 max side slopes).
- Culverts are required at all driveways (minimum 18-inch CMP but must meet capacity requirements of Arapahoe County Storm Water Manual for roadway overtopping).
- Rural areas are not required to place sidewalk but may be required to provide continuity of trail systems and/or pedestrian paths.

4.11.4.6 Required Signage On All Private Roadways

- Privately maintained roadways will be posted "PRIVATE DRIVE – This road is owned and maintained by Name of Owner of HOA".
- Privately maintained roadways shall include signage and striping consistent with the Manual on Uniform Traffic Control Devices (MUTCD) latest Edition.

4.11.4.7 Horizontal and Vertical Geometric Design

- All roadway design criteria for both horizontal and vertical geometrics shall conform to the standards detailed for public roadways in this manual.

4.12 RURAL ROADWAY CRITERIA

4.12.1 Drainage

4.12.1.1 All rural roadways shall convey storm water flows via roadside ditch (maximum 4:1) sideslopes to predetermined roadway drainage crossings.

4.12.1.2 Roadway drainage crossings shall consist of reinforced concrete pipe (18" minimum), reinforced concrete box culverts or bridges.

4.12.1.3 Access driveways shall convey storm water flows utilizing culverts (18" minimum CMP).

4.12.2 Horizontal alignment and curves shall meet or exceed the minimum standards for urban roadway design. In areas where the design criteria is either extremely difficult to obtain or cost prohibitive

a variance to this criteria may be sought and approved if deemed appropriate by Engineering Staff and the Board of County Commissioners.

4.12.3 Vertical alignment and curves shall meet or exceed the minimum standards for urban roadway design. In areas where the design criteria is either extremely difficult to obtain or cost prohibitive a variance to this criteria may be sought and approved if deemed appropriate by Engineering Staff and the Board of County Commissioners.

4.12.4 Proposed intersections shall meet or exceed the minimum standards for urban roadway design. In areas where the design criteria is extremely difficult to obtain or cost prohibitive a variance may be sought and approved if deemed appropriate by the Engineering Staff and the Board of County Commissioners.

4.12.5 Acceleration and deceleration requirements shall conform to Section 4.9 of this manual.

4.13 CONSTRUCTION TRAFFIC CONTROL

4.13.1 Pedestrian Traffic

4.13.1.1 Every precaution shall be taken to ensure that construction work does not interfere with the movement of pedestrian traffic, which shall be maintained on the sidewalk at all times. Flagmen shall be provided for guidance as necessary.

4.13.1.2 Where an excavation interrupts the continuity of the sidewalk, the contractor shall provide suitable bridge or deck facilities, to be supplemented by the use of such proper devices and measures as prescribed in the Manual of Uniform Traffic Control Devices (MUTCD) most recent edition, for the safe and uninterrupted movement of pedestrian traffic. The edges or ends of the pedestrian bridge or decking shall be beveled or chamfered to a thin edge to prevent tripping.

4.13.1.3 Temporary diversion walkways shall be hard surfaced and electric lighting shall be provided and kept continuously burning during hours of darkness, when required by the Director, PWD.

4.13.1.4 Unless otherwise authorized by the Director, PWD pedestrians shall not be channeled to walk on the traveled portion of a roadway.

4.13.1.5 Under certain conditions, it may be necessary to divert pedestrians to the sidewalk on the opposite side of the street. Such crossings shall only be made at intersections or marked pedestrian crossovers.

4.13.1.6 Facilities satisfactory to the Director, PWD shall be provided for pedestrians crossing at corners, pedestrian crossovers and public transportation stops.

4.13.2 Vehicular Traffic

4.13.2.1 Construction work zone traffic shall be controlled by signs, barricades, detours, etc. which are designed and installed in accordance with the MUTCD most recent edition, and applicable Arapahoe County Traffic Standards. Traffic control plan shall be submitted and approved by the Director, PWD or his designate prior to start of any construction.

4.13.2.2 During construction of new facilities, traffic control should strive to keep the motorist from entering the facility. The primary means to accomplish this are the use of temporary barricades, located in advance of the point where new construction joins existing and by appropriate signing. New construction shall not be opened to traffic, and

thus the construction traffic control removed, without the approval of the Chief Engineering Inspector and the Traffic Engineer.

4.13.2.3 In general terms, a construction traffic control plan must be drawn on a map. For minor projects or local roadways, a neat sketch of the roadways and the proposed control devices will suffice. For major projects **or** major roadways, the traffic control plan should be superimposed on as-builts, construction plan drawings, or other detailed map.

4.13.2.4 The MUTCD shall be the basis upon which the construction traffic control plan is designed, in concert with proper, prudent, and safe engineering practice. All necessary signing, striping, coning, barricading, flagging, etc., shall be shown on the plan.

4.13.2.5 In concept, County streets shall not be closed overnight, and work shall not force road or lane closures before 8:30 a.m. or after 3:30 p.m. If exceptions to this are required, this shall be so noted on the construction traffic control plan and must be specifically approved by the Director, PWD. Roadway closures exceeding 10 days shall be approved through the Board of County Commissioners.

4.13.2.6 Directional access on roadways may be restricted (minimum travel lane width in construction area is 10'), but proper controls including flagging must be indicated. Removal of on-street parking should be considered, and noted where applicable.