7.0 DEVELOPMENT OF CROSS-SECTIONS

7.1 DEVELOPMENT OF ALTERNATIVES

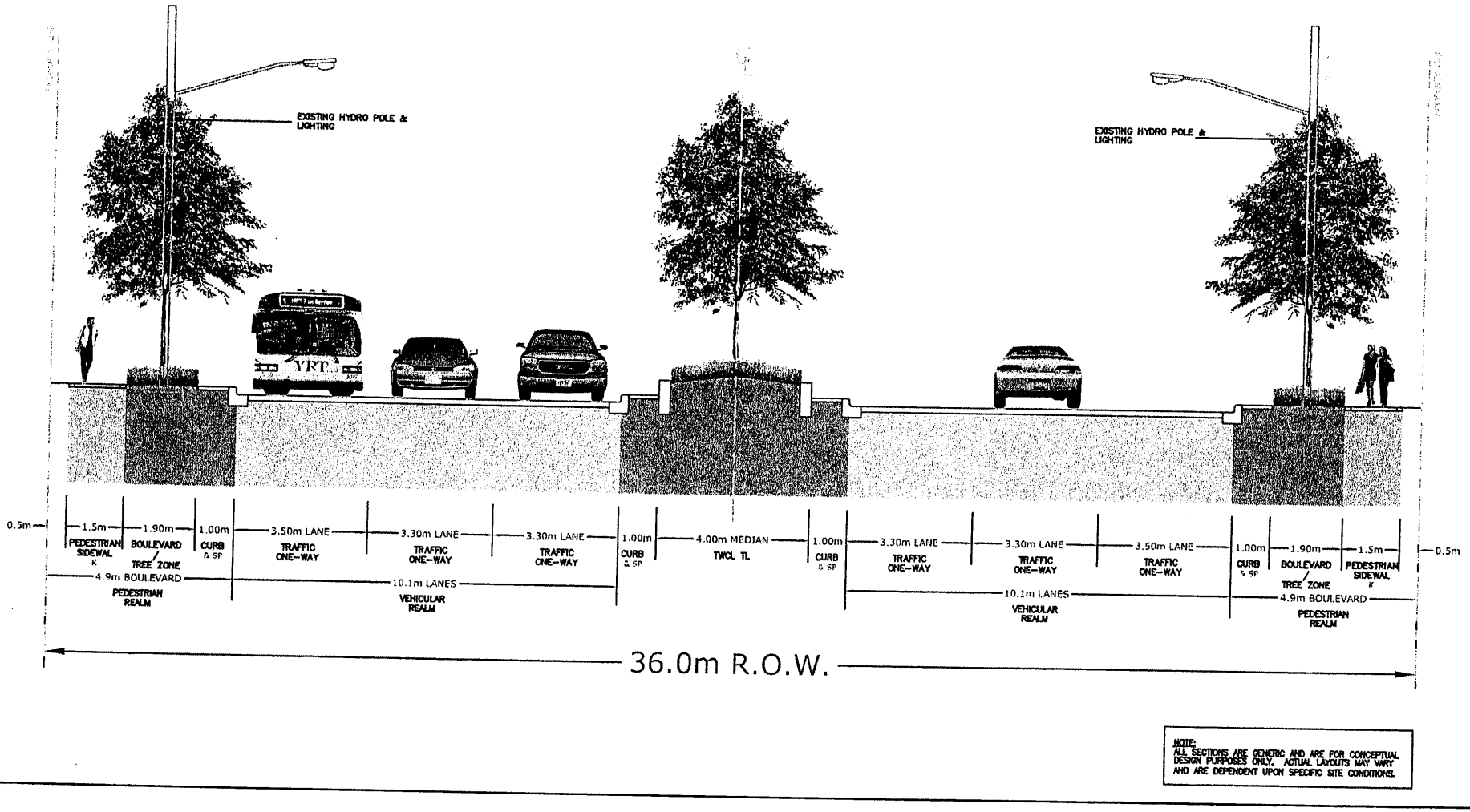
As illustrated in Section 6.0, many cross-sectional elements are variables, such as travel lanes, bike lanes, sidewalk, medians, etc. For instance, pavement width can range from 19.8 metres for six 3.3 metre wide lanes to 22.2 metres for six 3.7 metre wide lanes. Space allocated to sidewalks can range from 3.0 metres (1.5 metre sidewalk along each side of the street), to 4.0 metres (2.0 metre wide sidewalk along each side of the street) or even more in an urban environment with larger numbers of pedestrians. Variations can also reflect the following: whether transit exclusive lane or HOV lane are included; whether an exclusive bikeway or off-street bikeway are included; and whether a median is included. This can vary from 0 to 6 metres wide.

In view of the huge range of alternatives which could be developed using these variables, 12 alternatives were developed, which reflect a reasonable balancing of the alternative requirements. Some key features are the same for each alternative cross-sections. Key features include reduced lane widths to 3.3 metres per lane for median and middle lanes, and 3.5 metre wide curb lanes. It has also been assumed that the curb lanes would be dedicated for bus and/or HOV usage. Within the 36 metre right-of-way, the alternatives focus on how cyclists are accommodated and the width of the median. The 1.x series are cross-sections that do not have specific treatment to accommodate cyclists, with cyclists sharing the 3.5 wide curb lanes with buses and/or HOVs. The 2.x series are cross-sections that include exclusive bike lanes. The 3.x series are cross-sections that include an off-street bikeway adjacent to the sidewalk. Variations of each of these series include cross-sections that have no median, a 2 metre wide median, a 4 metre wide median and a 6 metre wide median, respectively. These alternatives were also compared to the standard cross-section illustrated in **Figure 7-1**.

The 12 alternatives developed are summarized in **Table 7-1** and presented in **Figures 7-2** to **7-13**.

Table 7-1
Alternatives

Alternative	Road Configuration	Median
1.1	Curb lane bus/HOV	6.0 metre median
1.2	Curb lane bus/HOV	4.0 metre median
1.3	Curb lane bus/HOV	2.0 metre median
1.4	Curb lane bus/HOV	No median
2.1	Bike lane/Curb lane bus/HOV	6.0 metre median
2.2	Bike lane/Curb lane bus/HOV	4.0 metre median
2.3	Bike lane/Curb lane bus/HOV	2.0 metre median
2.4	Bike lane/Curb lane bus/HOV	No median
3.1	Off-street bike lane with Curb lane bus/HOV	6.0 metre median
3.2	Off-street bike lane with Curb lane bus/HOV	4.0 metre median
3.3	Off-street bike lane with Curb lane bus/HOV	2.0 metre median
3.4	Off-street bike lane with Curb lane bus/HOV	No median

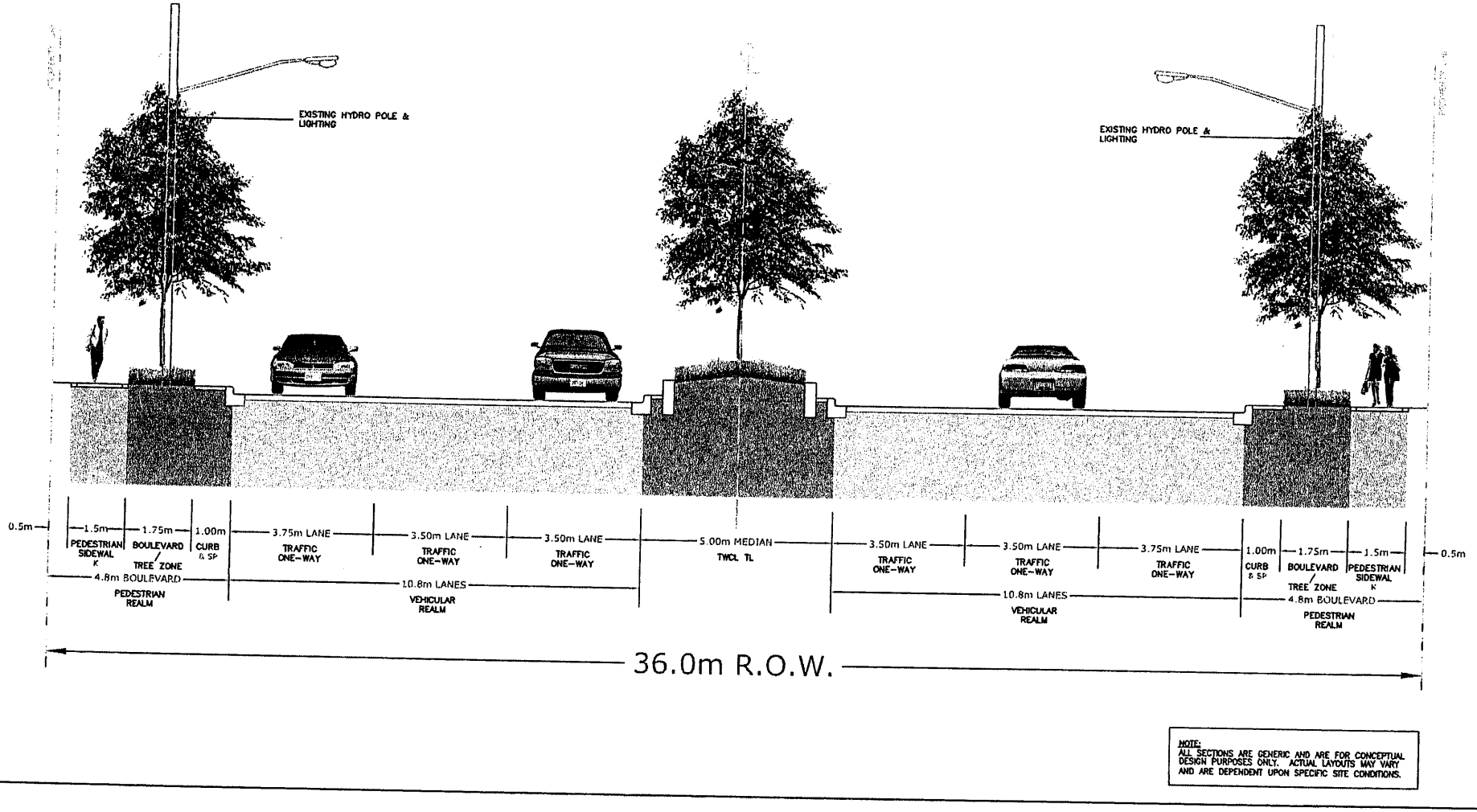


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-2
Alternative 1.1
Curb Lane Bus/HOV (6.0 m Median)

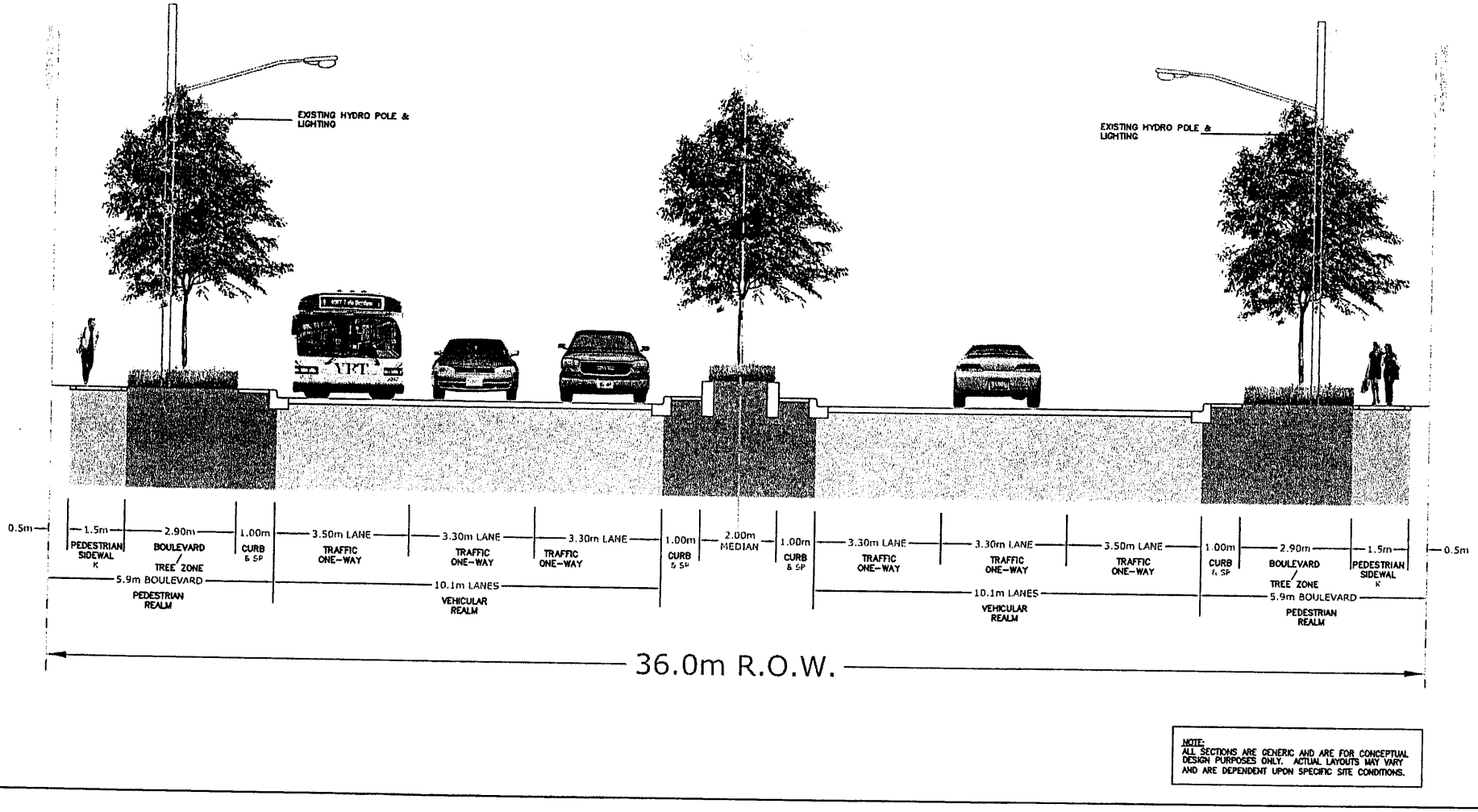


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-1
Standard 7 Lanes

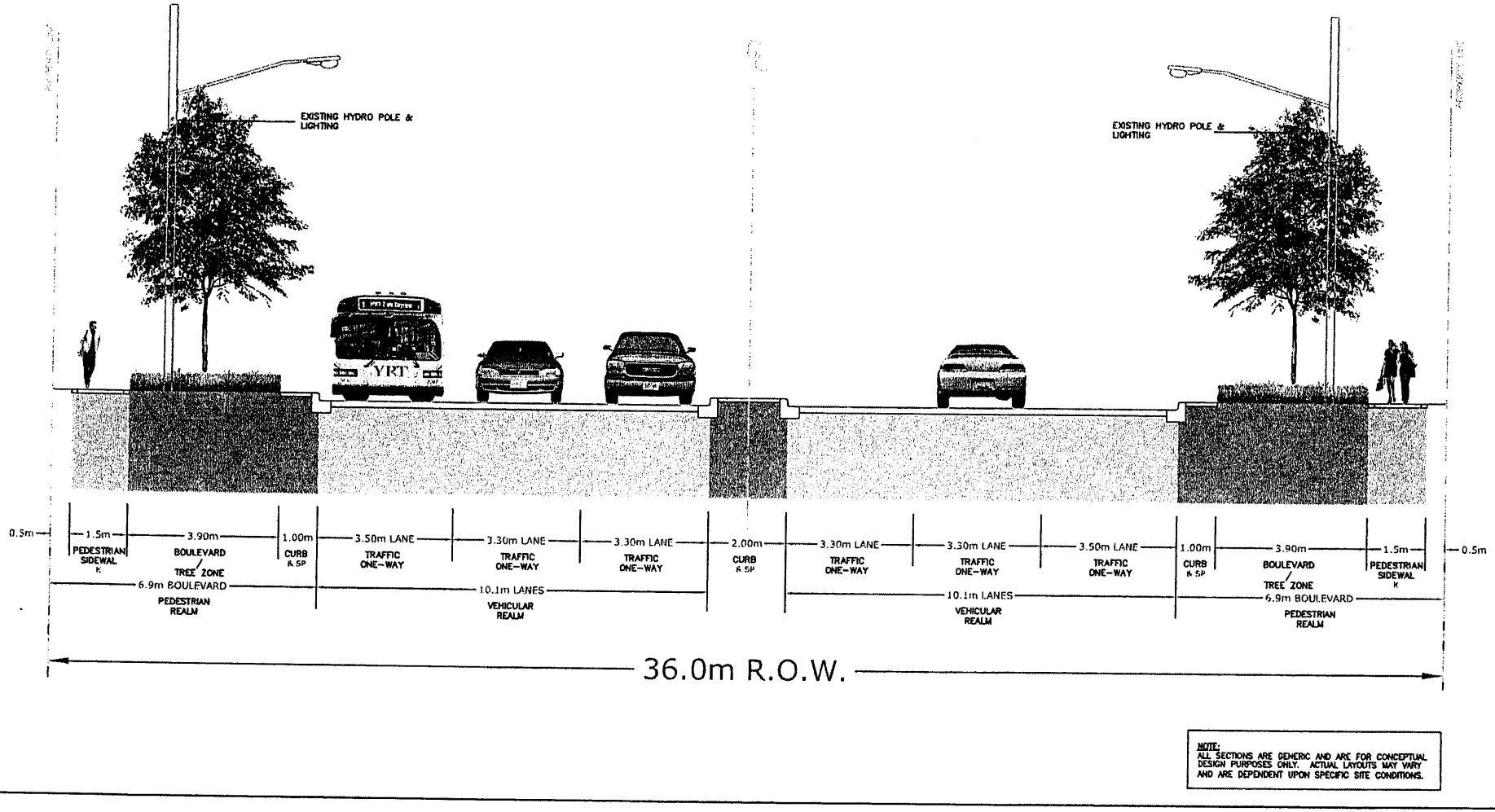


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-3
Alternative 1.2
Curb Lane Bus/HOV (4.0 m Median)

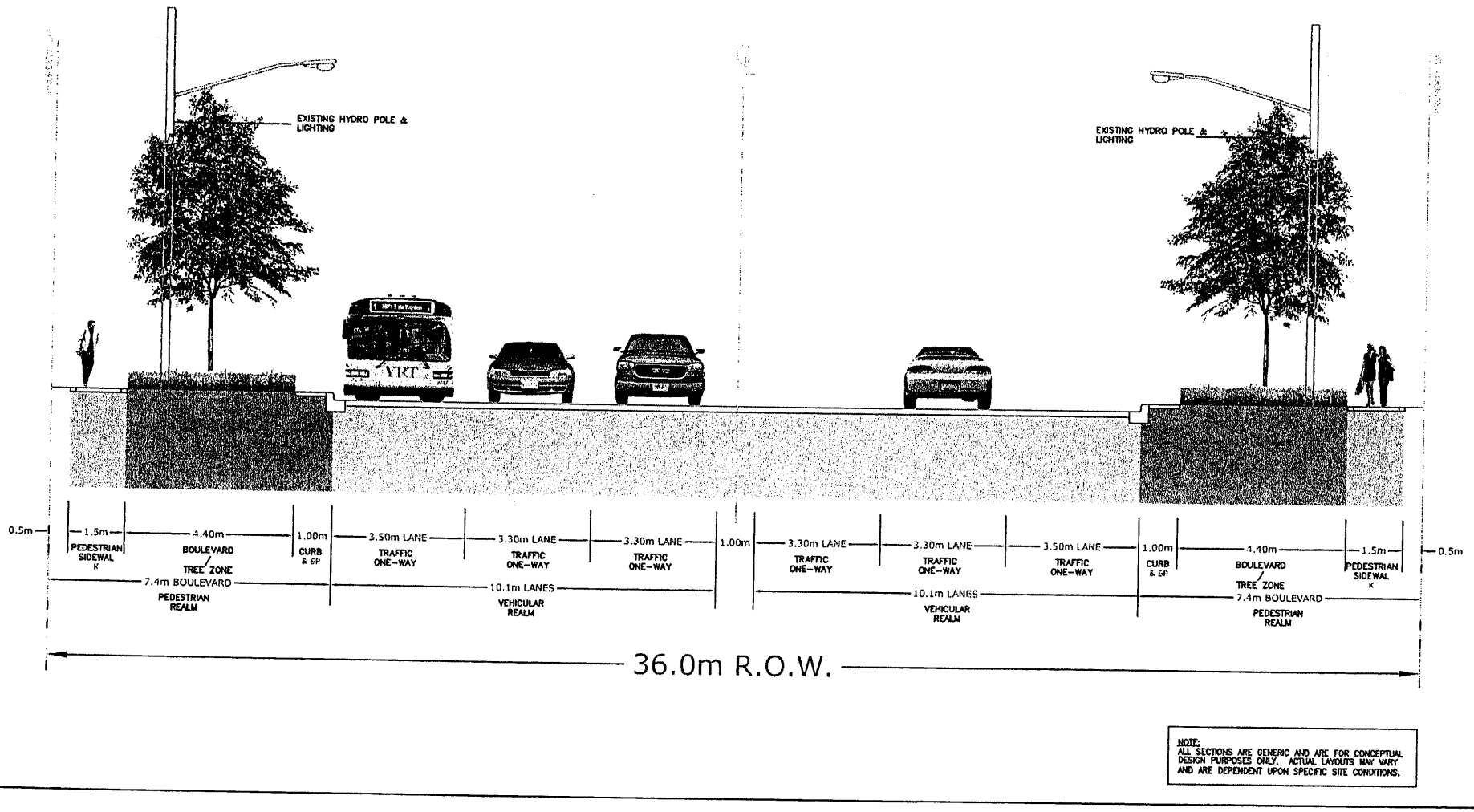


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-4
Alternative 1.3
Curb Lane Bus/HOV (2.0 m Median)

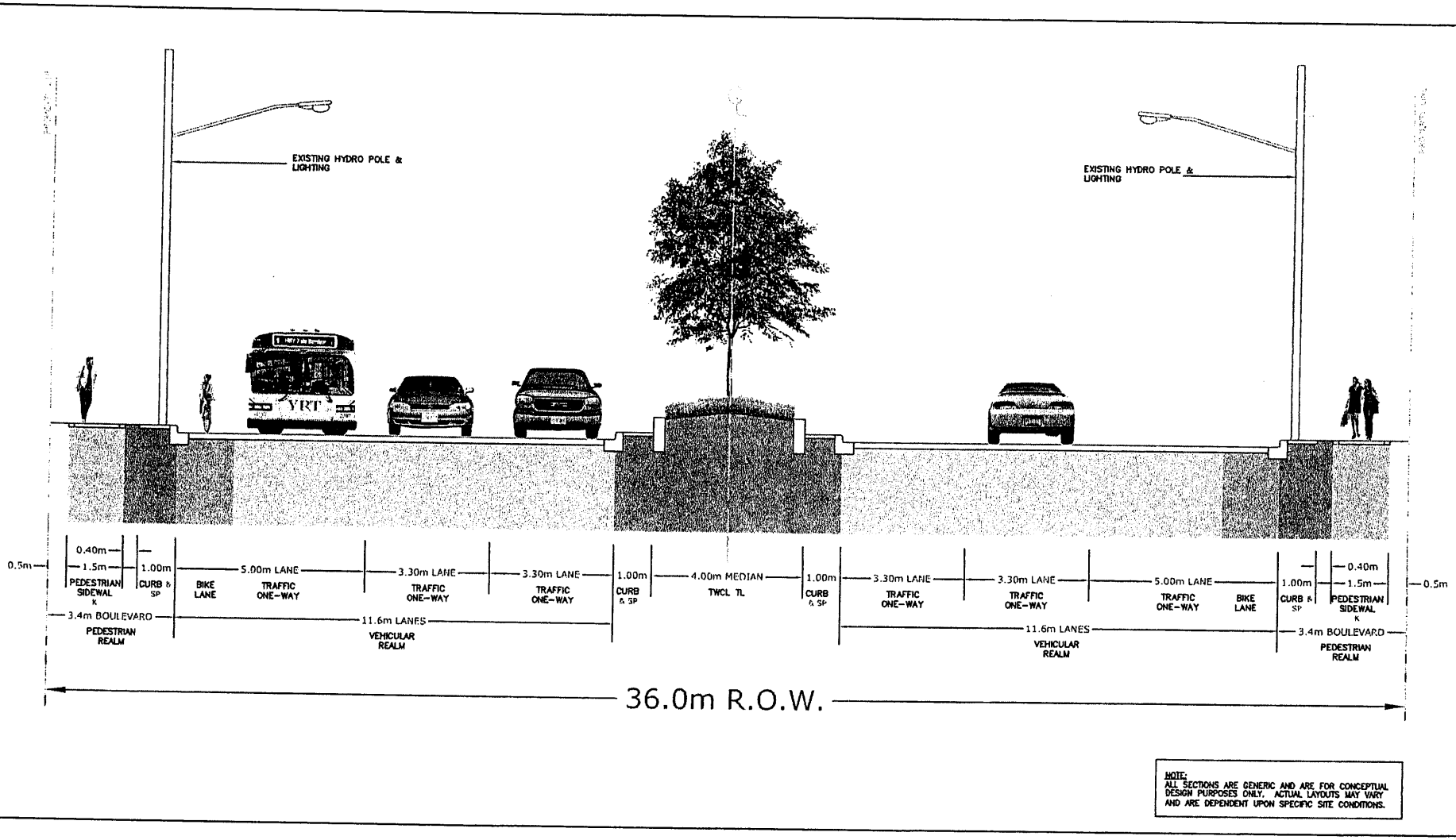


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-5
Alternative 1.4
Curb Lane Bus/HOV (No Median)

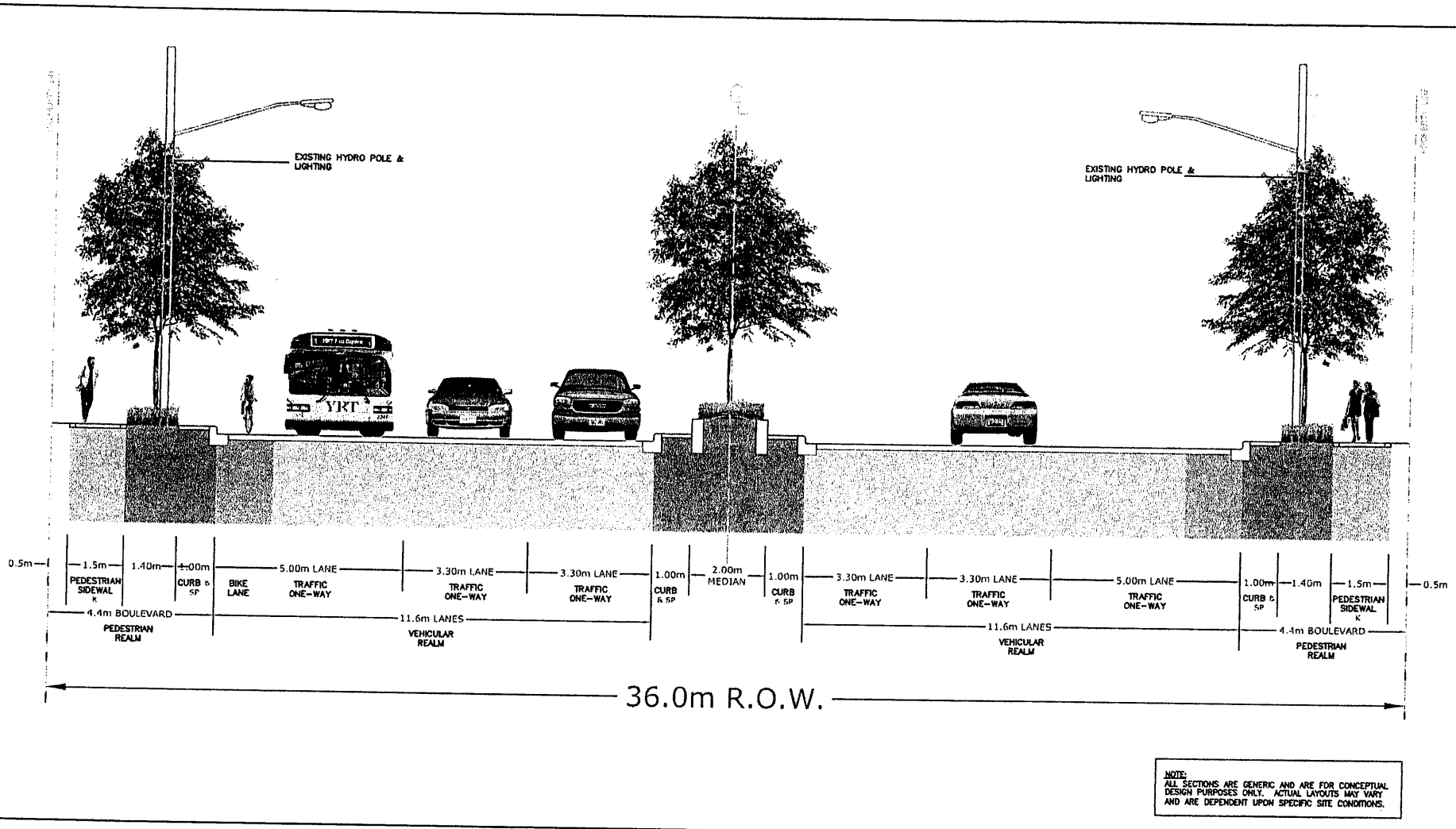


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-6
Alternative 2.1
Bike Lane/Curb Lane Bus/HOV (6.0 m Median)

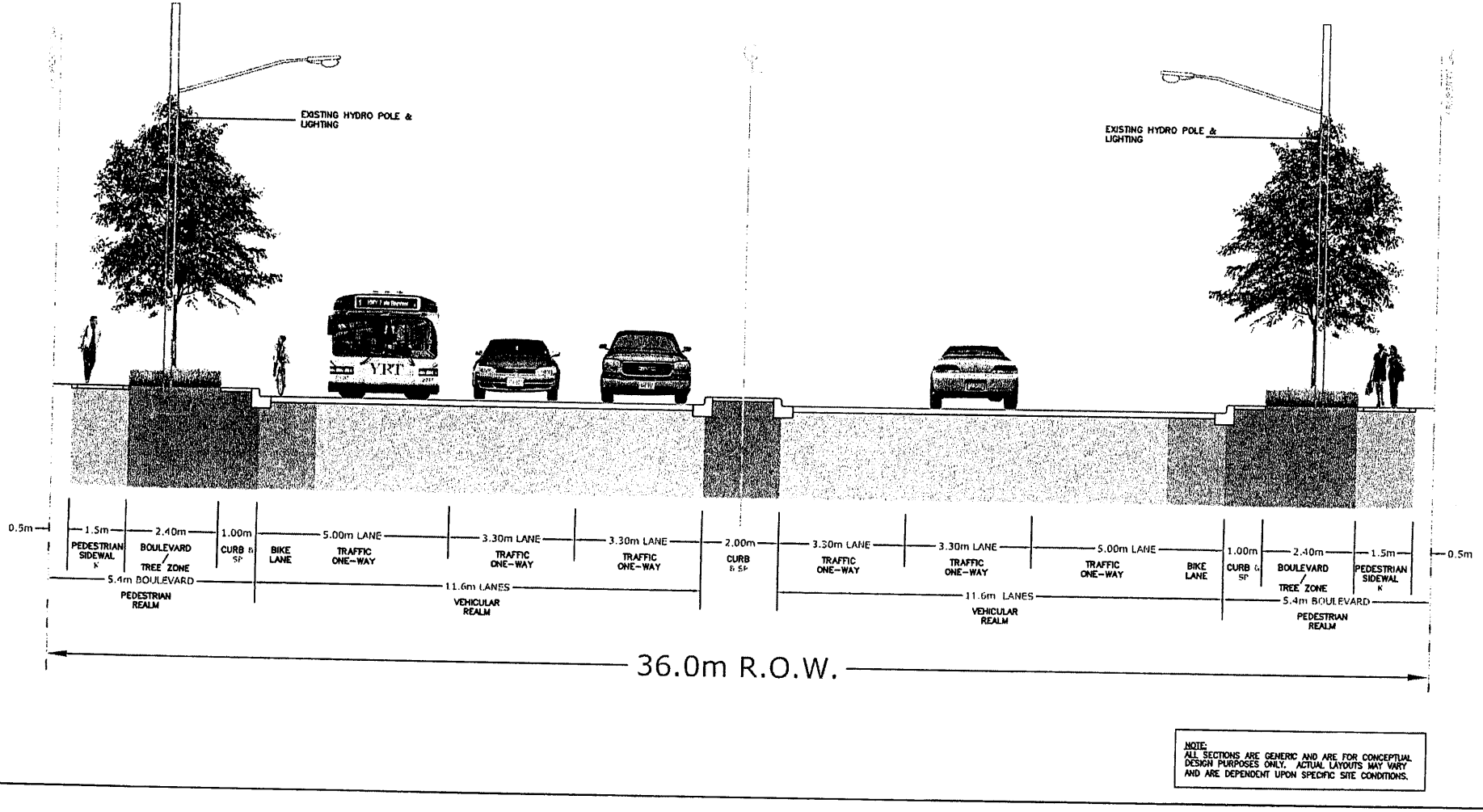


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-7
Alternative 2.2
Bike Lane/Curb Lane Bus/HOV (4.0 m Median)

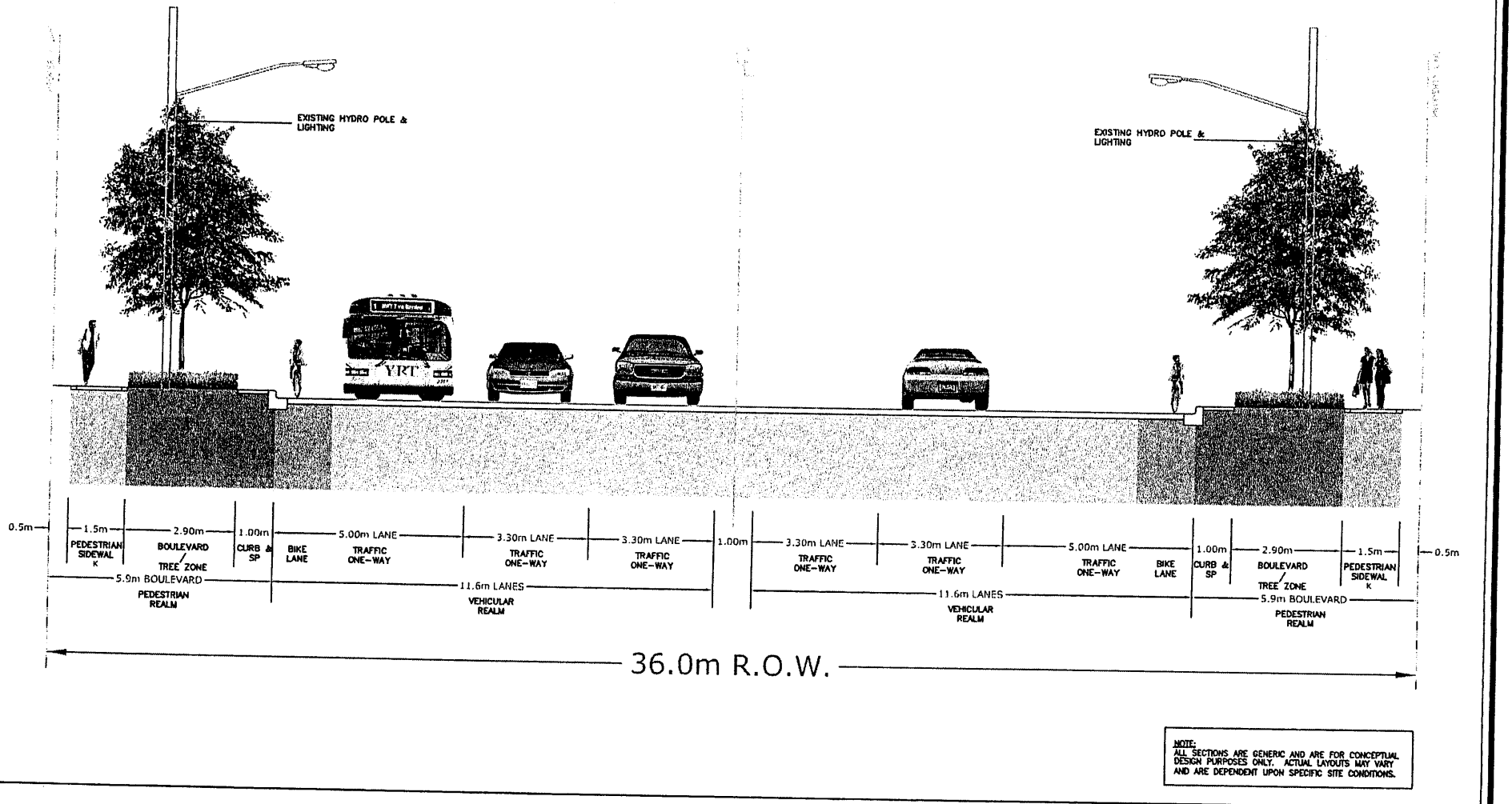


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-8
Alternative 2.1
Bike Lane/Curb Lane Bus/HOV (2.0 m Median)

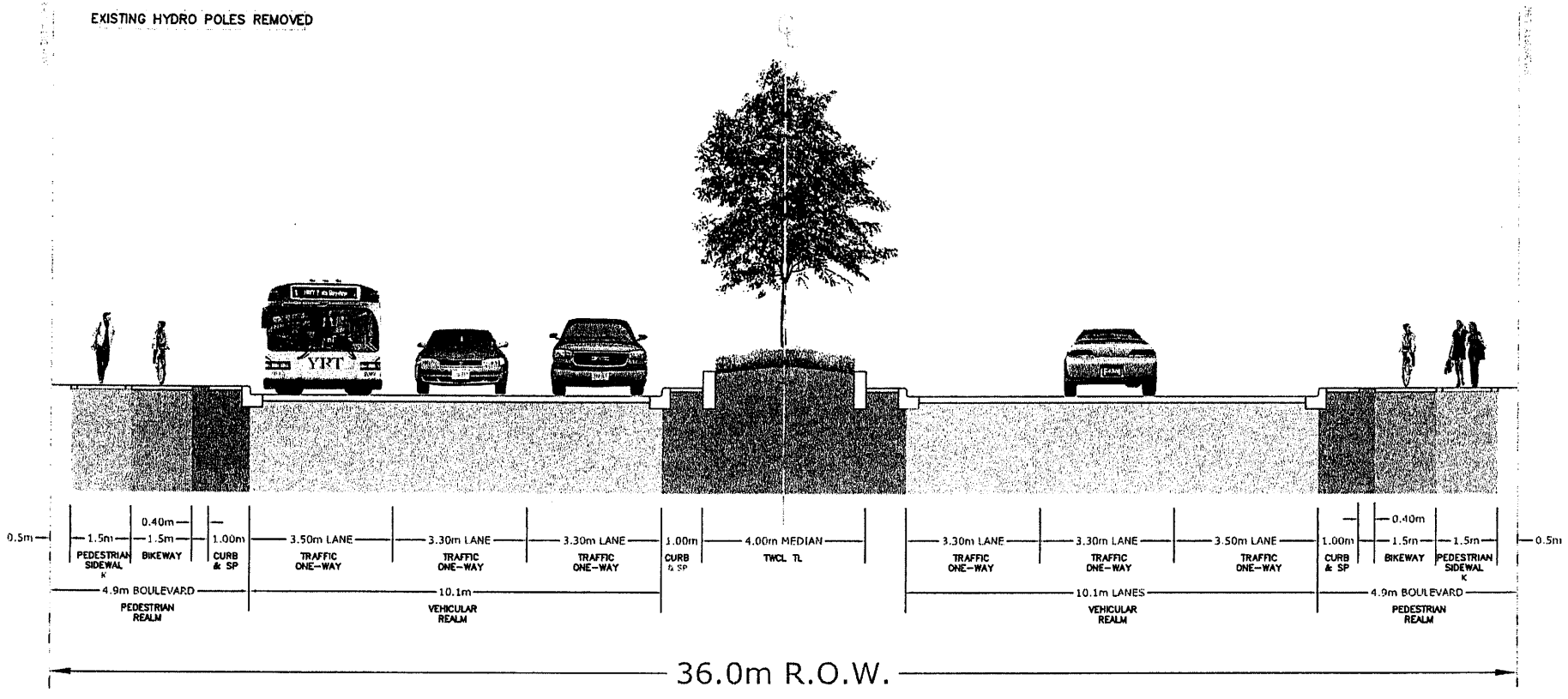


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-9
Alternative 2.4
Bike Lane/Curb Lane Bus/HOV (No Median)

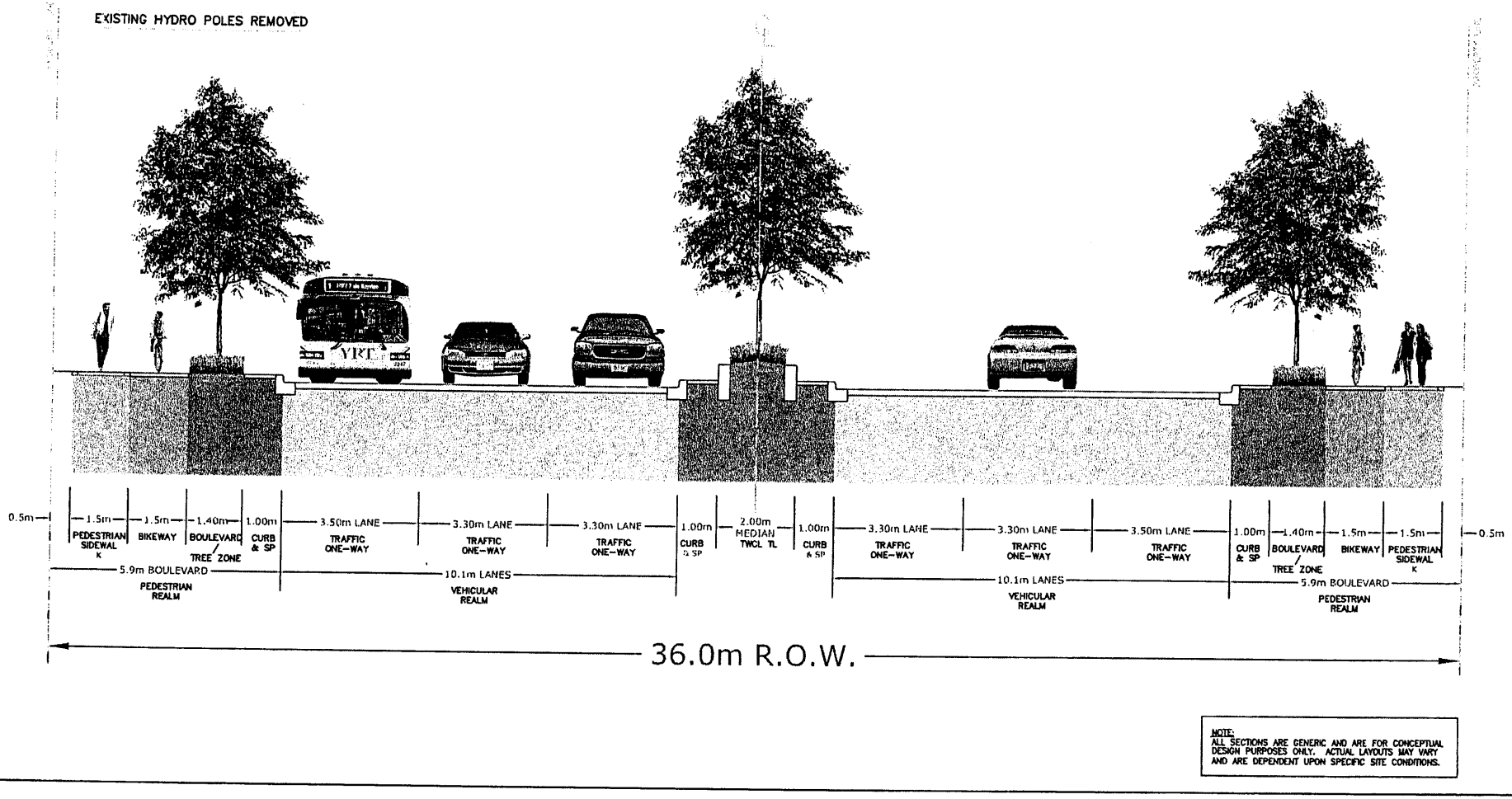


Marshall Macklin Monaghan

The MBTV Group

Texas Transportation Institute

FIGURE 7-10
Alternative 3.1
Off-Street Bike Lane with Curb Bus/HOV (6.0 m Median)

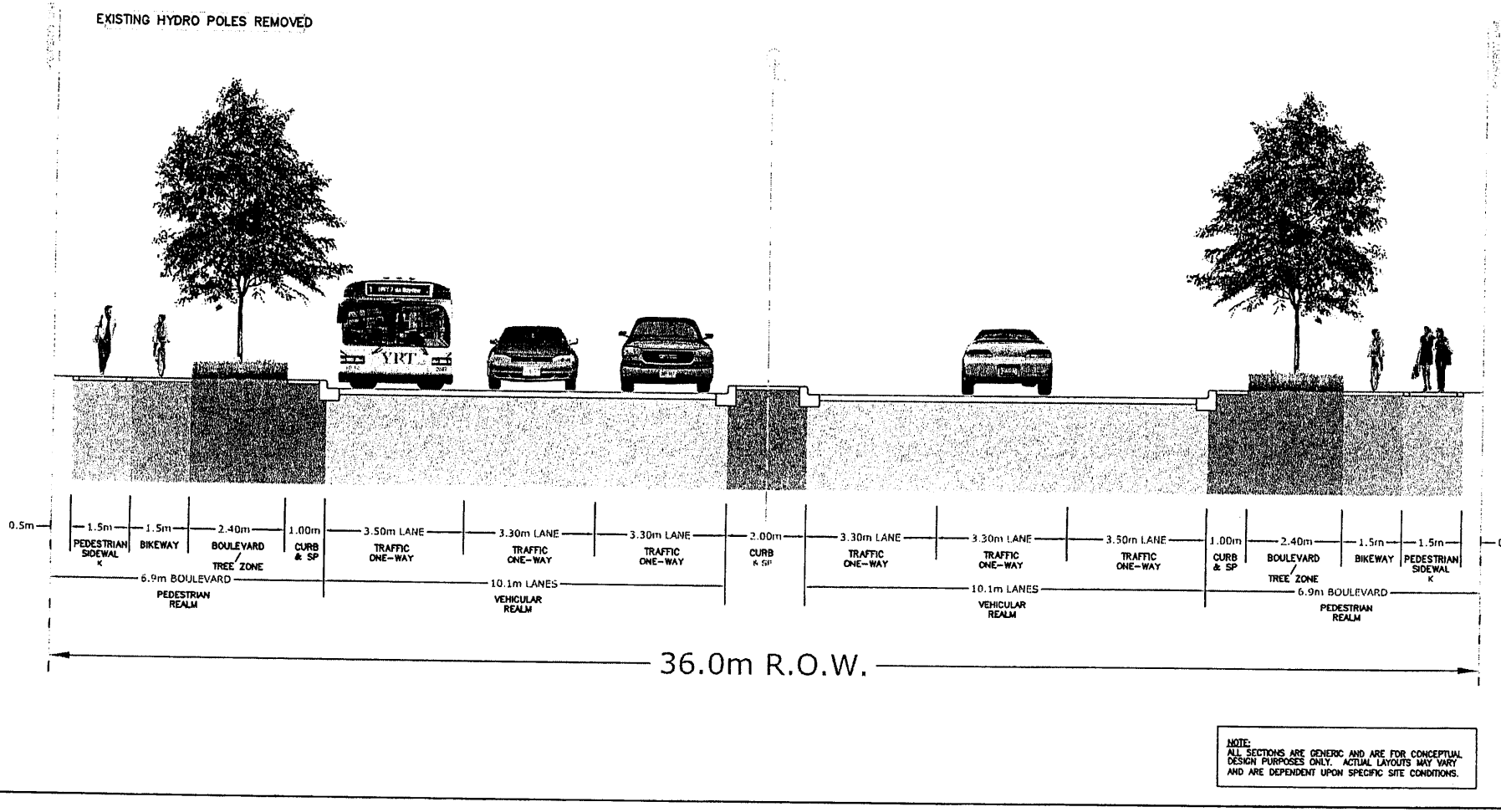


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-11
Alternative 3.2
Off-Street Bike Lane with Curb Bus/HOV (4.0 m Median)

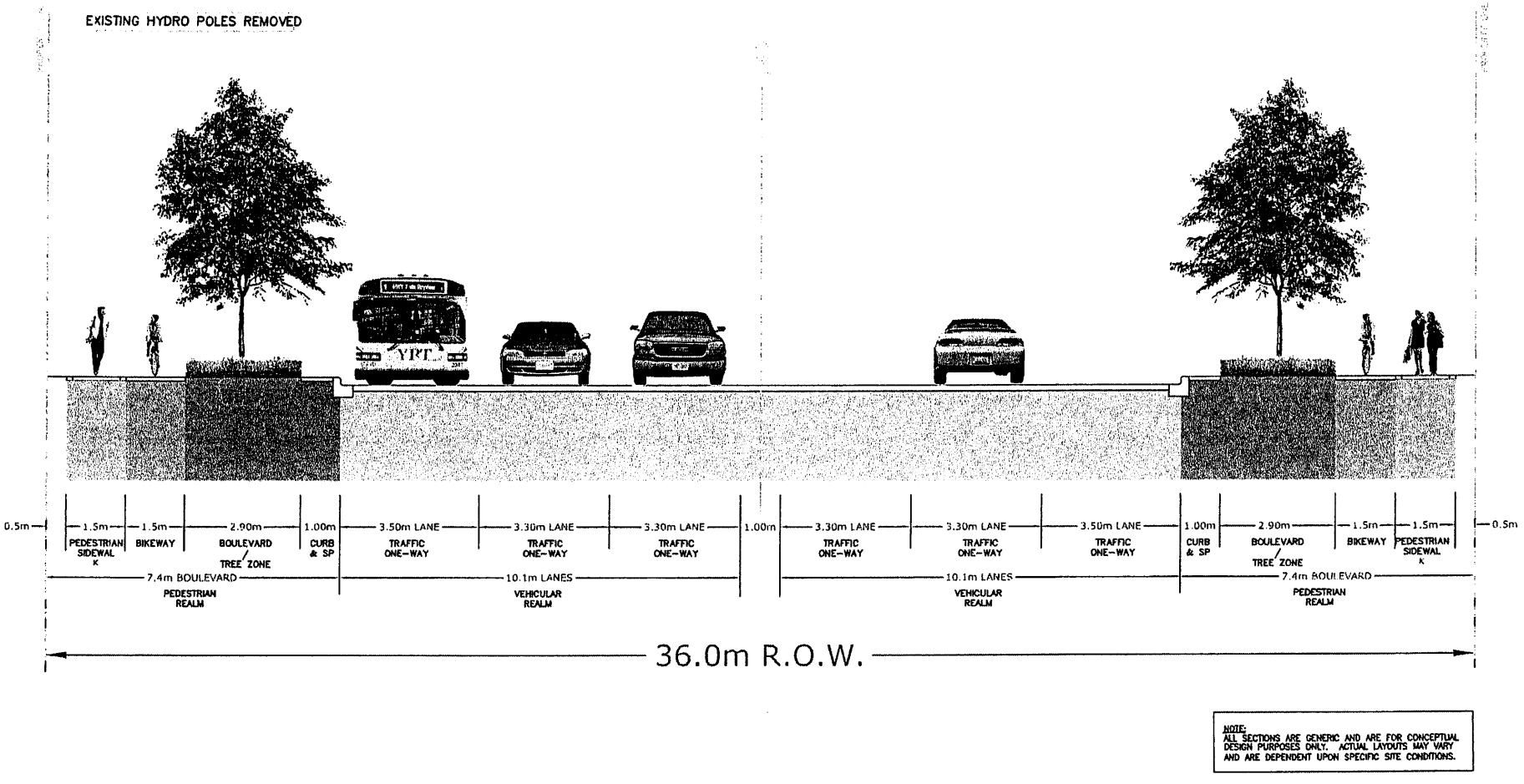


Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-12
Alternative 3.3
Off-Street Bike Lane with Curb Bus/HOV (2.0 m Median)



Marshall Macklin Monaghan

The MBTW Group

Texas Transportation Institute

FIGURE 7-13
Alternative 3.4
Off-Street Bike Lane with Curb Bus/HOV (No Median)

7.2 EVALUATION CRITERIA

Criteria were developed to evaluate the alternative cross-sections based on the transportation functionality, mobility and safety; cost; and community needs and values. The criteria are as follows:

7.2.1 Transportation Functionality/Mobility/Safety

The Transportation functionality/mobility/safety category weighs the benefits or disbenefits related to accommodating the various user groups including pedestrians, cyclists, transit, trucks, and automobiles in a safe and efficient manner, as well as other factors such as flexibility, corridor capacity and left turns at intersections.

- Pedestrians
  This criterion assesses how well the alternative cross-sections can accommodate pedestrians safely. Features such as raised medians can provide a refuge for pedestrians crossing the street. Reduced pavement crossing width would reduce pedestrian's exposure on the pavement and therefore increase safety. In addition, exclusive sidewalks are safer than facilities that need to be shared with cyclists. A sidewalk further offset from the pavement can also be perceived by pedestrians as safer and enhance walkability.

- Cyclists
  This criterion assesses how well the alternative cross-sections can accommodate cyclists safely. On-street exclusive bike lanes are a safe way to accommodate cyclists, whereas roadways without provision of space for cyclists at all and where cyclists need to use the curb lane (of 3.5 metre typical width), are the least safe. Off-street bike facilities are safer in that cyclists are riding on the boulevard and separated from motorists. However, collisions often occur at intersections including driveways, when cyclists are located in the boulevard area.

- Transit
  This criterion assesses how well the alternative cross-sections can accommodate transit vehicles safely. Increases in width of the curb lane would enhance safety and efficiency of transit vehicles. The extra width between the transit vehicle and the curb with the inclusion of on-street bike lane, can further enhance safety.

- Trucks
  This criterion assesses how well the alternative cross-sections can accommodate trucks safely and efficiently. Similar to transit, wider curb lane widths enhance truck travel, including safety. Provision of raised medians is safer than undivided roadways. However, raised medians limit property access and vehicles including trucks, would need to make mid-block U-turns or go around the block. Given the difficulty in accommodating mid-block U-turns for trucks, two-way left turn lanes are more desirable than raised medians in accommodating trucks.

- Automobiles (passenger vehicles)
  This criterion assesses how well the alternative cross-sections can accommodate passenger vehicles safely and efficiently. Lanes either too wide or too narrow are detrimental to safety. Provision of raised medians enhances safety as compared to undivided roadways and two-way centre left turn lanes.

- Flexibility
  This criterion assesses how readily/easily the alternative cross-sections can be transformed from the interim suburban/rural cross-section to the ultimate urban cross-section. The wider the total pavement width, the higher is the flexibility because of the higher compatibility between the interim and ultimate cross-section.

- Corridor Capacity
  This criterion assesses the implications of the alternative cross-sections on corridor capacity. Lane width is one of the factors affecting corridor capacity. Vehicles tend to travel faster on wider roadways. Undivided roadways with no left turn provisions would see left turning vehicles blocking one of the through lanes when waiting for a gap to make the turn, thus reducing overall corridor capacity as compared to provision of two-way left turn lanes, or raised medians, with left turning vehicles being accommodated at exclusive left turn lanes at median openings.

- Left Turns at Intersections
  This criterion assesses how well the alternative cross-sections can accommodate left turning vehicles at intersections. The wider the median, the more easily it is to provide a left turn lane (cut into the median) at intersections. A two-way centre left turn lane (mid-block) can be easily converted into an exclusive left turn lane at intersections.

7.2.2 Costs

- Capital Costs
  This criterion relates to the costs to build the alternative cross-sections. The wider the pavement, the more costly it is to build. Wider medians are more expensive to build than two-way left turn lanes.

- Maintenance Costs
  This criterion relates to the costs to maintain the alternative cross-section. The costs include maintenance of median and boulevard, irrigation of plants, as well as snow plowing of pavement. The wider the pavement and/or the median, the more costly it is to maintain.

7.2.3 Community Needs and Values

- Property Access
  This criterion assesses the impacts of the alternative cross-section on adjacent property access. A two-way centre left turn lanes which imposes no access constraints to outbound left turning vehicles and which can be used as a refuge area

for outbound left turns has least impact on access. Raised medians impose access restriction and affect property access. However, at median openings where left turns are permitted, outbound left turning vehicles can make use of the space provided at the median opening as a refuge area. In that case, the wider the median, the safer and better it is to accommodate the outbound left turning vehicles. Although there are no turn restrictions on undivided roadways, there is no refuge area to facilitate outbound left turns, thus making outbound left turns from the property less convenient.

- Utility Space
  This criterion relates to how the right-of-way accommodates utilities. Wider boulevards are more effective in accommodating utilities.

- Median Space
  This criterion assesses how well landscaping can be accommodated along the median, thus enhancing the aesthetics. Wider medians would allow more space for landscaping and the associated protective measures.

- Boulevard Space
  This criterion assesses how well landscaping can be accommodated along the boulevards, thus enhancing aesthetics. Wider boulevards would allow more space for landscaping, and therefore can make the street more pleasant.

- Community Character
  This criterion relates to the opportunity to develop alternative streetscapes to fit adjacent land uses. Narrower pavement can leave more space to develop alternative streetscapes which fit within the adjacent community.

- Mobility Choices
  This criterion assesses the mobility choices offered by the alternative cross-sections. The more modes that can be safely and efficiently accommodated, the larger the choices which are available.

7.3 ASSESSMENT OF ALTERNATIVES

The various alternative cross-sections and the existing 36 metre standard cross-section have been assessed on the basis of the above noted evaluation criteria. It must be recognized that no single alternative solution will meet all of these criteria. Accordingly, each alternative has been evaluated on the basis of whether it is "excellent", "very good", "good", "fair" or "poor" and assigned a point to it. Those alternatives which are "excellent" were assigned 5 points, with "poor" ones being assigned 1 point, and so on. The higher the overall score, the more desirable the cross-section is. The overall evaluation matrix with the comparison of the alternative cross-sections is shown in **Table 7-2**.

Table 7-2

Evaluation Matrix

	TRANSPORTATION FUNCTIONALITY, MOBILITY & SAFETY								Cost		COMMUNITY NEEDS & VALUES						
Alt	Pedestrians	Cyclists	Transit	Trucks	Automobiles	Flexibility	Corridor Capacity	Intersection Left Turns	Capital	Maintenance	Property Access	Utilities Space	Median Space	Boulevard Space	Community Character	Mobility Choices	SCORE
Weight	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Std	Good	Fair	Very Good	Excellent	Good	Very Good	Very Good	Excellent	Good	Very Good	Excellent	Fair	Poor	Fair	Good	Fair	
	3	2	4	5	3	4	4	5	3	4	5	2	1	2	3	2	52
1.1	Very Good	Poor	Good	Very Good	Excellent	Fair	Good	Very Good	Fair	Poor	Good	Fair	Excellent	Fair	Very Good	Good	
	4	1	3	4	5	2	3	4	2	1	3	2	5	2	4	3	48
1.2	Very Good	Poor	Good	Very Good	Excellent	Fair	Good	Good	Good	Fair	Fair	Good	Very Good	Good	Very Good	Good	
	4	1	3	4	5	2	3	3	3	2	2	3	4	3	4	3	49
1.3	Good	Poor	Good	Very Good	Excellent	Fair	Good	Good	Very Good	Good	Poor	Very Good	Fair	Very Good	Very Good	Good	
	3	1	3	4	5	2	3	3	4	3	1	4	2	4	4	3	47
1.4	Fair	Poor	Good	Good	Good	Fair	Poor	Good	Excellent	Very Good	Very Good	Excellent	Poor	Excellent	Very Good	Good	
	2	1	3	3	3	2	1	3	5	4	4	5	1	5	4	3	49
2.1	Good	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent	Very Good	Poor	Poor	Good	Good	Excellent	Poor	Fair	Excellent	
	3	5	4	4	5	5	5	4	1	1	3	3	5	1	2	5	54
2.2	Good	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent	Good	Fair	Fair	Fair	Fair	Very Good	Fair	Fair	Excellent	
	3	5	4	4	5	5	5	3	2	2	2	2	4	2	2	5	55
2.3	Fair	Excellent	Very Good	Very Good	Excellent	Excellent	Excellent	Poor	Good	Good	Poor	Good	Fair	Good	Fair	Excellent	
	2	5	4	4	5	5	5	1	3	3	1	3	2	3	2	5	53
2.4	Poor	Excellent	Very Good	Good	Good	Excellent	Poor	Good	Very Good	Very Good	Very Good	Very Good	Poor	Very Good	Fair	Excellent	
	1	5	4	3	3	5	1	3	4	4	4	4	1	4	2	5	53
3.1	Good	Good	Good	Very Good	Excellent	Fair	Good	Very Good	Fair	Poor	Good	Fair	Excellent	Fair	Very Good	Very Good	
	3	3	3	4	5	2	3	4	2	1	3	2	5	2	4	4	50
3.2	Good	Good	Good	Very Good	Excellent	Fair	Good	Good	Good	Fair	Fair	Good	Very Good	Good	Very Good	Very Good	
	3	3	3	4	5	2	3	3	3	2	2	3	4	3	4	4	51
3.3	Fair	Good	Good	Very Good	Excellent	Fair	Good	Excellent	Very Good	Good	Poor	Very Good	Fair	Very Good	Very Good	Very Good	
	2	3	3	4	5	2	3	5	4	3	1	4	2	4	4	4	49
3.4	Poor	Good	Good	Good	Good	Fair	Poor	Good	Excellent	Very Good	Very Good	Excellent	Poor	Excellent	Very Good	Very Good	
	1	3	3	3	3	2	1	3	5	4	4	5	1	5	4	4	48

Legend:

Excellent	5
Very Good	4
Good	3
Fair	2
Poor	1

7.4 RECOMMENDED CROSS-SECTION

As indicated in Table 7-2, the 2.x series, featuring the on-street bike lanes, generally have a higher score, given that they attempt to accommodate all modes of travel in a safe and efficient manner within the limited right-of-way. Alternative 2.2 which includes on-street bike lanes and a 4.0 metre median, yields the highest score (55), with Alternative 2.1 having the second highest score (54). The slightly lower score for Alternative 2.1 is mainly due to the higher cost associated with building and maintaining a wider median with landscaping features. However, Alternative 2.1 is more efficient and safer in terms of accommodating outbound left turns to enhance property access, and accommodating left turns at intersection because of the wider median.

The raised medians can also provide a refuge for pedestrians crossing the street. The wide medians would allow more space for landscaping and the associated protective measures, thus enhancing aesthetics of the corridor.

The on-street exclusive bike lanes are better in accommodating cyclists. The extra width between the transit vehicles and the curb with the inclusion of the on-street bike lane, can also enhance the safety of pedestrians walking on the sidewalks.

Thus, Alternative 2.1, with a 6 metre wide median, is recommended as the preferred alternative to be carried forward and applied to the case study corridors. The 6 metre wide median allows a car to be positioned perpendicular to the median when 'U' turns are being made. However, it is recognized that in some cases, median widths may need to be reduced, which would not allow a vehicle to be positioned perpendicular to the median.