6 DESIGN CRITERIA

6.1 Geometric Design Criteria

A Roadway Alignment Design Criteria Memo was prepared to present design criteria that guided the design and development of the preliminary plans and provide the basis for final design and construction documents. Design criteria were developed for:

- Design Speed
- Design Vehicle
- Sight Distance
- Geometric Alignment
- Intersection and Signalization
- Bicycle Lanes
- Bus Pullouts
- Bus Stops and Pullouts
- Toucan Pedestrian Crossings
- Pelican Pedestrian Crossings

The design criteria were developed based on the following documents:

- A Policy on Geometric Design of Highways and Streets 2004, 5th Edition, American Association of State Highway and Transportation Officials
- Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities, Institute of Transportation Engineers
- A Guide for Achieving Flexibility in Highway Design, May 2004, American Association of State Highway and Transportation Officials
- Guide for the Development of Bicycle Facilities, 1999, American Association of State Highway and Transportation Officials

Table 12 is a summary of roadway design criteria. Selected design criteria are further discussed in the following sections.

Table 12. Roadway Geometric Design Criteria Summary

Design Element	Design Criteria
Design Year	2030
Design Speed/Posted Speed	35 mph/35 mph
Design Vehicle	Indirect Left Turn-Around/Channelized Right: WB-67 Dual Left Turn: SU (inside lane), WB-50 (outside lane) Right Turn: WB-50 Single Left Turn: WB-50 Toucans/Mountain Ave: SU (all movements)

Table 12. Roadway Geometric Design Criteria Summary (continued)

Design Element	Design Criteria
Lane Width	11-ft. curb/uncurbed – Grant Road and cross streets *See Roadway Design Criteria, Detail A1 and Detail A2*
Bike Lane Width	6-ft. plus 1-ft. buffer (7-ft. total) for outside and between lanes – Grant Road, See *Roadway Design Criteria, Detail A1 and Detail A2* 5-ft. outside lane and between lanes for cross streets
Median Width	17-ft. *See Roadway Design Criteria, Detail A1 and Detail A2*
Sidewalk Width	8-ft. min., 20-ft. sidewalk/landscape area 6-ft. min., 9-ft sidewalk landscape area for cross streets *See Roadway Design Criteria, Detail A1 and Detail A2*
Right Turn Lane Width	12 feet – Grant Road and cross streets
Left Turn Lane Width	Single: 11-ft. – Grant Road and cross streets Dual: 11-ft. inside and 12-ft. outside plus 6-ft. offset/island
Minimum Radius	1400 feet
Minimum Length of Curve/Tangents	150 feet
Indirect Left Turn-Around Layout	50-ft outside radius with linear taper *See Roadway Design Criteria, Detail A3 and Detail A4*
Cross Slope (%)	2% normal, 4% maximum
Superelevation (Max)	Normal Crown (4% maximum adverse crown)
Maximum Gradient (%)	3%
Minimum Gradient (%)	0.3% (0.5% desirable)
Curb Return Radii (Major intersections)	35 feet
Curb Return Radii (Minor intersections)	25 feet
Turn Lane Storage Length Requirements	See Exhibit B1
Design Element	**Design Criteria**
Left Turn Lane Taper	Single - 150 feet reverse curves Dual – 150 feet reverse curves
Right Turn Lane Taper	180 feet linear taper
Right Turn Lane Channel Return Radii	*See Roadway Design Criteria, Detail A5*
Right Turn Lane Channel Return Radii (Add Lane)	*See Roadway Design Criteria, Detail A6*

6.1.1 Design Year

As feasible, Grant Road improvements will be designed and constructed to maximize accommodation of 2030 traffic conditions, and in particular 2030 forecast traffic projections. However, it must be recognized that the overall design directive for Grant Road is set forth by RTA requirements to construct a 6-lane

roadway from Oracle Road to Swan Road. As previously described, 2030 traffic projections on Grant Road exceed the capacity of a six-lane roadway with traditional at-grade intersection improvements. The Grant Road improvements are being designed to provide maximum accommodation of future traffic projections within the constraints of a six-lane roadway.

6.1.2 Design Speed, Target Speed/Posted Speed

ITE Proposed Recommended Practice for Walkable Major Urban Thoroughfares (2006) defines concepts of target speed and design speed:

- Target Speed is the speed at which vehicles should operate on a thoroughfare in a specific context, consistent with the level of multi-modal activity generated by adjacent land uses to provide both mobility for motor vehicles and a safe environment for pedestrians and bicyclists. The target speed is usually the posted speed limit.
- Design Speed is the speed that governs certain geometric features of the thoroughfare, primarily horizontal curvature, super-elevation, and sight distance. Design speed is typically higher than the posted speed limit to result in conservative values for design criteria such as sight distance or roadway alignment. The ITE Proposed Recommended Practice recommends that the design speed be 5 mph over the target speed.

A review of ITE and AASHTO guidelines for Grant Road suggests that the posted speed limit for an "intermediate principal arterial" should be in the range of 30 to 40 mph based on driveway density, existence of a median, on-street parking, signal density, pedestrian activity, and roadside development. ITE further recommends that a maximum speed limit of 35 mph be used for target speed on walkable streets like the future Grant Road. A posted speed of 35 mph offers the following:

- Is consistent with functional class of roadway, per the City of Tucson Major Streets and Routes Plan.
- Is consistent with other major corridors in City of Tucson. For example, the speed limit on Speedway Blvd is 35 mph.
- Provides a walkable and bikeable environment consistent with Grant Road Guiding Principles, and balances the need for safety, access, and regional mobility.

The Task Force approved the design team recommendation for the following:

- Target speed: 35 mph
- Posted speed limit: 35 mph
- Design speed: 35 mph

6.1.3 Design Vehicle

In keeping with the Context Sensitive Solutions approach to planning and designing Grant Road improvements, ITE recommends the use of a design vehicle and a control vehicle. Each is defined in the *ITE Proposed Recommended Practice (2006)* as follows:

- A Design Vehicle must be accommodated without encroachment into the opposing traffic lanes.
- A Control Vehicle less-frequently uses a facility and must be accommodated, but encroachment into the opposing traffic lanes, multi-point turns, or minor encroachments are acceptable.

The design vehicle influences such design criteria as lane width and curb radii. Typically the largest vehicle that can use a thoroughfare is selected as the design vehicle. However, in some areas it is not practical or desirable to choose the largest vehicle because of impacts on pedestrian crossing distances, speed of turning vehicles, or other community goals for the thoroughfare. Of particular importance is the selection of appropriate control and design vehicles for use in defining curb radii at streets that intersect with Grant Road.

For Grant Road improvements, the Task Force approved the design team recommendation for the following:

- Design vehicle City Bus
- Control vehicle: WB-57 and WB-76 (**see Table 12**).

6.1.4 Lane Widths

ITE Proposed Recommended Practice for Walkable Major Urban Thoroughfares (2006) emphasizes that street width is necessary to support desirable elements such as bicycle lanes and landscape median. However, excessively wide streets create barriers for pedestrians and encourage higher vehicle speeds. The ITE Proposed Practice states that on lower-speed urban thoroughfares (35 mph or less operating speed), a range of lane widths from 10 to 12-foot is appropriate (excluding gutter pan), and lanes that are 11-foot. wide are appropriate under most circumstances. An 11-foot travel lane is consistent with AASHTO guidelines including *AASHTO's Guide for Development of Bicycle Facilities (1999)* and recommendations in *A Guide for Achieving Flexibility in Highway Design (2004b).*

Benefits of narrower lane widths include a reduction in pedestrian crossing distance, and fewer impacts in right-of-way constrained environments such as Grant Road. For Grant Road improvements, the Task Force approved the design team recommendation for the following:

- Travel lanes: 11-foot wide travel lanes on Grant Road (curb and uncurbed).
- Right turn lanes: 12-foot wide for Grant Road and cross streets
- Single Left turn lanes: 11-foot wide for single left turn lanes on Grant Road; 12-foot wide for left turn lanes on north-south cross streets.
- Dual left turn lanes: 11-foot for include lane, and 12-foot wide for outside lane. Dual left turn lanes will also include a 6-foot median island that separates the left turn lanes from the through lanes. The median island is a pedestrian enhancement as described in **section 5.4.2**.

6.1.5 Sight Distance

Adequate sight distance is fundamental to the safety goals of the Context Sensitive Solutions approach to planning and designing Grant Road improvements. AASHTO criteria for stopping and intersection sight distance based on design speed should be used in the design of Grant Road.

6.1.6 Horizontal and Vertical Alignments

The design of horizontal and vertical curves is a controlling feature of roadway design which is affected by speed and affects speed. The public expressed a desire to maintain vertical alignment variations in Grant Road but also identified locations on Grant Road where adequate sight distance does not exist. Similarly, the public expressed a desire to maintain and increase the frequency of horizontal curves as a community asset and for speed control. The use of AASHTO design for urban streets is recommended by the *ITE Proposed Recommended Practice (2006)* and the low-speed urban design criteria (no super-elevation) are well-suited to the context of Grant Road.

Minimum horizontal curves were determined based on AASHTO design criteria, and considering *ITE Proposed Recommended Practice (2006).* Determination of minimum horizontal radius for Grant Road was determined considering *AASHTO Policy on Geometric Design of Highways and Streets* (2004) requirements for offset, length of curve, and length of tangent:

- *AASHTO Policy on Geometric Design of Highways and Streets* (2004), Exhibit 3-47, Calculated and Design Values for Traveled Way Widening on Open Highway Curves (Two-Lane Highways, One-Way or Two-Way).
- *AASHTO Policy on Geometric Design of Highways and Streets* (2004), page 229, General Controls for Horizontal Alignment
- *AASHTO Policy on Geometric Design of Highways and Streets* (2004), Exhibit 3-16, Minimum Radii and Superelevation for Low-Speed Urban Streets

6.2 Pavement Design Criteria

Design of flexible pavements will be simplified and condensed guideline based on current AASHTO guidelines developed by the City of Tucson Department of Transportation (TDOT). The TDOT guideline is identified as the Engineering Division's Active Practice Guideline (APG), dated June 1, 1987.

Design of rigid pavements will follow current AASHTO guidelines, modified for TDOT axle loading correction for busses as identified in Table 4 of the Flexible Pavement Design APG.

6.3 Drainage Design Criteria

Hydrologic and hydraulic design guidelines have been developed based on the following documents:

- Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona, Simons, Li & Associates, Inc., December 1989, Revised July 1998 (City of Tucson Drainage Manual)
- Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 14, Third Edition – Hydraulic Design of Energy Dissipators for Culverts and Channels
- City of Tucson and Pima County Standard Details for Public Improvements, 2003

Analysis and design of storm drains will follow Chapter 10 of the Design Manual. Chapter 4 of the Design Manual will be followed to determine pavement peak discharges. Storm drain catch basins and associated details will follow the City of Tucson and Pima County Standard Details for Public Improvement manual.

6.4 Street and Intersection Lighting Design Criteria

A photometric analysis of the Grant Road improvements was performed using the GE IES file 451002 for a 400 Watt High Pressure Sodium, Type III distribution and full cutoff lenses at a 40 foot mounting height.

The proposed street lighting was designed to meet the *Pima County Department of Transportation Street Lighting and ITS Conduit Design Manual* guidelines and the *City of Tucson and Pima County Standard Details For Public Improvements, 2003.* The design criteria and standard details used are as follows:

- *Roadway Classification/Lamp Wattage/Mounting Height/Spacing (Per PCDOT Street Lighting Manual, Sheet 6-02):* Major Commercial Classification/400W Lamp/40' Mtg Ht/60'-70' staggered spacing.
- *Distribution Type (Per PCDOT Street Lighting Manual, Sheet 6-00):* Type III.
- *Lighting Design Criteria (Per PCDOT Std Details, T-324):* Minimum average maintained horizontal illumination - 2.0 foot-candles, Maximum average-to-minimum uniformity ratio - 3:1.
- *Street Light Pole (Per PCDOT Std Details, T-446):* Type E Street Light Pole w/ 20-foot bent mast arm.
- *Light-Loss Factor (ADOT Std, PCDOT does not list a standard LLF):* 0.81.

The results of the photometric analysis using the above criteria are provided in **Table 14**. The light pole layout that was used in the photometric analysis is contained in the lighting plan sheets of the 30 percent construction plans.

Table 13. Grant Road Improvements Photometric Analysis

Grant Road Improvements Segment		Average	Average/Min.
15th Ave to Oracle Road	WB	2.65	2.94
	EB	2.70	2.90
Oracle Road to Stone Avenue	WB	2.03	, 2.94
	EB	2.22	3.00
Stone Avenue to 1st Avenue	WB	2.40	2.93
	EB	2.37	2.82
1st Avenue to Park Avenue	WB	2.40	2.86
	EB	2.10	3.00
Park Avenue to Mountain Avenue	WB	2.31	2.31
	EB	2.43	2.89
Mountain Avenue to Campbell Avenue	WB	2.37	2.82
	EB	2.29	2.76
Campbell Avenue to Tucson Boulevard	WB	2.53	2.81
	EB	2.21	2.99
Tucson Boulevard to Country Club Road	WB	2.56	2.88
	EB	2.38	2.98
Country Club Road to Alvernon Way	WB	2.29	2.97
	EB	2.31	2.96
Alvernon Way to Columbus Boulevard	WB	2.37	2.96
	EB	2.35	2.90
Columbus Boulevard to Swan Road	WB	2.44	2.90
	EB	2.38	2.98
Swan Road to Arcadia Avenue	WB	2.37	2.58
	EB	2.43	2.83
Oracle Road	NB	2.30	2.91
	SB	2.43	2.93
Stone Avenue	NB	3.52	2.98
	SB	3.38	2.99
1st Avenue	NB	3.12	2.86
	SB	3.24	2.89
Mountain Avenue	-	4.20	2.12

Table 13. Grant Road Improvements Photometric Analysis (continued)

Alvernon Way	NB	3.15	2.94
	SB	3.04	2.98
Swan Road	NB	2.96	2.87
	SB	3.00	2.94