To: **Broadway Citizens Task Force**
From: **Broadway Project Team**
Date: **August 25, 2014**
RE: **August 26, 2014 CTF Meeting Materials for Item 3.** *Technical Review of 96-Foot and Current 118-Foot Street Design Concepts*

This memorandum investigates the implications of narrowing the nominal right-of-way from 118' to 96', and how various performance measures adopted for this project would be affected.

Plausible Street Sections

Figures 1a and 1b show how the 118' and 96' nominal widths could be configured to accommodate three transit scenarios: (1) side-running bus rapid transit (BRT) or streetcar; (2) center-running BRT or streetcar; and (3) center-running light rail transit (LRT). The BRT/streetcar lanes could be operated either as mixed flow or exclusively for transit.

Nominal vs Actual Right-of-way Width

The term "nominal" refers here to the base width of the street section where it is not influenced by turn lanes at intersections, curvature of the street, widening for bus pullouts, cycle track bus stop bypasses, providing local access lanes to maintain front parking and site access for businesses, and other features of the street design concept. Left turn lanes are required at median openings provided for access to side streets, typically at 600' intervals. That works out to about every other block. At larger intersections, right turn lanes are also required. The street section needs to be widened to accommodate these lanes as well as the transition between them and the nominal section.

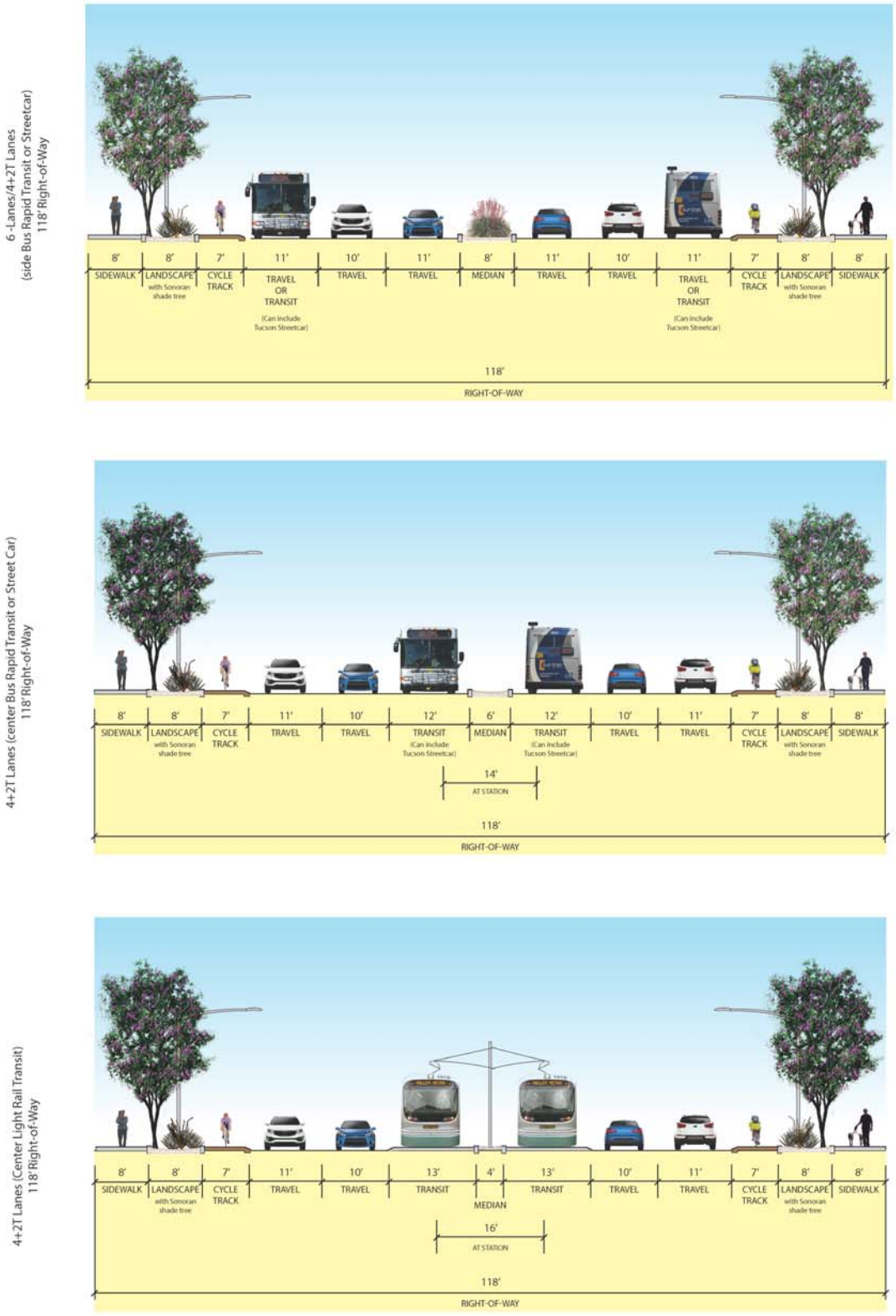

Figure 1a. Plausible Street Configurations -- 118’ Right-of-way Widths

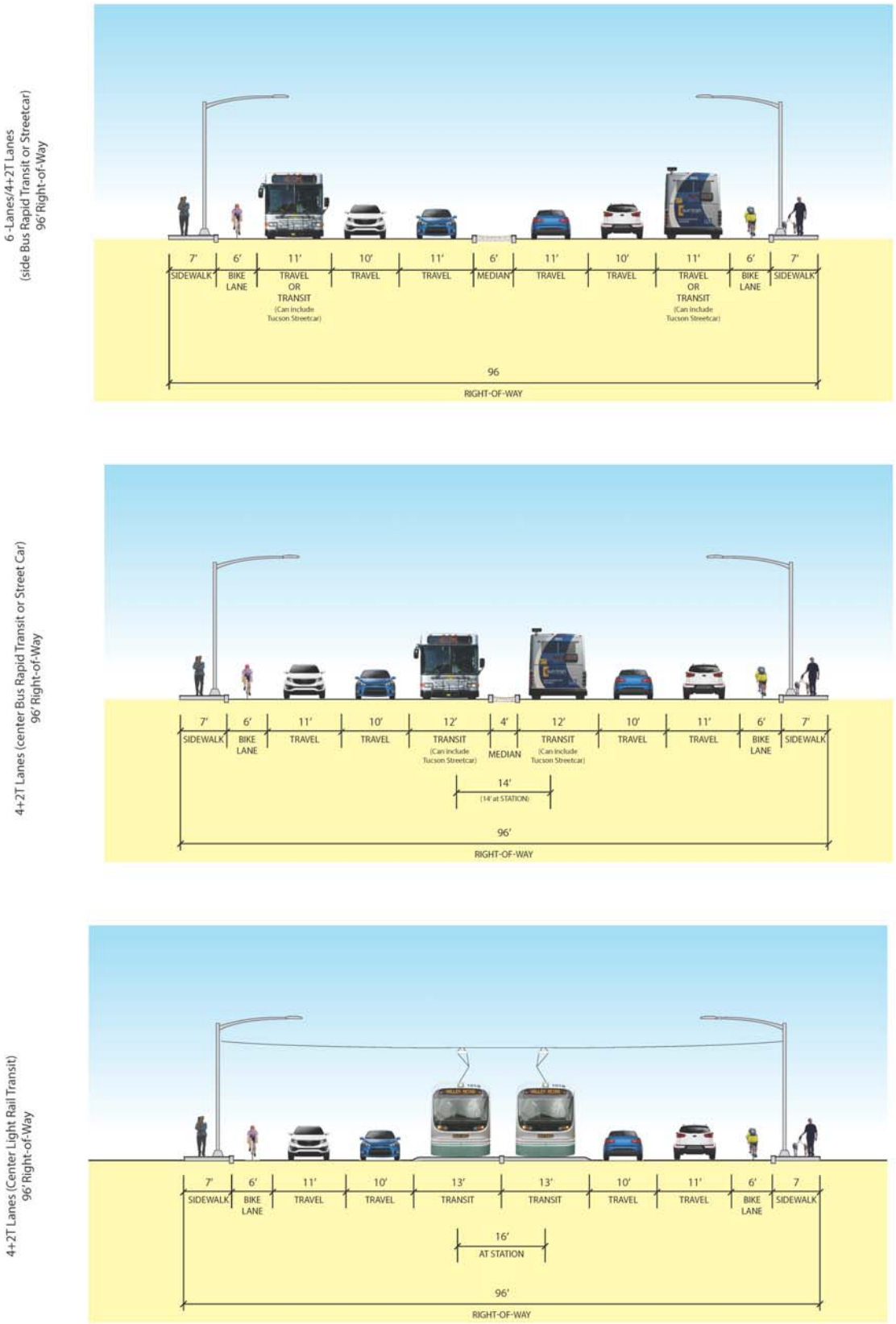

Figure 1b. Plausible Street Configurations -- 96' Right-of-way Widths

Street Element Widths

Table 1 shows the range of widths accepted by various entities for particular elements of the street section. AASHTO is the American Association of State Highway and Transportation officials and is the primary source of design criteria for streets and highways. Its latest publication is A Policy on Geometric Design of Highways and Streets published in 2004. It is based on extensive research and most state and municipal transportation agencies have adopted its recommendations.

PCDOT is the Pima County Department of Transportation, and COT is City of Tucson. Both have largely accepted the AASHTO guidelines and in fact have joint details and standards in many cases.

ITE is the Institute of Transportation Engineers. Its publication Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities has greatly influenced the Broadway corridor design process. That publication identifies lane widths for a range of "context zones". C-4 General Urban and C-5 Urban Center are both shown here as they are the most applicable to the existing conditions along Broadway within the project area, as well as relate to potential future development as allowed in existing zoning.

Also shown in Table 1 are the values being used for the Grant Road Corridor and therefore tacitly accepted by the City. The last column indicates the widths that have been used for the Broadway studies to date, some would be considered substandard. As discussed later, these have not been approved by TDOT or City legal staff, and may have to be adjusted in the final design.

Table 1. Street Element Widths Prescribed by Various Entities

Street Element	AASHTO	PCDOT	COT	ITE	Grant	Broadway
Inside traffic lane (against median)	11-12 (1)	12'	12' (2)	10'-12' (C-4) 10'-11' (C-5)	11'	11'
Middle and outside traffic lanes	11-12 (1)	11'	11' (2)	10'-12' (C-4) 10'-11' (C-5)	11'	10,11'
Right turn lane (against curb)	11-12 (1)	13'	12' (2)	10'-12' (C-4) 10'-11' (C-5)	12'	10'
Left turn lane (against curb)	11-12 (1)	13'	12' (2)	10'-12' (C-4) 10'-11' (C-5)	11'	10'
Left turn lane	11-12 (1)	12'	11' (2)	10'-12' (C-4) 10'-11' (C-5)	11'	10'
Bike lane	5'	6'	5' min. 6' preferred	5' min 6' preferred	7'	7' cycle track and bike lane
Median (mid-block)	4' min	20-24'	20' (3)	4' to 18'	17'	8' (118' R/W) 6' (96' R/W)
Median at left turn lane	4' min	6'	7'	6'-8' desired	8'	6' (5)
Sidewalks	4' min. 6' next to curb	5'	6' (4)	8' (C-4) 10' (C-5)	8' + 12' Buffer	8' (118' R/W) 7' (96' R/W)

1. AASHTO allows 10-foot lanes in highly restricted areas having little or no truck traffic.
2. COT allows 10-foot lane (11-foot against curb) when there is not a bus route.
3. 20 feet required when curb to curb distance exceeds 75 feet.
4. Can be reduced under special conditions.
5. 6' required for sheltering pedestrians and wheel chairs.

Design Vehicle

ITE calls for the "design vehicle" to be the largest vehicle that will use the facility on a regular basis. It needs to be accommodated without encroachment into the adjacent lanes. Also defined is the "control vehicle" which is the largest vehicle that would occasionally use the facility and would need to be accommodated only on an infrequent basis. The control vehicle is allowed to encroach upon the adjacent lanes.

For Broadway, the largest vehicle that is likely to use the corridor on a regular basis is a City transit bus and has been considered to this point as the design vehicle. The control vehicle would be a WB-67 truck that would make deliveries occasionally. Intersections and median openings will be checked during final design to ensure that the control vehicle can navigate the project with some encroachment if necessary.

Minimum Radius of Curvature and Tracking

The distance over which the transition from the nominal section to the widened sections at intersections is governed by the minimum radius of curvature required for the travel lanes. Because Broadway is a low-speed urban arterial, neither super-elevation (i.e.; banking of the road bed to improve traction and comfort for vehicle passengers) nor design speed are factors. Instead, minimum radius of curvature is governed by the ability of the design vehicle to remain in the lane through the curve. Rear wheels do not follow the same track as the front wheels through a curve. For larger vehicles such as busses and trucks, lanes may need to be widened to allow the tracking to be confined to the lane. The minimum radius of curvature used in the design studies to date is 1,400'.

Width of Travel Lanes

Table 2 shows the computed lanes width Wc required to accommodate the tracking of both the design vehicle and control vehicles identified above. It can be seen that based on a radius of 1,400', the tracking width for a bus is 11.6'. In the outside lane, where encroachment into the center lane and bike lane is physically possible, this may be acceptable though 12' would be recommended for both safety and functional reasons. The 12' would allow some additional encroachment that can be expected if the driver does not remain exactly centered within the lane.

With an 11' middle lane some encroachment into the adjacent lanes is likely. A 10' middle lane could not be used by busses or larger trucks and could be justified only if those vehicles are somehow relegated to the outside or inside lanes. A 10' middle lane has been used in the Broadway studies to date.

It can be seen that increasing the radius of curvature is not particularly helpful in reducing the tracking width. A 3,000' radius for example only reduces this width to 11.2'. Using 10' lanes for busses and trucks would in effect require a straight alignment since no tracking outside of the lane would be permissible. That in turn would result in a median width of 16' since tapering down to narrower widths between intersections would not be possible.

Table 2. Width of Traveled Way (Wc)

Curve Radii	Wc for Bus	Wc for WB-67 Truck
510 feet	12.6 feet	14.2 feet
600 feet	12.4 feet	13.8 feet
800 feet	12.1 feet	13.1 feet
1,000 feet	11.9 feet	12.7 feet
1,200 feet	11.8 feet	12.4 feet
1,400 feet	11.6 feet	12.2 feet
2,000 feet	11.5 feet	11.9 feet
3,000 feet	11.2 feet	11.5 feet

Acceptability of Non-Standard Widths

The use of less-than-standard lane widths and minimum radius of curvature could be construed as not meeting the current standard of care as far as safety is concerned. The City would need to determine if there is added potential for liability associated with this, and if so if it is willing to accept that.

Median Widths

Only one of six nominal sections, the 118' side running BRT or streetcar concept, provides enough center median width to meet the TDOT landscape architects minimum 7-foot width for landscaping. Four of the other nominal sections have narrower medians that would be hardscaped, and one, the 96' center running light rail concept, does not have a median in the nominal condition. Widening the median to accommodate the left turn bays and street curvature allows some additional areas to have landscaping, and in some cases trees (16' is currently assumed to be an allowable width for the planting of the street tree species that is being indicated in the alignment designs and street sections), for portions of the alignment from Euclid to Country Club. This widening of the median establishes the overall width of the paved roadway since the travel and bike lanes are defined off the median curb.

Buffer Widths

Eight-foot buffers between the roadway and sidewalk are provided with each of the 118' options. That buffer would accommodate landscaping including trees to shade the pedestrian environment and provide for physical separation and buffering of pedestrians from moving traffic, creating the walkable environment that is desired for Broadway. The landscaping also will generally enhance visual quality, sense-of-place, reduce urban heat island effect, and similar non-transportation performance measures. It would also accommodate street lights, signs, and surface utility features such as transformers and power poles without disrupting pedestrian movement.

The 96' options have no buffer between the roadway and sidewalk. The 7' sidewalk width would have to accommodate street lights, signs, and surface utilities as well as walkers. The 7' width would not provide enough width for trees or other landscaping, current TDOT practice is to not landscape areas less than 4 feet wide, and in the case of a 7' wide pedestrian area, the minimum width per ADA would be 4' with 5' width every 200 feet, this would only leave 3' of width for potential landscaping which is not feasible. Given the maintenance issues of weeding a gravel or rock area of 3' width with no other landscaping, the assumption is that the entire 7 foot width would be concrete. In some cases, utility cabinets and transformers may be too wide for the sidewalk to meet ADA requirements. Additional right-of-way would be needed at those locations. The 7' width does not perform well in terms of pedestrian comfort or safety, universal design, urban heat island, visual quality, sense of place, and similar non-transportation performance measures.

Trial Layout of 118' and 96' Options

Trial configurations have been developed for street alignments from Euclid to Country Club, based on the 118' and 96' nominal right-of-way widths. Drawings comparing the two widths are available on the project website at http://tdot.tucsonaz.gov/broadway/citizens-task-force. The drawings are named *03a_118', 96' Comparison-West.pdf* and *03b_118', 96' Comparison-East.pdf*. These reflect the west and east mile segments as the names indicate.

The Problem with Specifying Right-of-Way Width for Narrow Street Sections

In developing these configurations, it became apparent that the widening necessary for turn lanes rather than the nominal width controls the street width for most of the project length. With the 118' alternative for example, only 981' of the 10,800 alignment--about 9%--actually has the 8' nominal median width. The rest is wider, controlled by the widening necessitated by the intersections. For the 96' option, only 669' or about 6% is controlled by the nominal 6' median width. Table 3 tabulates the results.

It would make sense to define a corridor right-of-way width if the median were wide enough to accommodate left turns without widening. That would be at least 16' in this case.

Table 3. Lengths Where Nominal Widths Apply

Location	118'	96'
West Mile		
1. Through Fremont Intersection	104'	--
East Mile		
2. Through Olsen Intersection	89'	--
3. West of Smith	274'	194'
4. East of Stratford	390'	306'
5. East from Stewart	124'	169'
	981'	669'
Total corridor length:	10,800'	
Percent actually at nominal width:	9.1%	6.2%

Straightening the alignment may also result in more of the roadway at the nominal width. Shifting and curving the alignment is an aspect of minimizing impacts to parking, access, and buildings.

Conclusions

Several conclusions can be drawn from the information presented here.

1. The pavement elements of the street sections are already at least as narrow as acceptable practice allows. The only exceptions are the 7' cycle track could be replaced with a 5' bike lane reducing the 118' by 4', and the 6' bike lane of the 96' section could be reduced to 5' saving a total of 2'. Both have safety implications that are likely unacceptable to the City. Both also contradict the effort to create an environment that encourages biking as an alternative transportation mode.

2. The walking environment suffers similarly with the 96' section. Though a 7' sidewalk seems adequate for just walking, the presence of street lights, power poles, fire hydrants, etc. will force two people walking abreast to separate when passing other pedestrians going the opposite direction. Lack of shy distance next to buildings could have a similar effect. In some cases the sidewalk will likely need to be widened to maintain a minimum ADA clearance of 3'. The lack of separation between the sidewalk and roadway will be detrimental to the pedestrian environment--again contrary to an important project performance measure.

3. The 96' section provides no landscape. The entire section will consist of pavement and concrete. This visually bleakness would work against visual quality, sense of place, an environment that encourages shopping as well as walking and biking, and other design elements intended to enhance non-transportation vitality of the corridor. The lack of landscape will also not perform well in relation to urban heat island effect.

4. The 96' section does little to actually reduce the roadway width. For over 90% of the project length the width is determined by the widening for the intersections. The nominal width plays a very small part in determining the actual street geometrics. The only width reduction that can be achieved is through narrowing the bike lanes and sidewalk/buffer areas.