TRAFFIC SIGNAL DESIGN MANUAL

City of Tucson Department of Transportation
Traffic Engineering Division

FIRST EDITION
MAY 2003

TABLE OF CONTENTS

TABLE OF CONTENTS
Continued

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Purpose

This first edition of the City of Tucson Traffic Signal Design Manual expands upon existing guidelines to more completely identify guidelines, practices, and standards for the design of City of Tucson traffic signals. Roadway lighting requirements are addressed only to the extent that intersection lighting is provided at signalized intersections. The purpose of this manual is to provide a consistent set of guidelines, practices, and standards for use by designers, contractors, and City of Tucson Department of Transportation Traffic Engineering Division (COT/DOT/TED) staff.

This manual supplements the 2000 edition and subsequent updates of the Manual on Uniform Traffic Control Devices (MUTCD). It should be used in conjunction with the 1994 edition of the Pima County/City of Tucson Standard Specifications for Public Improvements, and the Pima County/City of Tucson Standard Details for Public Improvements.

Application of Manual

This manual assembles and documents guidance developed by COT/DOT/TED regarding typical traffic signal design, operations, and construction. It is designed to expedite the production and review of plans by providing equipment placement guidelines, plan formatting instructions, drafting guidance, and standard notes. This manual will also serve as a reference for COT/DOT/TED staff in the construction and operation of traffic signals. Designers and contractors should be able to use the information presented in this manual to develop plans consistent with COT/DOT/TED standards. Users of this manual are encouraged to use engineering judgment when site specific conditions exist that are not addressed in this manual.

The fact that new design techniques are presented herein does not imply that existing signal designs are unsafe, nor does it mandate the initiation of improvement projects. This publication is not intended as a policy for maintenance or rehabilitation projects. For projects of this type, where major revisions to the intersection signal system are not necessary or practical, existing designs may be retained. Specific site investigations and crash history analysis often indicate that the exiting design features are performing in a satisfactory manner. The cost of full reconstruction for these facilities, particularly where major realignment is not needed, will often not be justified. Rehabilitation projects enable highway agencies to improve highway safety by selectively upgrading existing intersection features without the cost of full reconstruction.

The intent of this policy is to provide guidance to the designer by referencing a recommended range of values for critical dimensions. It is not intended to be a detailed design manual that could supercede the need for the application of sound principles by the knowledgeable design professional. Sufficient flexibility is permitted to encourage independent designs tailored to particular situations. Minimum values are either given or implied by the lower value in a given range of values. The larger values within the ranges will normally be used where the social, economic, and environmental (S.E.E.) impacts are not critical.

The highway, vehicle, and individual users are all integral parts of transportation safety and efficiency. While this document primarily addresses signal design issues, a properly equipped and maintained vehicle and reasonable and prudent performance by the roadway user are also necessary for safe and efficient operation of the transportation facility.

Revision Process

All users are also encouraged to suggest changes to the manual. Suggestions should be submitted in written and/or diagram form to COT/DOT/TED. Each suggestion will be reviewed and responded to. If COT/DOT/TED staff agree with the suggested change or addendum, the manual will be updated to reflect the change in the next revision.

Should questions arise in the use of this manual, users are referred to the City of Tucson Traffic Engineering Administrator.

James Glock, P.E. Director, City of Tucson Department of Transportation	Richard B. Nassi Traffic Engineering Administrator, City of Tucson Department of Transportation

1. GENERAL INFORMATION

This section provides general information regarding traffic signal designs, sheet assignments, and sheet numbering protocols.

A. Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
AWG	American Wire Gauge
COT/DOT/TED	City of Tucson Department of Transportation Traffic Engineering Division
IESNA	Illuminating Engineering Society of North America
IISNS	Internally Illuminated Street Name Sign
IMSA	International Municipal Signal Association
LED	Light Emitting Diode
MUTCD	Manual on Uniform Traffic Control Devices
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
PCDOT/TED	Pima County Department of Transportation Traffic Engineering Division
PPG	Policies, Procedures and Guidelines

B. Definitions

Accessible Pedestrian Signal	A device that communicates information about pedestrian timing in nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces.
Advance Loop	A loop used in advance of an intersection that detects a vehicle's passage, and which is typically used to extend the green interval.
Approach	All lanes of traffic moving toward an intersection or a mid block location from one direction, including any adjacent parking lane(s).
Backplate	A thin strip of material that extends outward from and parallel to a signal face on all sides of a signal housing to provide a background for improved visibility of the signal indications
Beacon	A highway traffic signal with one or more signal sections that operates in flashing mode
Clear Zone	Term used to designate the unobstructed, relatively flat area provided beyond the edge of the traveled way for the recovery of errant vehicles. The clear zone includes any shoulder or auxiliary lanes.
Call Loop	An embedded loop that detects a vehicle and indicates to the controller that a vehicle requires a change in phase.
Conduit Run	A underground conduit from pull box to pull box or from pull box to pole foundation. Often conduit in the same trench are given one conduit run number.

B. Definitions (continued)

Conventional Pedestrian Signal	A device that communicates information about pedestrian timing in conventional (i.e., visual) format.
Coordinated Traffic Signal System	A system of traffic signals for which a timed relationship exists between adjacent traffic signals within the system.
Curb Access Ramp	A short section of the pedestrian access route that joins the street elevation to the public sidewalk elevation, through a cut in the curb face.
Curb Access Ramp Landing	A level area on a public sidewalk, adjoining a curb access ramp, used for maneuvering and waiting.
Emergency Vehicle Pre-emption	Transfer of normal operation of a traffic signal to a special mode of operation that quickly gives the green phase for the direction of traffic from which the approaching emergency vehicle is arriving.
HAWK	High intensity Activated crossWalK. A signalized pedestrian crossing that utilizes flashing and steady red and yellow signal indications.
Intersection Control Beacon	A beacon used only at an intersection to control two or more directions of travel
Lead-in Cable	Cable used from the controller cabinet to the embedded loop detectors.
Louver	A device that can be mounted inside a signal visor to restrict visibility of a signal indication from the side, or to limit the visibility of the signal indication to a certain lane or lanes.
Major Street	The street normally carrying the higher volume of vehicular traffic at an intersection.
Minor Street	The street normally carrying the lower volume of vehicular traffic at an intersection.
Multiconductor Cable	A combination of conductors insulated from one another. The component conductors of the multiconductor cable may be either solid or stranded and have a common insulation covering.
Multiconductor Cable Schematic	An illustration of multiconductor cabling requirements for a traffic signal design that replaces/supplements the conductor schedule.
NEMA Traffic Signal Phasing Diagram	A diagram illustrating traffic movements at a signalized intersection that utilizes NEMA standard movement designations.
Pedestrian Crossing Beacon	Signal devices that are used in conjunction with pedestrian crossing locations.
Pedestrian Indication	A signal head, which contains the symbols WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DON'T WALK), that is installed to direct pedestrian traffic at a traffic control signal.
Pedestrian Push Button Station	A button to activate pedestrian timing.

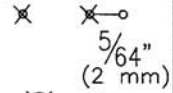
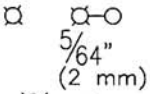
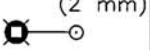
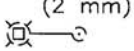
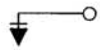
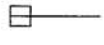
B. Definitions (continued)

Pre-emption Beacon	A flashing strobe mounted on the signal mast arm to indicate emergency vehicle detection.
Pre-emption Sensor	A device that registers the request from an emergency vehicle for priority control of an intersection.
Presence Loop	An embedded loop that detects vehicles within the loop area.
Pulse Loop	An embedded loop that detects a vehicle and notifies the controller of an approaching vehicle, typically used in advance of an intersection (see advance loop).
Span-Wire Installation	A traffic signal installation in which the traffic signal heads are suspended from wires that span the intersection, rather than installed on a mast arm.
Stop line	A pavement marking that indicates where motor vehicles should begin to queue for a red traffic signal indication.
Traffic Signal Face	The front part of an assembly of one or more signal faces together with the associated protective housings
Traffic Signal Head	An assembly of one or more signal faces together with the associated signal housing.
Traffic Signal Indication	The illumination of a signal lens or equivalent device
Traffic Signal Lens	That part of the signal section that redirects the light coming directly from the light source and its reflector, if any.
Traffic Signal Terminal Strip	Component of the terminal compartment in the traffic signal mounting assembly where the conductor is attached to the signal head.
Video Detection	Vehicle detection accomplished through the use of machine vision technology.
Warning Beacon	A beacon used only to supplement an appropriate warning or regulatory sign or marker.
Yellow Pedestrian Activated Flasher	Yellow flashing signal that is activated by the pedestrian and which emphasize the location of a crosswalk.

C. Symbols

CADD Symbols are shown on Figures 1-1A and 1-1B on the following pages.

FEATURE	PEN SIZE	NEW	PEN SIZE	EXISTING
TRAFFIC PEDESTRIAN CONTROL BUTTON	1	1/8" (3 mm)	00	1/8" (3 mm)
TRAFFIC CONTROL CABINET WITH FOUNDATION	1		00	
PULL BOX (1), NO. 3-1/2	1	7/64" (3 mm)	00	7/64" (3 mm)
PULL BOX, NO. 5	1	7/64" (3 mm)	00	7/64" (3mm)
PULL BOX, NO. 5 W/ EXTENSION	1	7/64" (3 mm)	00	7/64" (3 mm)
PULL BOX NO. 7	1		00	
PULL BOX NO. 7 W/ EXTENSION	1		00	
(1) TELEPHONE PULL BOXES SHALL BE DESIGNATED BY "T", ELECTRIC BY "E" AND TRAFFIC BY "TS" (TYP. ALL SIZES)				
SERVICE CABINET W/ FOUNDATION	1		00	
RAILROAD CABINET W/ FOUNDATION	1		00	
DETECTOR LOOP	1		00	
TRAFFIC COUNT STATION	1		00	

FEATURE	PEN SIZE	NEW	PEN SIZE	EXISTING
POLE W/ LUMINAIRE: (W/O AND WITH MAST ARM) -	1		00	
LUMINAIRE W/ PHOTOCELL (ON POLE) -------	1		00	
LUMINAIRE W/ PHOTOCELL ————————	1		00	
TRAFFIC SIGNAL - - - - - - - - - - - - - - - - - -	1		00	
POLE WITH MAST ARM AND SIGNAL - - - - - - - -	1		00	
TRAFFIC SIGNAL WITH TURN ARROW - - - - - - -	1		00	
FLASHING SIGNAL - - - - - - - - - - - - - - - - -	1		00	
PEDESTRIAN SIGNAL - - - - - - - - - - - - - - - -	1		00	
POLE KEY NUMBER ————————	1		00	
CONDUIT RUN NUMBER - - - - - - - - - - - - - - -	1		00	

D. Standard References for Traffic Signals

The following are standard reference documents for the design of traffic signals.

1. For new or upgraded signal installations, the number of signal indications and their location should conform with requirements in Part IV of the *Manual on Uniform Traffic Control Devices* (MUTCD).

2. Equipment, materials and installation procedures should meet or exceed the 1994 Pima County/City of Tucson Standard Specifications for Public Improvements, and 1994 Pima County/City of Tucson Standard Details for Public Improvements, unless noted otherwise in the construction documents, or superseded by direction in this manual.

3. All installations should meet *National Electric Code* requirements.

4. Steel pole, control cabinet, and electric service pedestal foundations should be positioned beyond the clear zone requirements, whenever possible, as specified in the 1996 AASHTO *Roadside Design Guide* (convert to English measurements).

5. Plans should conform to the City of Tucson, Department of Transportation, Engineering Division, Active Practice Guidelines, *Office Procedure No. 8-1552-002, Rev. No. 1, 9/12/00*

E. Standard References for Street Lighting at Signalized Intersections

While this manual is not intended to be a street lighting design manual, intersection lighting is included in traffic signal designs. For this reason, standard references for intersection lighting are specified.

1. Street lighting design should meet or exceed average illuminance per the AASHTO publication, *An Informational Guide for Roadway Lighting*, 1984.

2. Pole locations should be positioned beyond the AASHTO clear zone requirement, whenever possible, as specified in the AASHTO *Roadside Design Guide*, 1996 (convert to English measurements).

3. Light distribution shall satisfy the Pima County Outdoor Lighting Code, October 16, 2001.

4. All installations should meet *National Electric Code* requirements.

5. Installations shall be in conformance with Roadway Lighting – Illuminating Engineering Society of North America, ANSI/IESNA RP-8, 2000.

The presence of nearby overhead power lines may prevent the installation of one or more light poles or signal combination poles on the corners to avoid their conflict with power lines (lighting would not be provided).

F. Sheet Assignment

1. Overview

   A single traffic signal design only package typically is comprised of three sheets, as enumerated below:

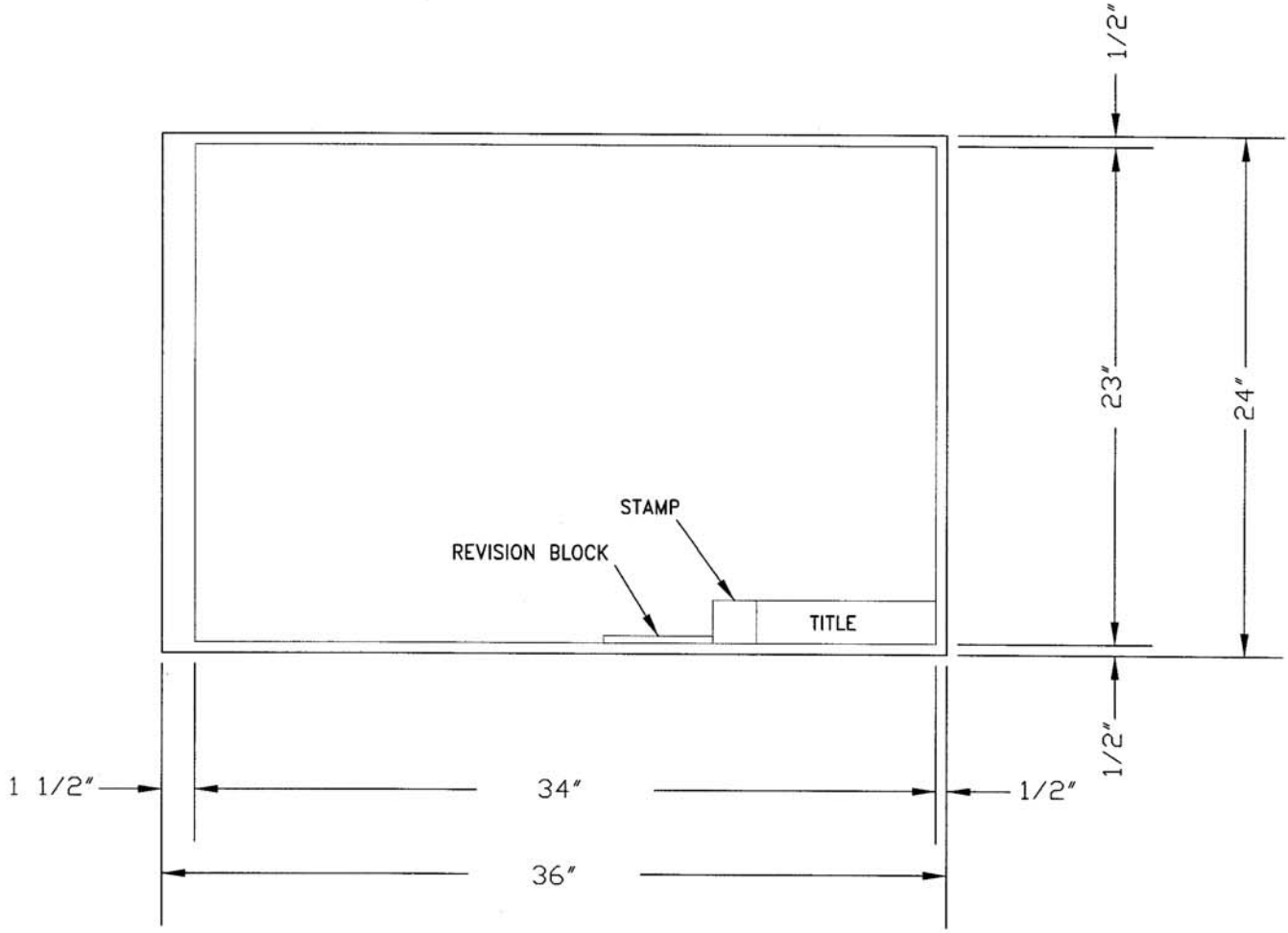
   a. Sheet 1 – Cover Sheet
   b. Sheet 2 – Plan View and General Traffic Signal Layout Sheet
   c. Sheet 3 – Pole and Conductor Schedule Sheet

   The final sealed/signed sheets should be drawn on mylar. Vellum and bluelines are acceptable for intermediate submittals. Details regarding requirements for each sheet are provided in the following guidance. Example plans are provided in the Appendix A for reference.

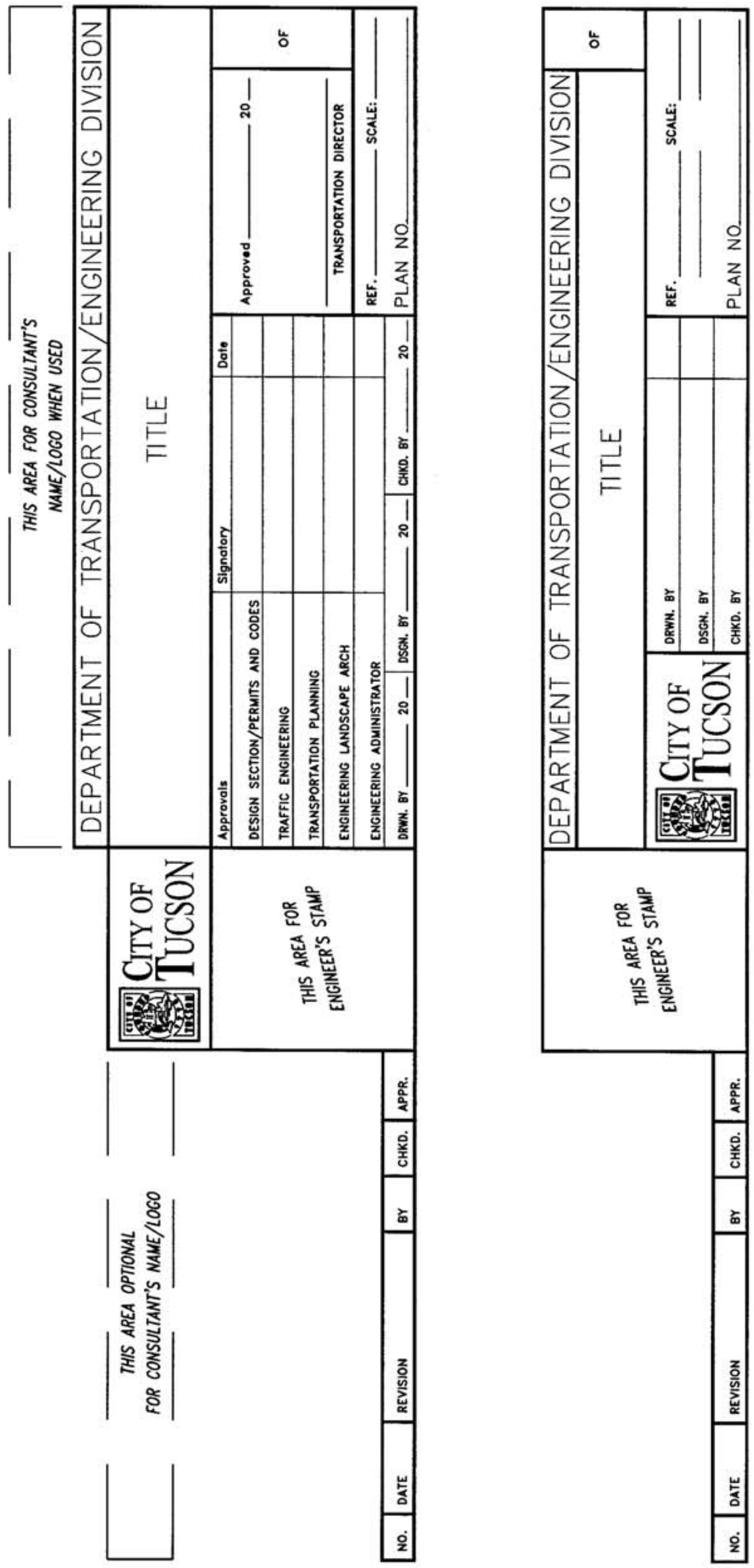
   Traffic signal designs are frequently included as part of a larger civil design package, which may include multiple signal designs. In these instances, no separate cover sheet for signal design is required. Sheets showing the pole and conductor schedule follow the corresponding plan view.

2. **Sheet 1 – Cover Sheet**

   This is to be the first sheet in a set of plans. This sheet shall be 24"x36"as shown in Figure 1-2, and a title block as shown in Figure 1-3. The cover sheet will show the locations and the extent of the work to be performed and is to be drawn to the scale of 1”=100’. The cover sheet shall also show the name of the job, subdivision name, map and plat book and page, development number (if applicable), job number, plan number, sheet index, typical sections (may need additional sheets), legend for symbols, general notes and a location map at a scale of 3”= 1 mile in the upper right hand corner. Starting with the cover sheet all sheets will have a sequential page number located on the lower right hand corner (no letters).



ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 1-2
REVISED:		Plan Cover Sheet	PAGE 10 of 58



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TRAFFIC SIGNAL DESIGN MANUAL

FIGURE 1-3

Plan Title Block

3. Sheet 2 – Plan View and General Traffic Signal Layout Sheet

The plan view of the proposed intersection geometry and traffic signal installation should be drawn to a scale of 1"=20' and contain the following elements:

a. NEMA Traffic Signal Phasing Diagram (vehicle and pedestrian)

b. North Arrow (oriented so that North is at the top of the sheet)

c. Graphical scale

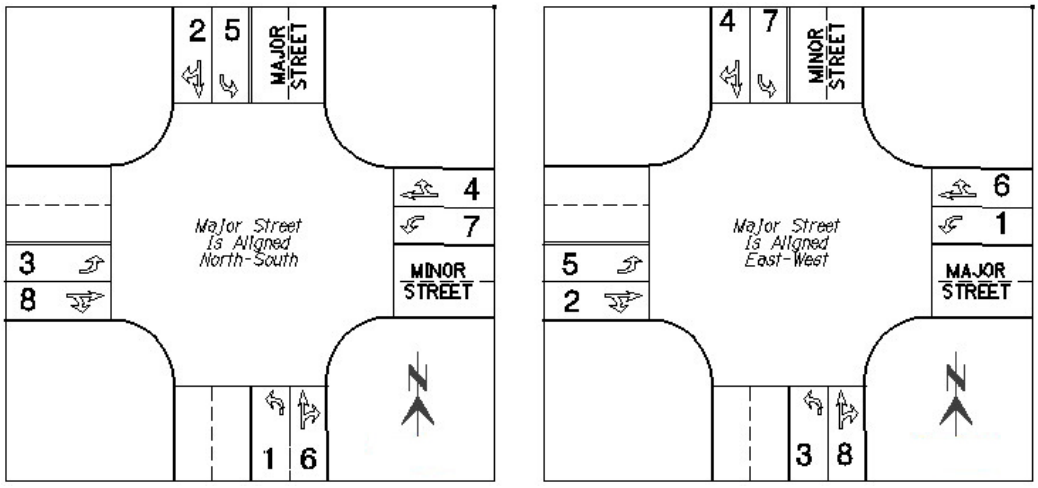
d. Blue Stake emblem

For the purposes of streamlining traffic signal operations, NEMA standard phase designations should be used. The NEMA movements should be oriented such that phases 2 and 6 align with the major street. For a street with an east-west major street, phase 2 should be eastbound and phase 6 should be westbound. For an intersection for which the main street is oriented North-South, phase 2 is southbound and phase 6 is northbound. The geographic orientation of phasing is presented in Figure 1-4. For intersections of two major streets, COT/DOT/TED will provide direction for phasing orientation.

Additionally, the traffic signal phasing diagram should show both vehicular and pedestrian movements. North arrow indication will be utilized with the phasing diagram.

The plan view should also show existing geometry, existing equipment and existing utilities.

Figure 1-4
NEMA Standard Movements



4. Sheet 3 - Pole and Conductor Schedule Sheet

This sheet shows the pole schedule and the multiconductor cable schematics. These should be prepared according to the following guidelines/standards. Refer the sample set of plans in Appendix A.

Pole Schedules should include the following information:

a. Pole identification letter and schematic of pole showing the type of heads and the dimensions between the heads.

b. Pole type

c. Signal and luminaire mast arm lengths

d. Signal mounting assembly types and face types

e. Pedestrian push button stations and signs

f. Luminaires

g. Remarks, which typically include, installation of photocell, mounting of cameras and/or pre-empt sensors, Internally Illuminated Street Name Signs (IISNS)

h. Reference standards in the Pima County / City of Tucson Standard Details for Public Improvements

i. Low-voltage and high-voltage circuits shall be displayed on the conduit and conductor schedule and should include conduit run identification numbers, size and quantities and conductor description, and quantity in each conduit, or

j. Conductor schedule shall be provided. The table below illustrates the column headings to be included in the pole schedule. Each pole will have a separate row/line in the pole schedule.

Table 1-1
Pole Schedule Column Designations

POLE NUMBER	POLE TYPE	MAST ARM		SIGNALS		PED PB TYPE/SIGN	FOUNDATION	LUMINAIRE	REMARKS
		SIGNAL	LUMIN	MTG.	FACE				

5. Other Sheets

Other sheets may be included in the plan set as required by the design project. Other sheets may include interim construction phasing or demolition plans. Use of additional sheets should be approved by COT/DOT/TED Project Manager.

G. CAD Level Structures

Refer to the latest City of Tucson, Department of Transportation, Engineering Division drafting standards.

H. Other Related Studies

1. Traffic Signal Warrant Analysis

   At the start of the design process, COT/DOT/TED will provide information on the type of control traffic to be used for intersections. However, the designer may on occasion be asked to prepare a warrant study for new signal installations. The warrants as found in the MUTCD are used for making such a study. There are 8 warrants which relate to the volume, delay, and accident experience of the intersection. Satisfying one or more of these warrants may be an indication that installation of traffic signals is appropriate.

2. Left-Turn Warrant Study

   A left turn warrant study using City of Tucson criteria is typically completed by COT/DOT/TED for the existing year volumes prior to the traffic signal design, when necessary.

3. Traffic Signal and Lighting Report

   A Traffic Signal and Lighting Report may be required under certain circumstances.

4. Project Traffic Engineering Report

   For many roadway civil designs, a project Traffic Engineering Report may have been completed. This report presents existing and future conditions and discusses proposed improvements. The report also includes information about proposed traffic signal operation and phasing.

2. POLE PLACEMENT STANDARDS AND GUIDELINES

A. Curb Access Ramp Locations

Curb access ramps are required by the Americans with Disabilities Act (ADA). These ramps should be provided via two separate ramps per corner, one for each crossing direction. Special circumstances may require the use of single joint ramps, which requires the pre-approval of the COT/DOT/TED Project Manager.

B. Curb Access Ramp Landings

A curb access ramp landing is a relatively flat area to be used by a pedestrian to access and activate a pedestrian push button.

A landing should be provided at the top of each curb access ramp. The landing should contain a 60-inch square or 60-inch circle, and should slope no more than 1:48 in any direction, in accordance with the Final Report of the Public Rights-of-Way Access Advisory Committee (January 2001). The landing should be provided with a stable, firm, and slip resistant surface. Poles, utility boxes, and other obstructions shall not be located in the curb access ramps or in the landings.

C. Relationship of Curb Access Ramps with Crosswalks and Stop Lines

The location of the curb access ramps determines the location of the marked crosswalks and associated stop lines. The stop lines determine the placement of the detection loops and any "near right" poles. Therefore, the design/location of any of these features must be coordinated with the design of the other features. Listed below are design/operation factors to be balanced in the location of curb access ramps, crosswalks, and stop lines:

1. Align crosswalks and stop lines as close to perpendicular to the approach traffic lanes as possible.

2. Center the curb access ramps in the crosswalks.

3. Locate curb access ramps near the radius PT and PC.

4. Minimize pedestrian exposure to turning vehicles.

5. Ensure that the pedestrians waiting at the radius, at both curb access ramps, are readily visible to approaching and turning vehicle drivers.

6. Minimize pedestrian crossing distance and crossing time.

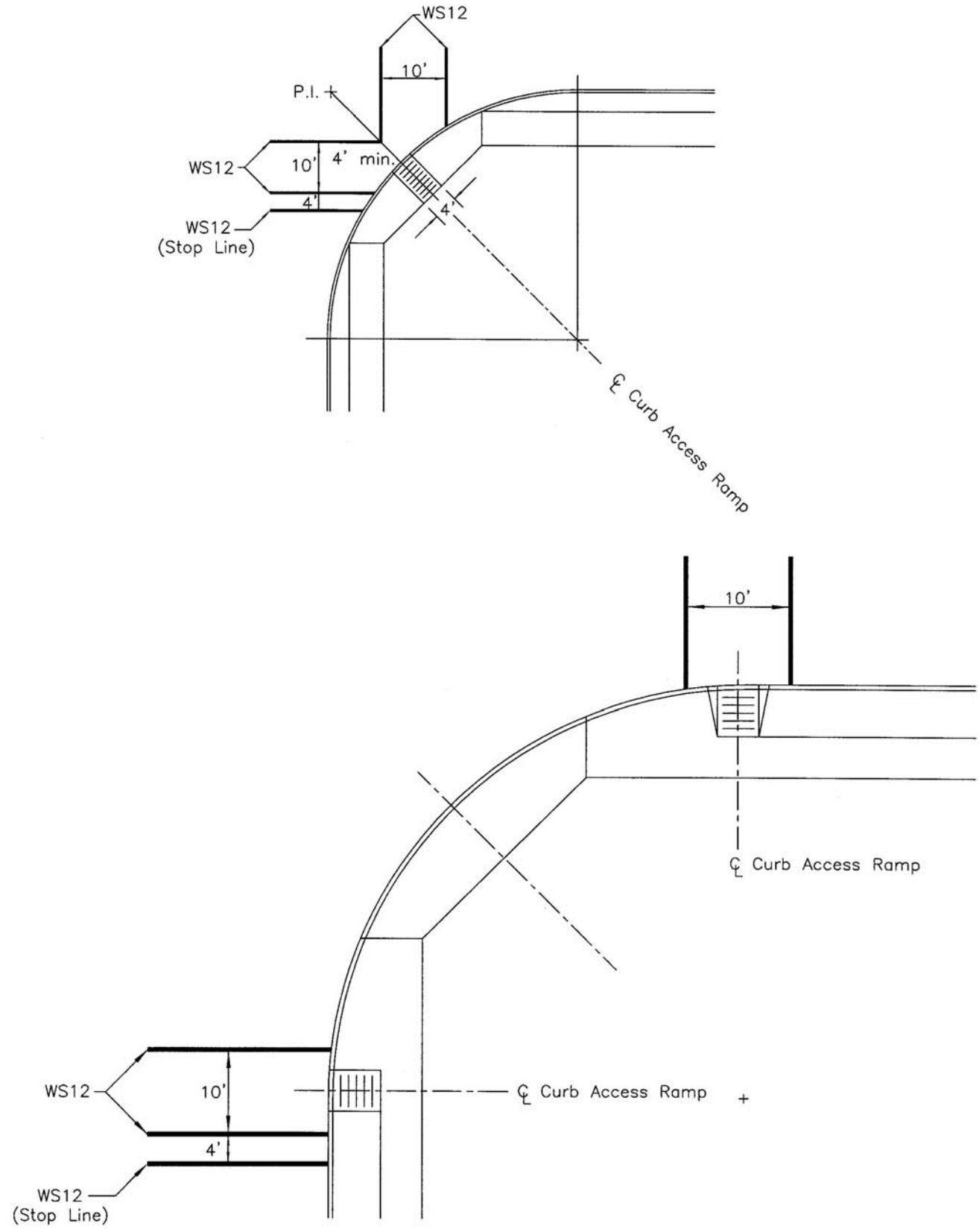
7. Clarify and simplify the pedestrians crossing route.

See Figure 2-1 for an illustration of the relationship between crosswalk and stop line.

D. General Considerations For Traffic Signal Pole Locations

Traffic signal poles should be located to provide for the best visibility of signal faces by balancing the following design issues.

1. Accommodate right-of-way limitations.
2. Locate signal heads (vehicle and pedestrian heads) to maximize visibility and minimize confusion.
3. Accommodate approach lane configuration.
4. Accommodate alignment of intersecting roadways (skew intersections).
5. Accommodate approach alignment (horizontal and vertical curves).
6. Minimize the number of poles for signal heads, pedestrian buttons, and street lighting.
7. Provide street lights in reasonable locations.
8. Account for nearby underground and overhead utilities (existing/proposed).
9. Account for nearby drainage structures, bridges and embankments.
10. Account for nearby buildings, walls, fences, and other structures.
11. Account for the corner radius.
12. Determine reasonable curb access ramp locations.
13. Enhance access to pedestrian push buttons.
14. Account for nearby trees and other landscaping features.
15. Use standard mast-arm lengths.



ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2—1
REVISED:		Pole Placement Standards & Guidelines	PAGE 17 of 58

While recognizing the above issues, the following signal pole location criteria should also be incorporated:

1. The distance between the stop line and the mast arm heads should be 70 feet to 150 feet.

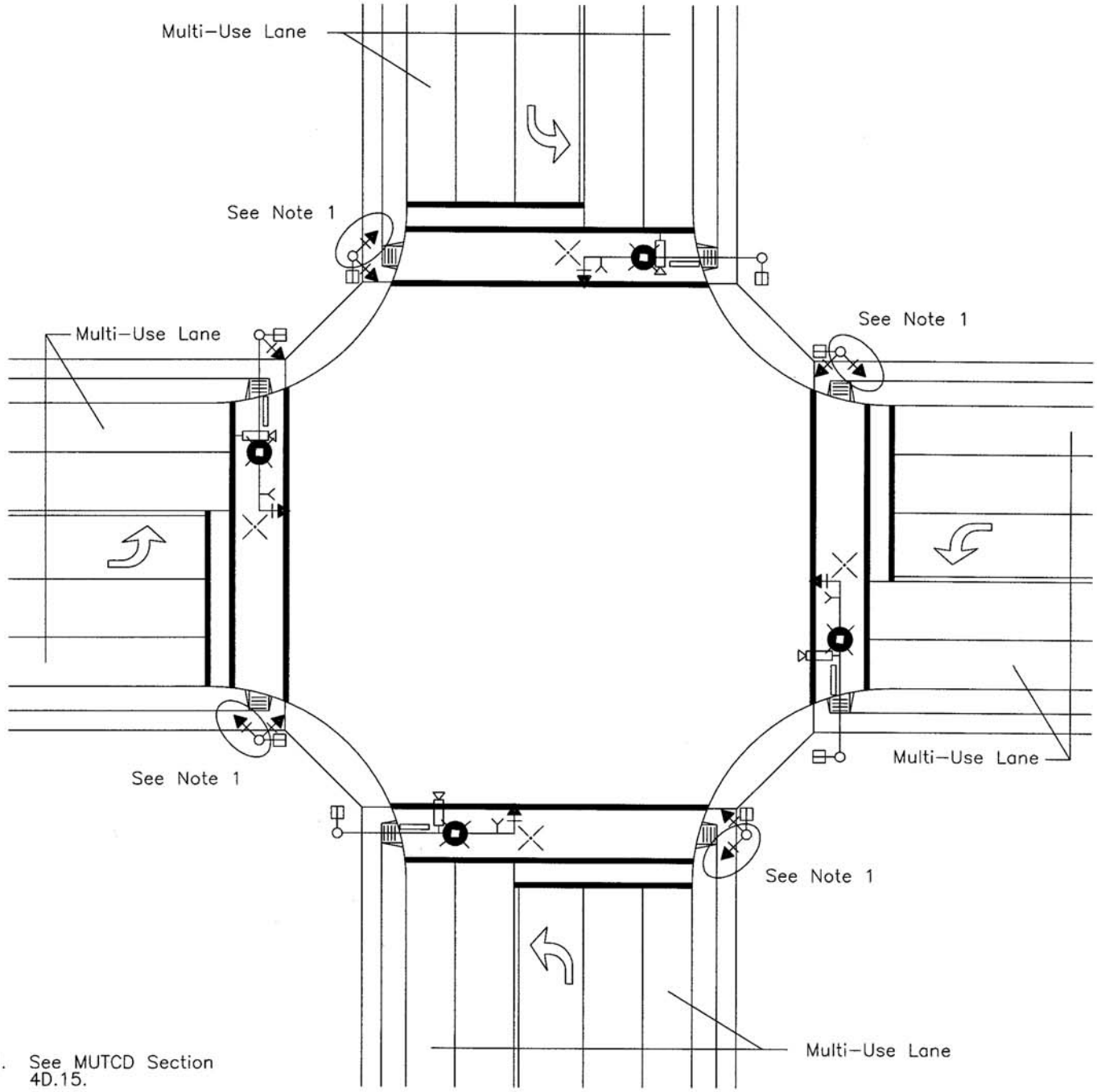
2. Luminaries should be positioned to light crosswalks.

3. Poles or posts should not obstruct pedestrian routes. (DO NOT INSTALL in curb access ramps or landings.)

4. Pedestrian push buttons for intersecting approaches should not be within 10 feet of each other. (MUTCD and ADA requirements should also be satisfied.)

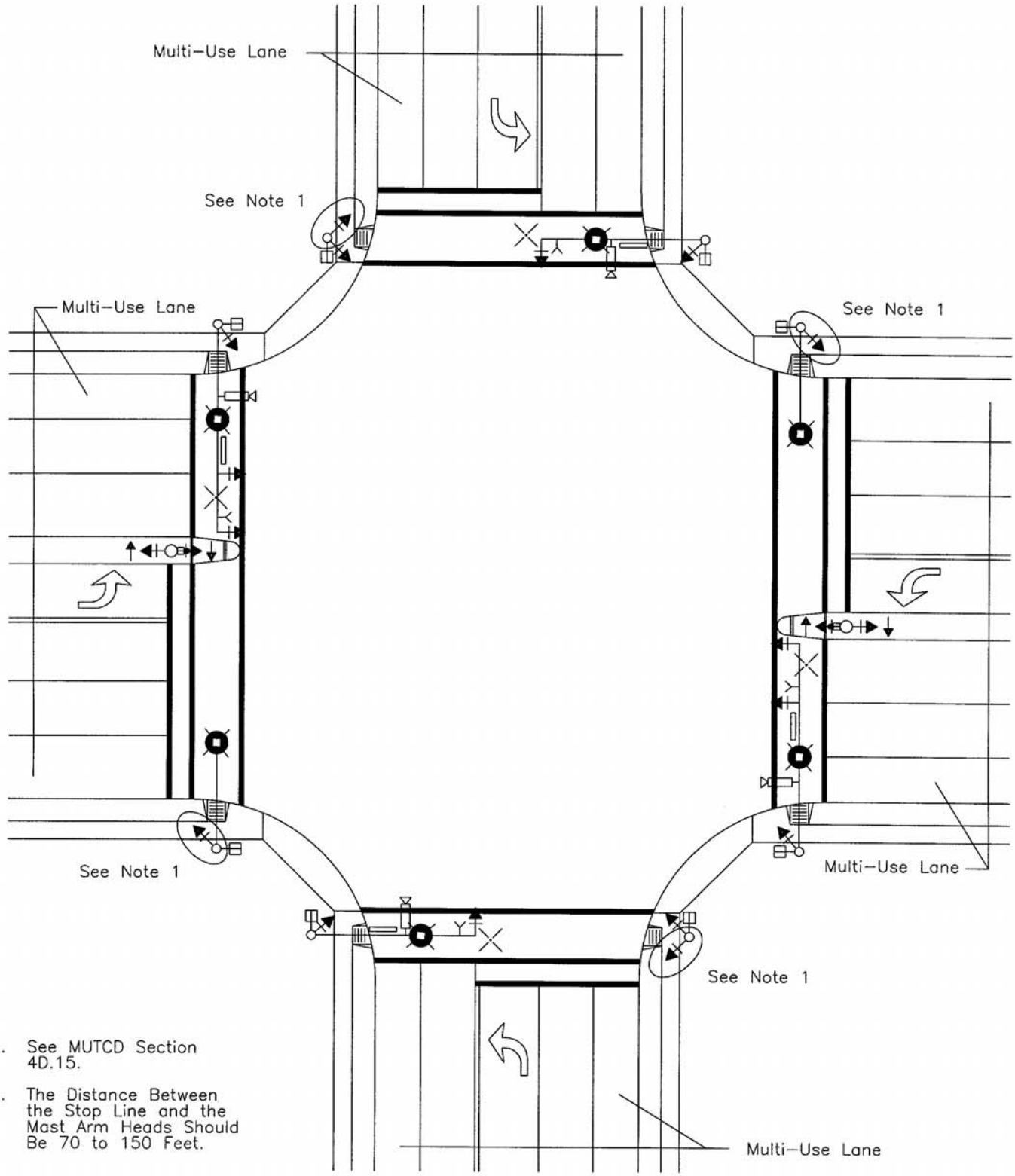
5. Use standard mast arm lengths (30 feet or 40 feet for Type Q poles, 45 feet or 55 feet for Type R poles).

See Figures 2-2 through 2-12 for sample drawings illustrating common intersection and signal configurations.



1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–2
REVISED:		Pole Placement Standards & Guidelines 3L Undivided X 3L Undivided	PAGE 19 of 58



1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

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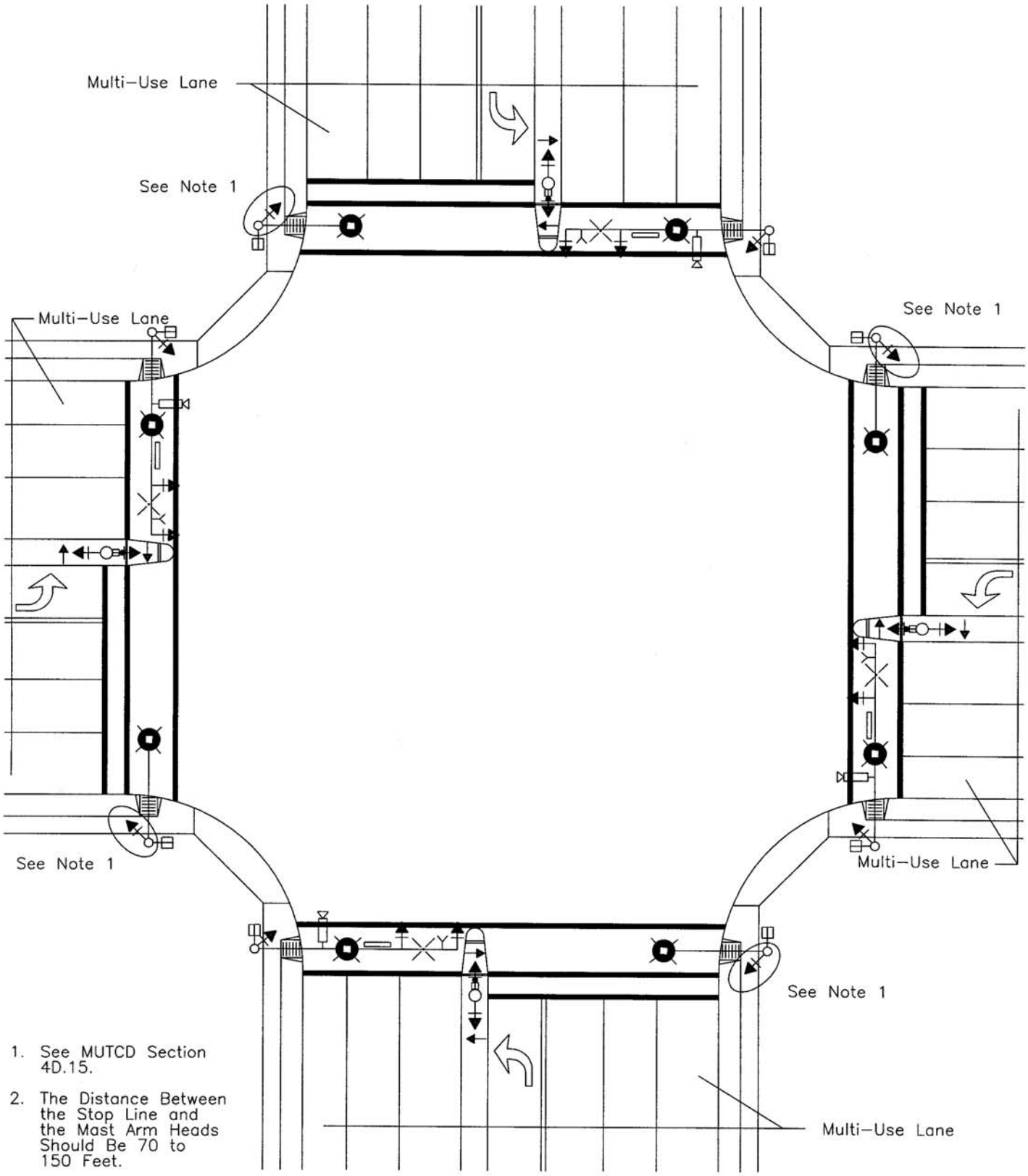
REVISED:		Pole Placement Standards & Guidelines 3L Undivided X 4L Divided	PAGE 20 of 58



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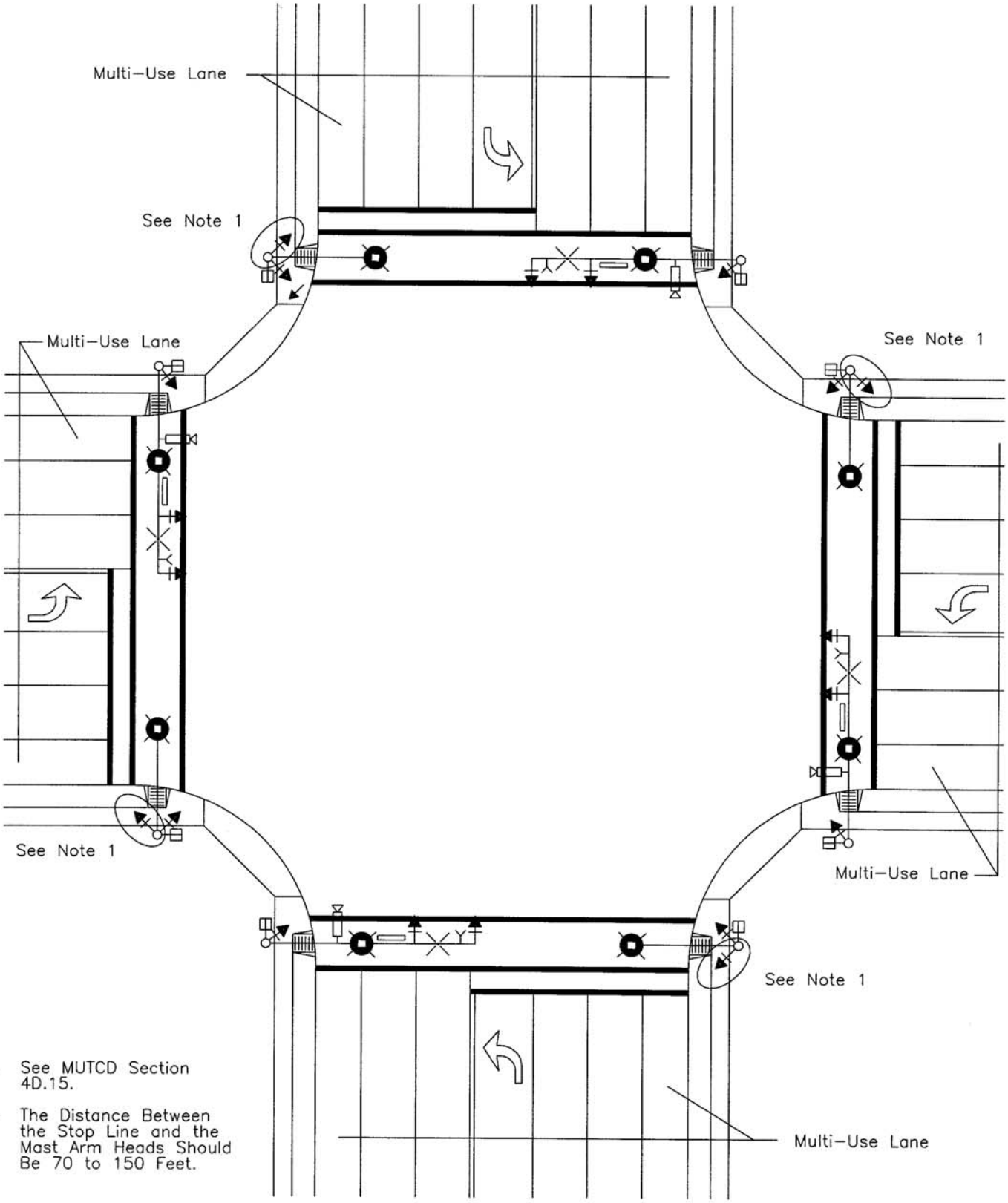
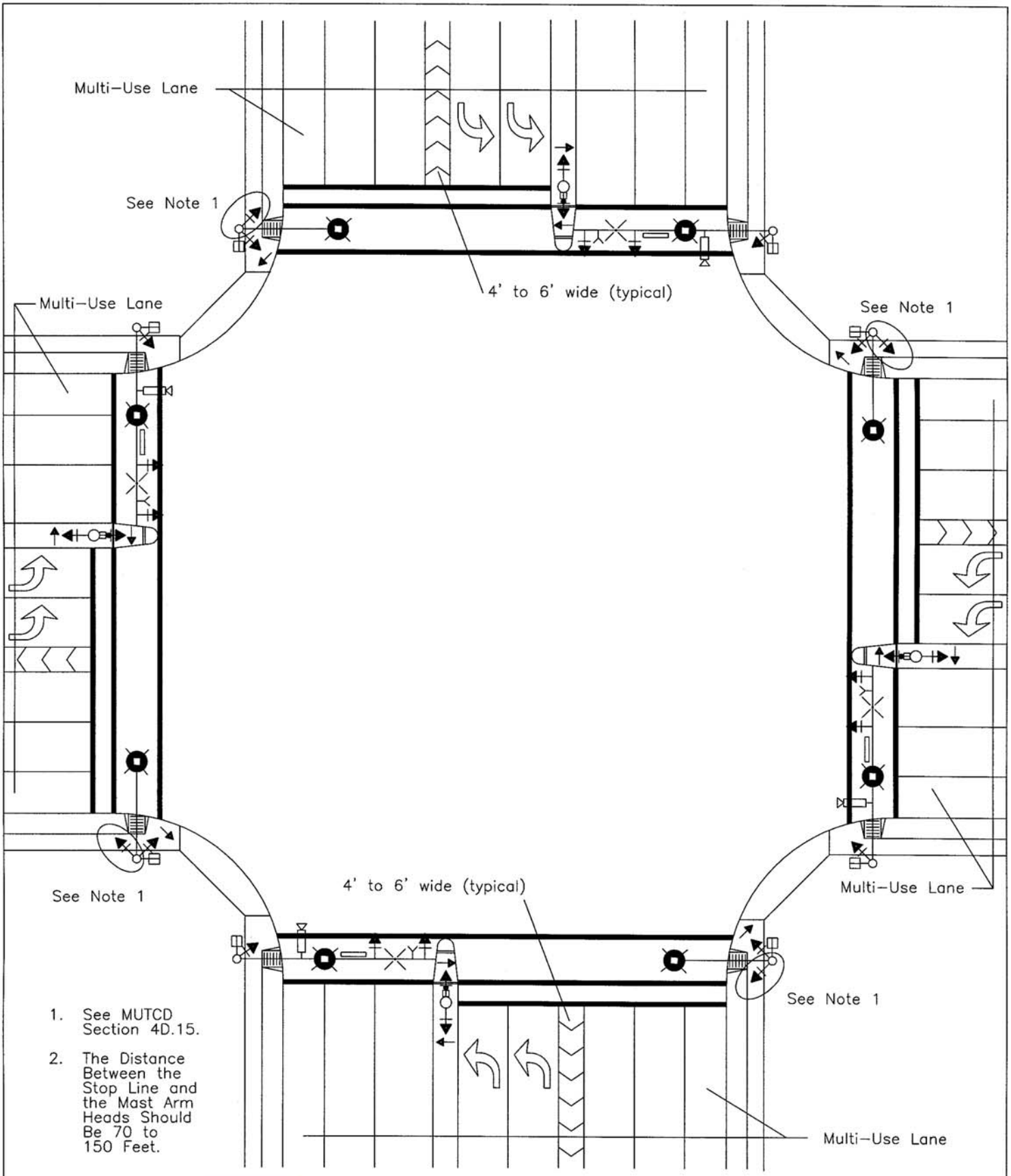
REVISED:		Pole Placement Standards & Guidelines 4L Divided X 4L Divided	PAGE 21 of 58



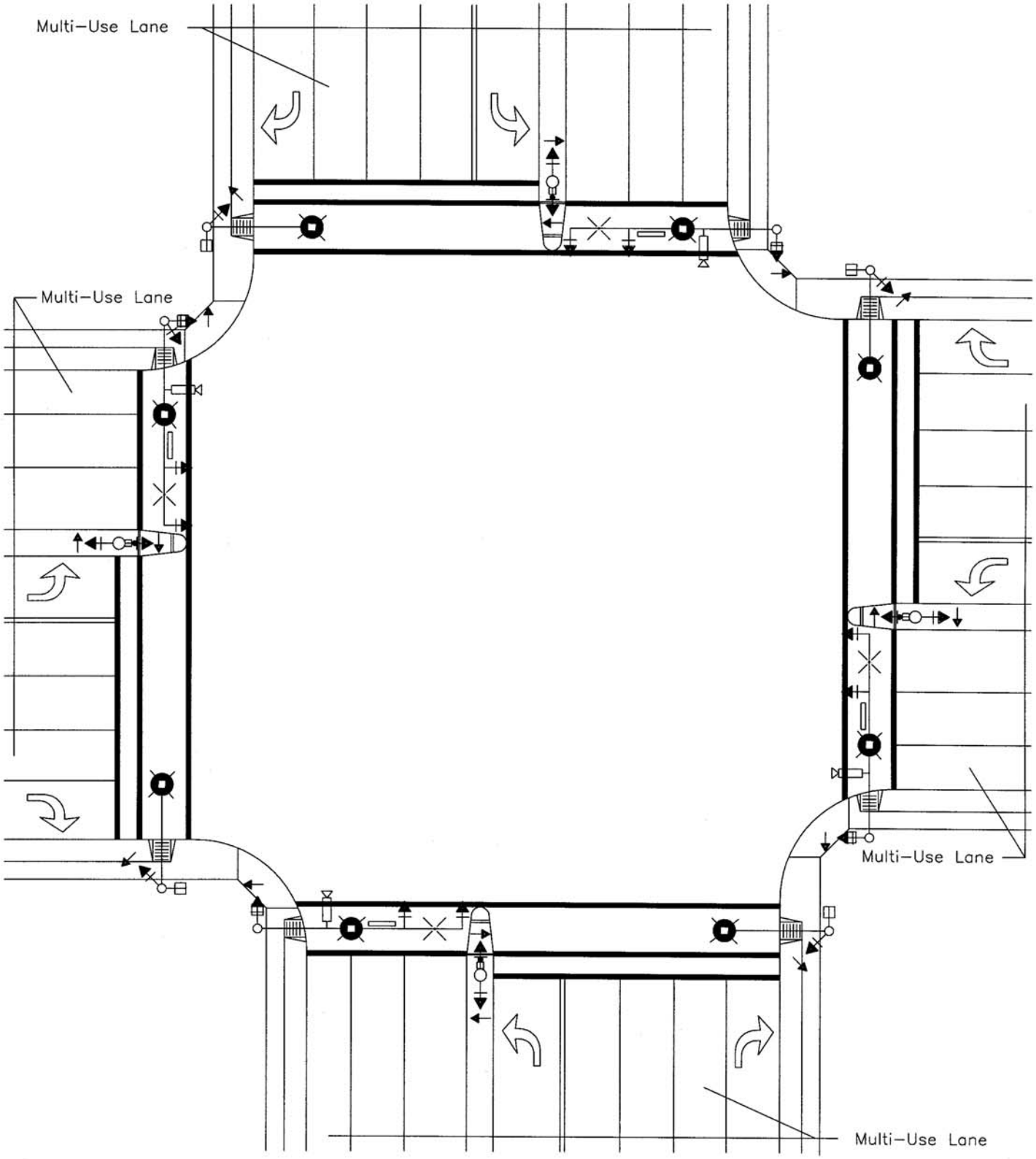
1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

ISSUED: 05 / 03		CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–5
REVISED:		Pole Placement Standards & Guidelines 5L Undivided X 5L Undivided	PAGE 22 of 58

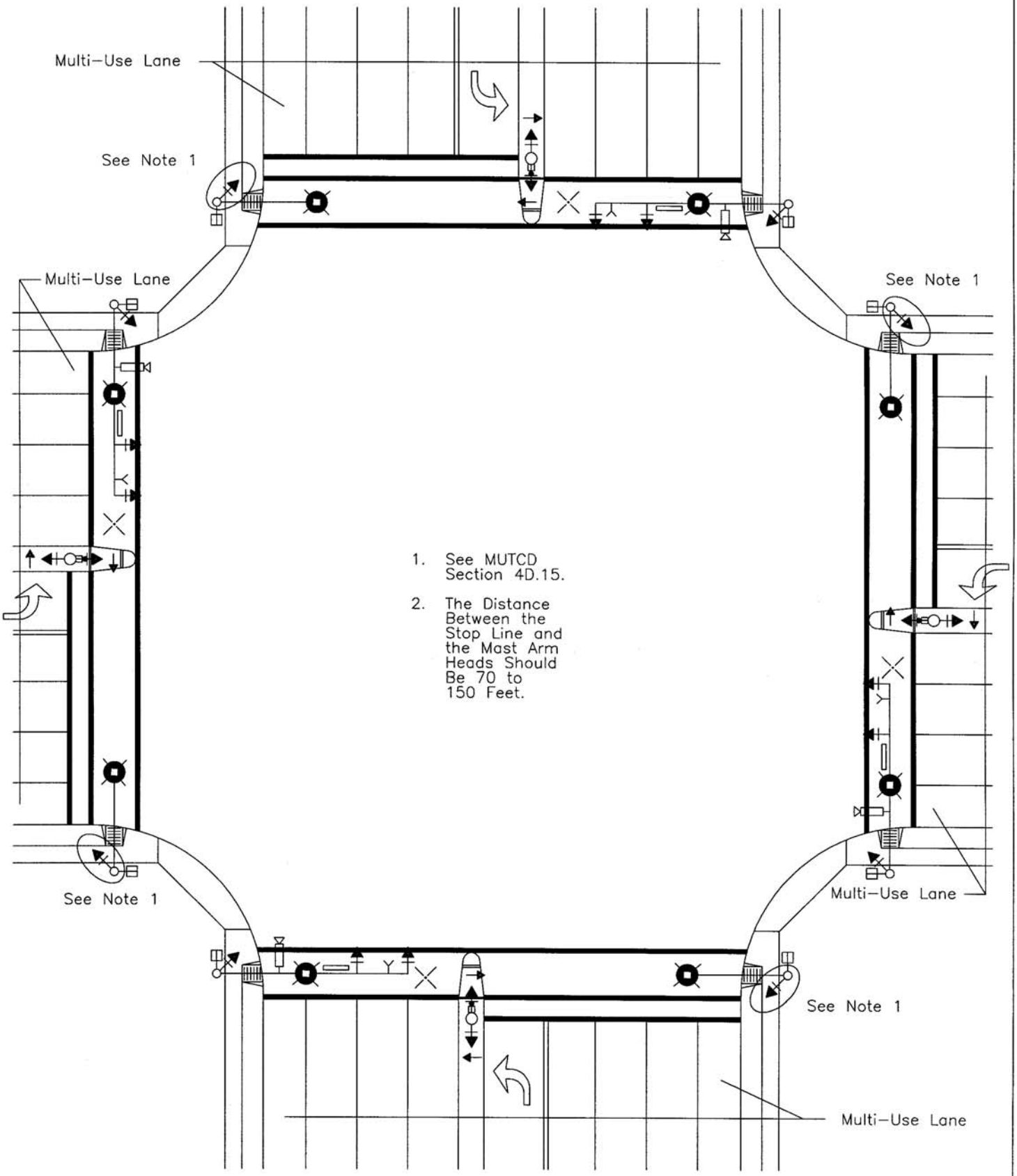


1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

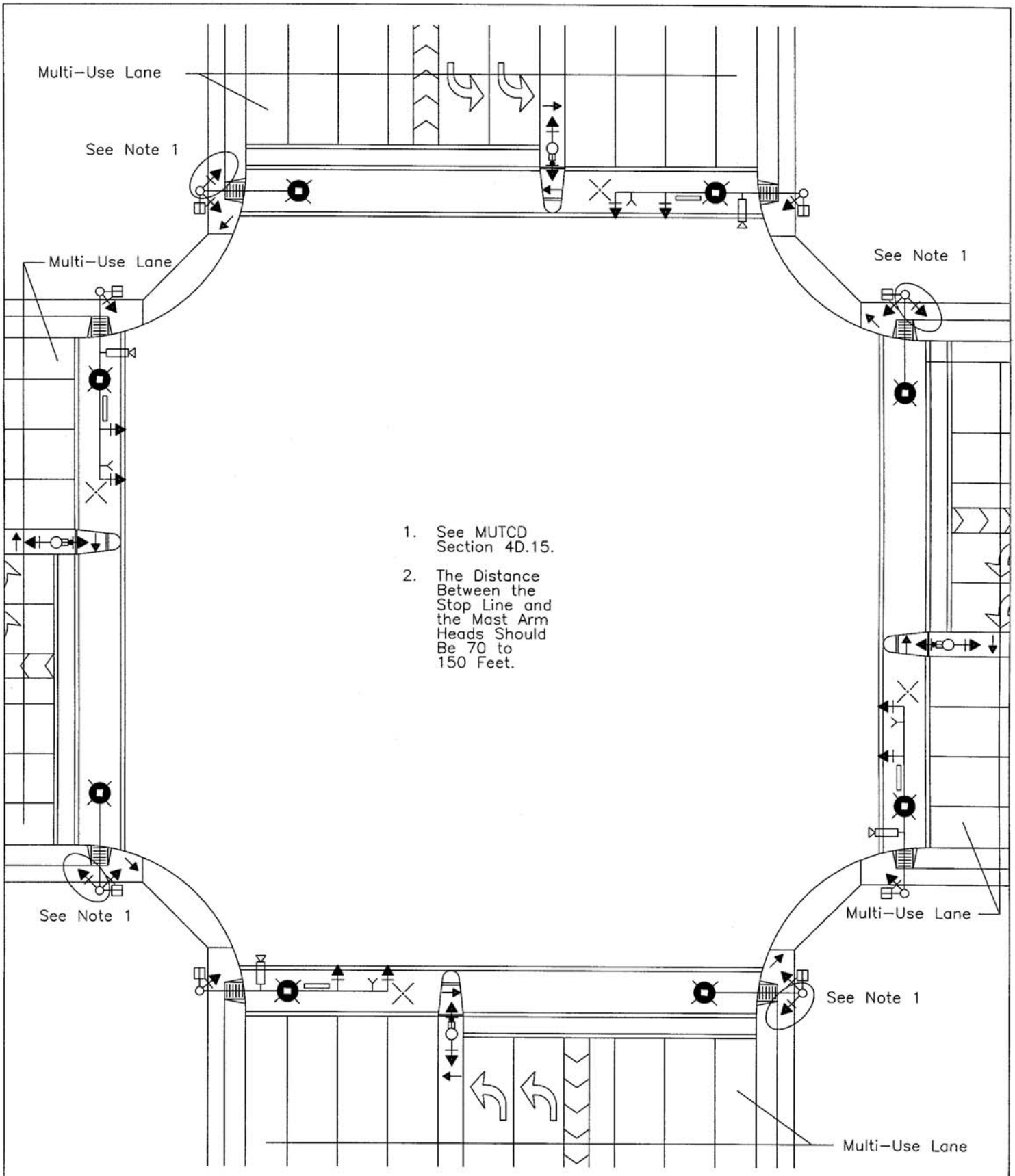
ISSUED: 05 / 03	CITY OF TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–6
REVISED:		Pole Placement Standards & Guidelines 4L Divided X 4L Divided, Dual Left	PAGE 23 of 58



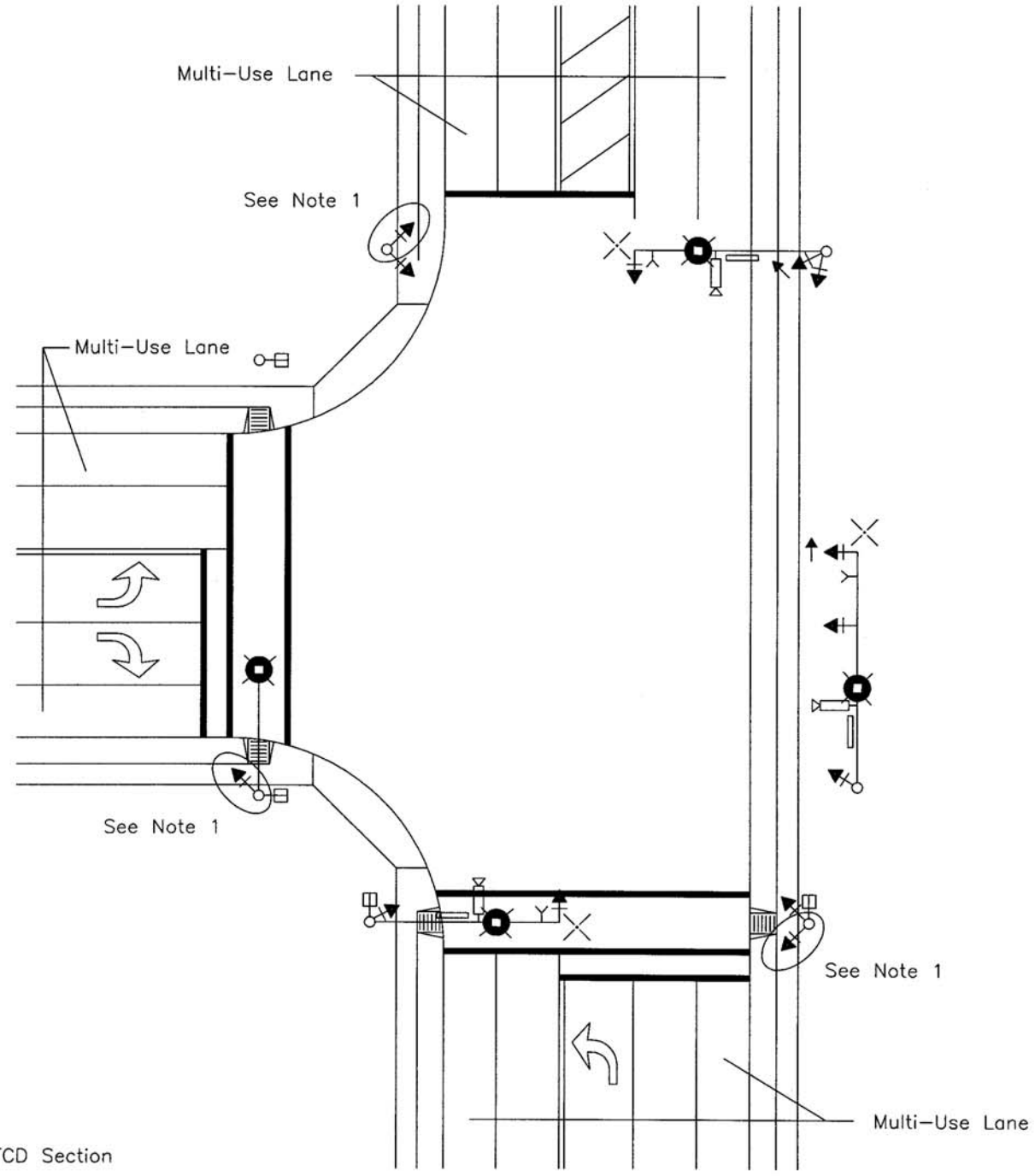
ISSUED: 05 / 03	CITY OF TUCSON FOUNDED 1775	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–7
REVISED:		Pole Placement Standards & Guidelines 4L Divided X 4L Divided, Right Turn Lane	PAGE 24 of 58



ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–8
REVISED:		Pole Placement Standards & Guidelines 6L Divided X 6L Divided	PAGE 25 of 58

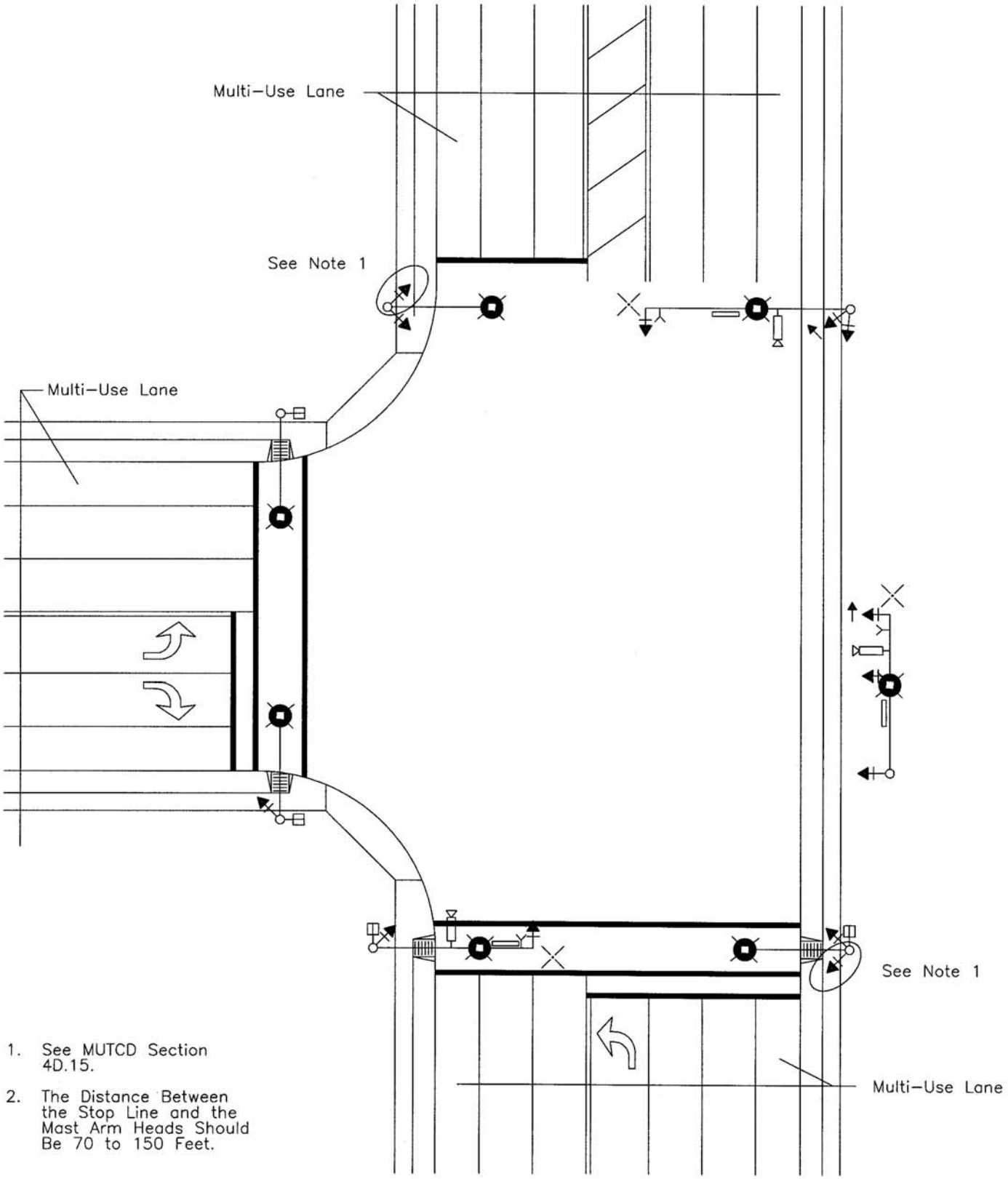


ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–9
REVISED:		Pole Placement Standards & Guidelines 6L Divided X 6L Divided, Dual Left	PAGE 26 of 58



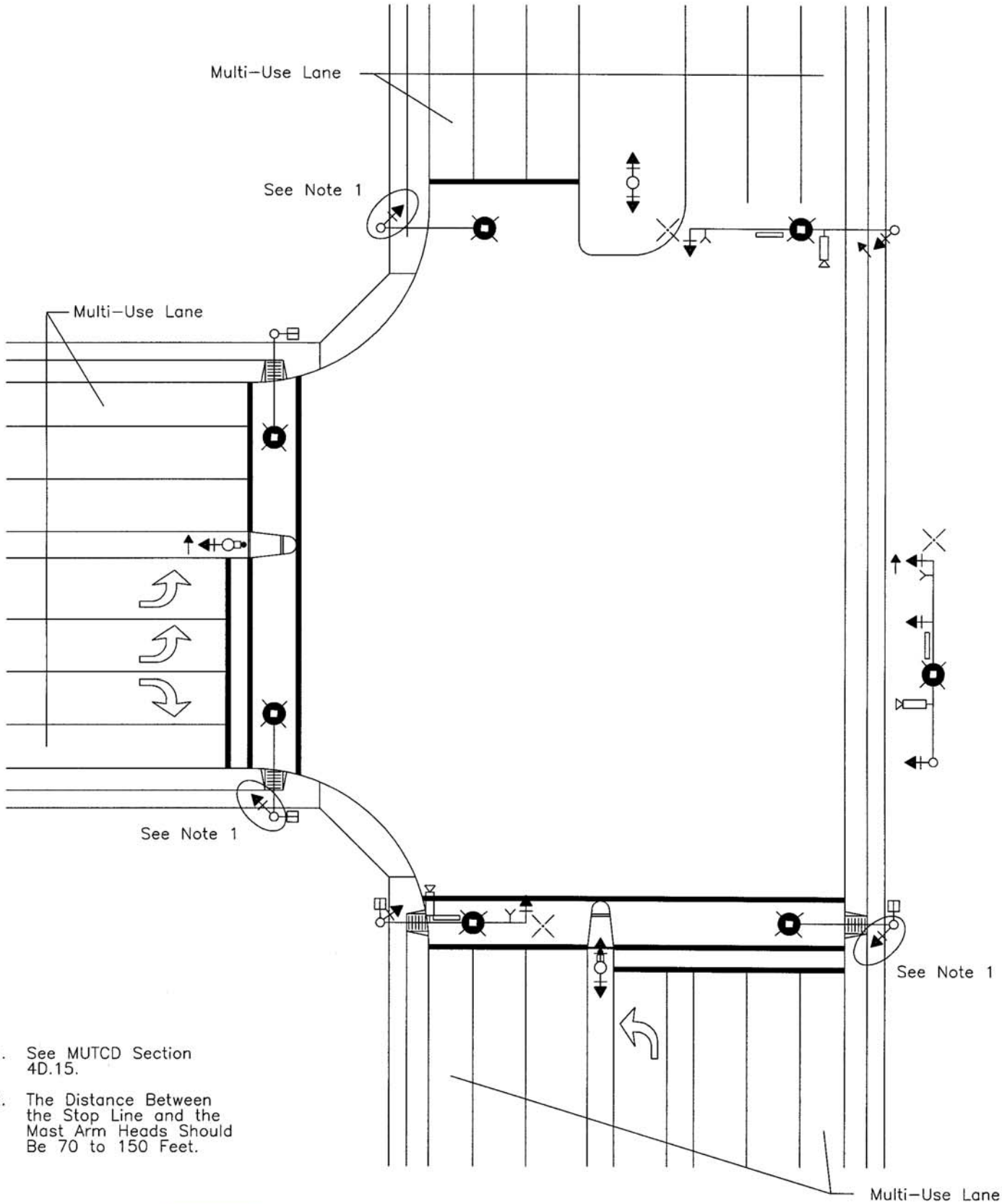
1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–10
REVISED:		Pole Placement Standards & Guidelines 3L Undivided X 3L Undivided, T–Intersection	PAGE 27 of 58



1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–11
REVISED:		Pole Placement Standards & Guidelines 5L Undivided X 4L Undivided, T–Intersection	PAGE 28 of 58



1. See MUTCD Section 4D.15.
2. The Distance Between the Stop Line and the Mast Arm Heads Should Be 70 to 150 Feet.

ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 2–12
REVISED:		Pole Placement Standards & Guidelines 4L Divided X 4L Undivided, Dual Left, T–Int.	PAGE 29 of 58

3. TRAFFIC SIGNAL FACES AND MOUNTING HARDWARE

A. Traffic Signal Indications

1. All signal lenses shall be 8-inch or 12-inch diameter and in conformance to the MUTCD Section 4D.15.

2. All traffic signal indications should utilize light emitting diodes (LEDs) as the light source, with the exception of the yellow circular indication, which should be an incandescent lamp. All arrow and pedestrian indications shall be LED.

B. Traffic Signal Faces

1. Typical traffic signal faces should be yellow polycarbonate. The traffic signals at signalized intersections shall be Type C, F, H, Q, INV J, or as illustrated in MUTCD Figure 4D-3 (o), which should be used for span-wire installations. All signal faces should have black aluminum louvered backplates.

2. Optically programmed or louvered heads may be used if the physical geometry or operational problems indicate their use. The COT/DOT/TED Project Manager must approve the use of optically programmed or louvered heads.

3. Left turn signal faces shall be Type H or Q, or MUTCD Figure 4D-3 (o).

4. Right turn signal faces shall be Type H or Q and will generally have a flashing right yellow arrow instead of a green arrow.

5. Type D and E signal faces shall be used as flashing beacons (see Section 11).

6. See Figure 3-1 for HAWK signal head layout.

Traffic signal faces are shown in Standard Detail T.S. 8-1 of the Pima County/City of Tucson Standard Details for Public Improvements.

C. Placement Considerations For Traffic Signal Faces

Placement of traffic signal faces will consider the following:

1. The requirements of MUTCD Sections 4D.15, 4D.16, and 4D.17 shall be satisfied.

2. Minimum spacing of traffic signal faces should be 12 feet unless otherwise requested.

3. Traffic signal faces for one direction of travel should not obstruct the visibility of signal faces for the opposing direction of travel.

4. Install one overhead signal face on 30' mast arms, two on longer mast arms. Use a minimum of one overhead face per approach.

5. Provide a far left indication at locations not having median island poles.

6. Provide two or three faces for left turn lanes, as discussed below:

   a. Single left-turn lane – Provide one overhead face positioned over or near the right edge of the double yellow line. Provide a second face on the far left corner on a Type A pole or street light pole near the stop line for opposing traffic. For locations having islands, signals shall be on the near and far side islands.

   b. Dual left-turn lane – Provide one overhead signal face aligned with or near the line separating the left turn lanes. Provide a second signal face on the far left corner, as discussed in item a, above.

      For locations having islands, replace the overhead signal face with a signal face mounted on a Type A pole in the medians as discussed in item a, above. Provide a third signal face on the far left corner.

7. Provide two signal faces for right-turn lanes having right-turn signal phasing, as detailed below:

   a. Provide a far side mounted signal face.

   b. Provide a near right signal face on a Type A pole or street light pole near the stop line.

   c. Right turn signals will generally have a flashing right yellow arrow instead of a green arrow.

8. Use prohibited/protected left turn phasing (Type H or Q face) unless otherwise directed by COT/DOT/TED

9. Additional signal faces may be needed when the view of the normal signal faces are concealed from approaching drivers due to horizontal or vertical alignment.

   Refer to Figures 2-2 through 2-12 for sample drawings illustrating common intersection and signal configurations.

D. Traffic Signal Mounting Hardware

All mounting assemblies for traffic signals mounted on mast arms and poles should conform with Table 3-1.

Table 3-1
Mounting Assemblies for Type C, F, H, Q, and INV J Traffic Signal Faces On Mast Arms and Poles

	Type of Mounting Assembly by Mounting Location		
	Mast arms	Top of Type A pole	Side of pole
Type of Mounting	Type II*	Type IV Type VI	Type V Type VII Type VIII

*ASTRO Brackets may be used when approved by COT/DOT/TED.

Span wire traffic signal installations shall use two spans of 3/8 inch utility grade galvanized seven strand steel wire between poles. An aluminum adjustable bracket with a wire entrance and a three foot extension shall be used to connect the two spans and support the traffic signal assembly.

4. PEDESTRIAN CONTROL FEATURES

As with curb-access ramps, pedestrian control features need to meet accessibility standards.

A. Conventional Pedestrian Signals

1. Conventional pedestrian signals are typically utilized for all legs of all intersections. There may be occasions where some legs of some intersections will be without crosswalks. These will be intersection and project specific.

2. Pedestrian signals will be of the conventional type, as depicted in the Pima County/City of Tucson Standard Details for Public Improvements, unless otherwise approved by the COT/DOT/TED Project Manager.

B. Accessible Pedestrian Signals

1. Accessible Pedestrian Signals are described in detail in the MUTCD Section 4E.06. Accessible pedestrian signals communicate information about pedestrian signal timing in a non-visual format, through the use of audible tones (or verbal messages) and vibrating surfaces.

2. Upon request for an accessible signal for a particular location, COT/DOT/TED will conduct an engineering study that considers the safety and effectiveness for pedestrians in general, as well as the information needs of pedestrians with visual disabilities. Accessible pedestrian signals should conform with MUTCD Section 4E.06.

C. Pedestrian Signal Indications and Push Buttons

1. Pedestrian signal indications should utilize light emitting diodes (LEDs).

2. The pedestrian push button shall be a 2-inch stainless steel ADA button.

D. Placement Considerations for Pedestrian Signal Heads and Detectors

1. Mount the pedestrian push button adjacent to the landing on the sidewalk area leading to the crosswalk.

2. Mount the pedestrian push button no further than 5 feet from the extension of the crosswalk lines and within 10 feet of the curb line, unless the curb ramp is longer than 10 feet.

3. For two pedestrian push button stations on the same corner, mount the pedestrian push buttons on poles or posts separated by at least 10 feet, whenever possible.

4. The control face of the push button should be parallel to the direction of the crosswalk controlled by the push button.

5. Typically, pedestrian push button stations are installed on medians on Type A poles or on pedestrian push button posts.

6. Pedestrian signal heads should be placed to maximize the visibility of the signal for pedestrians using the crosswalk for which the signal head provides indications.

E. Other Pedestrian Control Features

1. Pedestrian push button signing should be R10-3b in the 2000 MUTCD, Page 2B-43.

2. Mounting assemblies for pedestrian signal indications shall be Type XI.

5. LIGHTING REQUIREMENTS FOR TRAFFIC SIGNAL INSTALLATIONS

COT/DOT/TED may require advance intersection street lighting. Intersection lighting is included at signalized intersections. The following are considerations for intersection street lighting.

A. Considerations for Intersection Lighting

1. Illuminate each approach. At a minimum, utilize one luminaire for each leg of the intersection. Wider streets, higher volumes and/or urban conditions may require two fixtures per leg.

2. Location of luminaire poles should meet guidance contained in Chapter 2 of this document.

3. Light distribution should conform with Pima County Outdoor Lighting Code, October 16, 2001.

4. All installations should meet *National Electric Code* requirements.

5. Roadway Lighting – Illuminating Engineering Society of North America, ANSI/IESNA RP-8, 2000 provides guidelines that can be used by the designer upon approval of the COT/DOT/TED Project Manager.

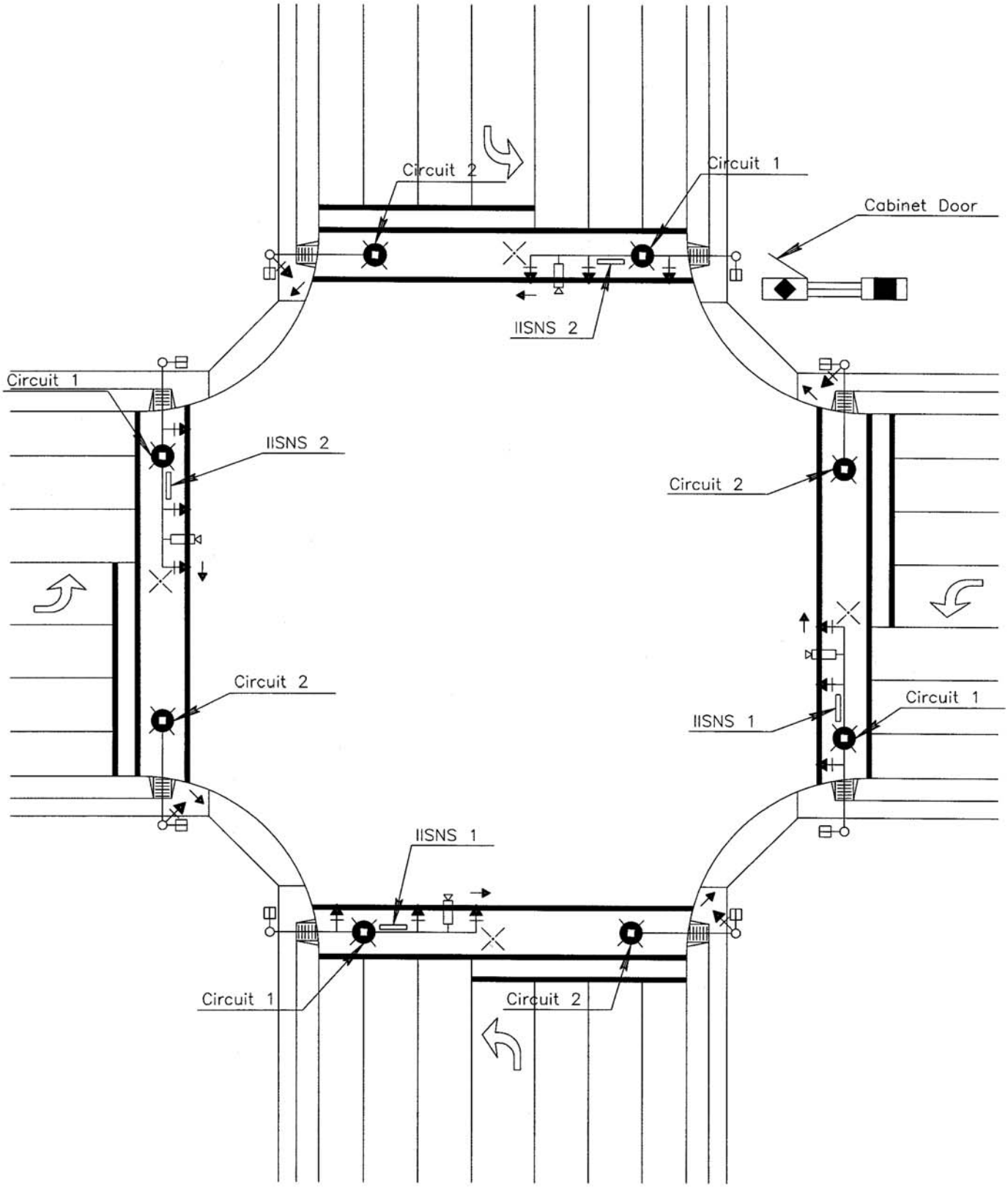
B. Lighting Requirements for Traffic Signal Installations

1. Intersection lighting shall use 120 volt, 400 watt high pressure sodium luminaires with horizontal cut-off lenses meeting Pima County/City of Tucson specifications. Use of other wattage and voltage requires prior approval from the COT/DOT/TED Project Manager.

2. The street lighting photo electric cell shall be mounted on the luminaire on the pole closest to the traffic signal controller cabinet.

3. For corners with dual luminaires, provide alternating separate circuits for each luminaire.

Power for the street lighting should come from the metered service pedestal. Refer to Figure 5-1 for circuit design.



ISSUED: 05 / 03	CITY OF FOUNDED 1775 TUCSON	CITY OF TUCSON DEPARTMENT OF TRANSPORTATION TRAFFIC SIGNAL DESIGN MANUAL	FIGURE 5-1
REVISED:		Street Lighting Circuit Diagram	PAGE 36 of 58

6. CONTROLLER CABINET AND ELECTRIC SERVICE PEDESTAL

A. Equipment Requirements

1. The electric service pedestal installed shall be a metered 120/240 volt 125 amp unit conforming to detail T.S. 18-1. The equipment shall meet local utility company design requirements.

2. The controller cabinet shall be supplied by the City unless otherwise specified.

3. A concrete service pad shall be constructed on the door side of the controller cabinet foundation.

4. All specified traffic controller assembly items shall meet the applicable environmental and testing standards of NEMA publication TS-2-1998.

B. Placement Requirements

1. Controller cabinet and electric service pedestal foundations shall be positioned beyond the AASHTO clear zone requirement of both roadways whenever possible.

2. Controller cabinets shall be located to provide technicians working at the controller cabinet visibility of the indications on both streets. The door of the cabinet shall face away from the roadway.

3. Controller cabinets and electric service pedestals shall not be located in areas susceptible to water immersion, flooding, or sprinkler spray.

4. The service pedestal shall be placed as close as possible to the service point.

7. VEHICLE DETECTION STANDARDS AND GUIDELINES

A. Detection Types

The City uses both inductive loops and video detection systems.

B. Detection Guidelines

Use machine video detection unless otherwise directed by COT/DOT/TED.

C. Video Detection System Guidelines

1. Video detection system equipment shall be provided by the City unless otherwise specified..

2. The contractor shall install and align the video detection cameras and shall provide all field terminations, except for coaxial and in cabinet connections.

3. Cameras are typically mounted on luminaire mast arms. (Twenty-foot mast arms on Type Q poles and 25 foot mast arms on Type R poles.)

D. Vehicle Loop Detection Guidelines

Vehicle loop detection guidelines apply when vehicle detection loops are utilized. In addition, vehicle loop detection may be used where horizontal and/or vertical geometries interrupt line of sight, or where glare may be an issue.

1. Vehicle loop detection deviating from the Detection Guidelines will be used upon direction by the COT/DOT/TED Project Manager.

2. Driveways or median breaks near a traffic signal may require “call” vehicle detection loops, if video detection is not used.

3. Pulse loops are installed in series.

4. Vehicle Loop Detection Equipment

    a. Presence Loops

        i. Quadrupole presence loops (6' x 70') are typically used for left-turn lanes. A 50 foot distance should separate the approach edge of the loop from the center of the stop line. If used in a shared/right turn lane, establish the need for a short presence loop to serve the right turn movement or curve the loop parallel to the corner return.

ii. Quadrupole presence loops (4' x 10') are used for bicycle and golf cart detection when bike or auxiliary lanes are present. Its use is not necessary at legs of intersections equipped with video detection. A 10-foot distance separates the approach edge of the loop from the center of stop line.

b. Pulse Loops

Pulse loops (6' x 6') are typically used in advance of an intersection to notify the controller of an approaching vehicle. The distance from the center of the stop line to the center of the loop is the distance a vehicle travels in three seconds, based on the posted speed limit. See Table 7-1, below.

Table 7-1
Placement of Pulse Loops
(6'x6')

Posted Speed (mph)	Distance[1] (ft)
25	110
30	135
35	155
40	180
45	200
50	220

Note: [1] Calculated distance is from the center of the Stop Line to the center of the loop, rounded up to next 5 foot increment

8. CONDUCTOR CABLE REQUIREMENTS

A. General

1. Wiring for City of Tucson traffic signals is based on the use of multiconductor cables rather than individual conductors. Wiring for street lighting uses individual conductors.

2. Signal conductors installed shall be IMSA 19-1 multiconductor cable in 14 AWG Solid 7- and 16-conductor configurations.

3. Three feet of slack in the conductor cable, measured from the top of the pull box, shall be provided in each pull box.

B. Signal Conductor Requirements

1. An unspliced IMSA 19-1 16-conductor cable should be installed from the controller cabinet to the terminal block of each pole.

2. From the terminal block single conductors shall be run through the mast arm to each indication as needed. For locations not having left turn arrows two spare conductors shall be run for future arrows.

3. A pedestrian push button station located by itself should be powered by a #14 AWG IMSA 7-conductor cable.

C. Street Light Conductor Requirements

1. Intersection street light luminaires should be fed from the metered pedestal. The City will use a contactor in the cabinet.

2. Three #10 AWG IMSA XHHW conductors for street lighting and IISNS should be installed from each luminaire to the concrete pull box adjacent to the pole foundation.

3. Three conductor IMSA cable should be installed from the luminaire with photoelectric cell to the pullbox adjacent to the pole.

4. Separate street light conductors should be run from the controller cabinet to each corner of the signalized intersection.

5. For corners with two street lighting fixtures, provide two circuits to the corner and wire each fixture on a separate circuit (see Figure 5-1).

D. Internally Illuminated Street Name Sign (IISNS) Conductor Requirements

1. The IISNS shall be fed from the traffic signal controller cabinet.

2. Two #10 AWG XHHW conductors should be installed from each IISNS to the concrete pull box adjacent to the pole foundation.

3. Install the two IISNSs for each direction of travel on separate circuits, so that if one circuit fails, both street signs will not be affected (see Figure
4. 5-1).

E. Loop Detector Conductor Requirements

1. All vehicle roadway detection loop cable shall be 14 AWG IMSA 51-5-1994 (Detecta-Duct) stranded cable.

2. Loop detector lead-in cable from the loop pull box to the cabinet shall be 16 AWG IMSA 50-2-1984, shielded cable with a UL rating of 600 volts.

3. No splices shall be allowed in roadway detection loop cable or lead-in cable except at the pull box adjacent to loop.

4. Loop detector conductors should come in one conduit to the curb line, and cross the curb line perpendicularly. Provide separate saw cuts for each loop up to conduit.

F. Telephone Conductor Requirements

1. Provide telephone interconnect to the controller cabinet.

2. Telephone interconnect cable shall be 20 AWG IMSA 4-conductor, shielded stranded cable.

3. Telephone interconnect cable shall be unspliced.

4. At locations with video detection, a second telephone circuit may be needed.

G. Emergency Vehicle Pre-emption Conductor Requirements

1. The emergency vehicle pre-emption sensor and associated components shall be the Strobecom II 2090-SD detector with the 2140 Optical Signal Processor Card and 1881 Card Cage and Harness.

2. Conductors for preemption beacons shall be 4-conductor, cabled, stranded, UL listed, and rated for 600 volts. The cable jacket shall be PVC, blue in color, and 0.032 inch minimum thickness.

3. Beacons are installed on top of the signal head at the mast arm tip. Sensors are mounted on the mast arm approximately six feet to the right of the signal head at the mast arm tip.

H. Video Detection Requirements

1. The City will supply the video detection cameras. The field mounting cable that is installed from the camera to the pole base shall be compatible with the camera.

2. The video power cable from the pole hand hole to the controller cabinet shall be compatible with the system provided.

3. Video power shall not be connected to photocell.

9. CONDUIT AND PULL BOX REQUIREMENTS

A. General Requirements

1. Provide conduit to each corner of the intersection in a ring configuration, under all intersection approaches.

2. Provide separate conduit for low-voltage and high-voltage conductors.

   a. Low voltage conductors include: emergency pre-empt sensor, telephone interconnect, detector cable, and video feed back to controller cabinet.

   b. High voltage conductors include: signal and street lighting conductors, emergency-vehicle pre-emption beacon, video power, and photo cell.

3. Label all conduit runs on plan sheet (i.e., trench).

B. Conduit Size and Placement

1. See Figure 9-1 for conduit size guidelines.

2. For divided highways, not using video detection conduit for advance pulse loops should be installed on the roadside.

3. Conduit that is installed under existing paved driveways that are not scheduled to be reconstructed as part of this project should be installed by means of boring.

C. Pull Box Considerations

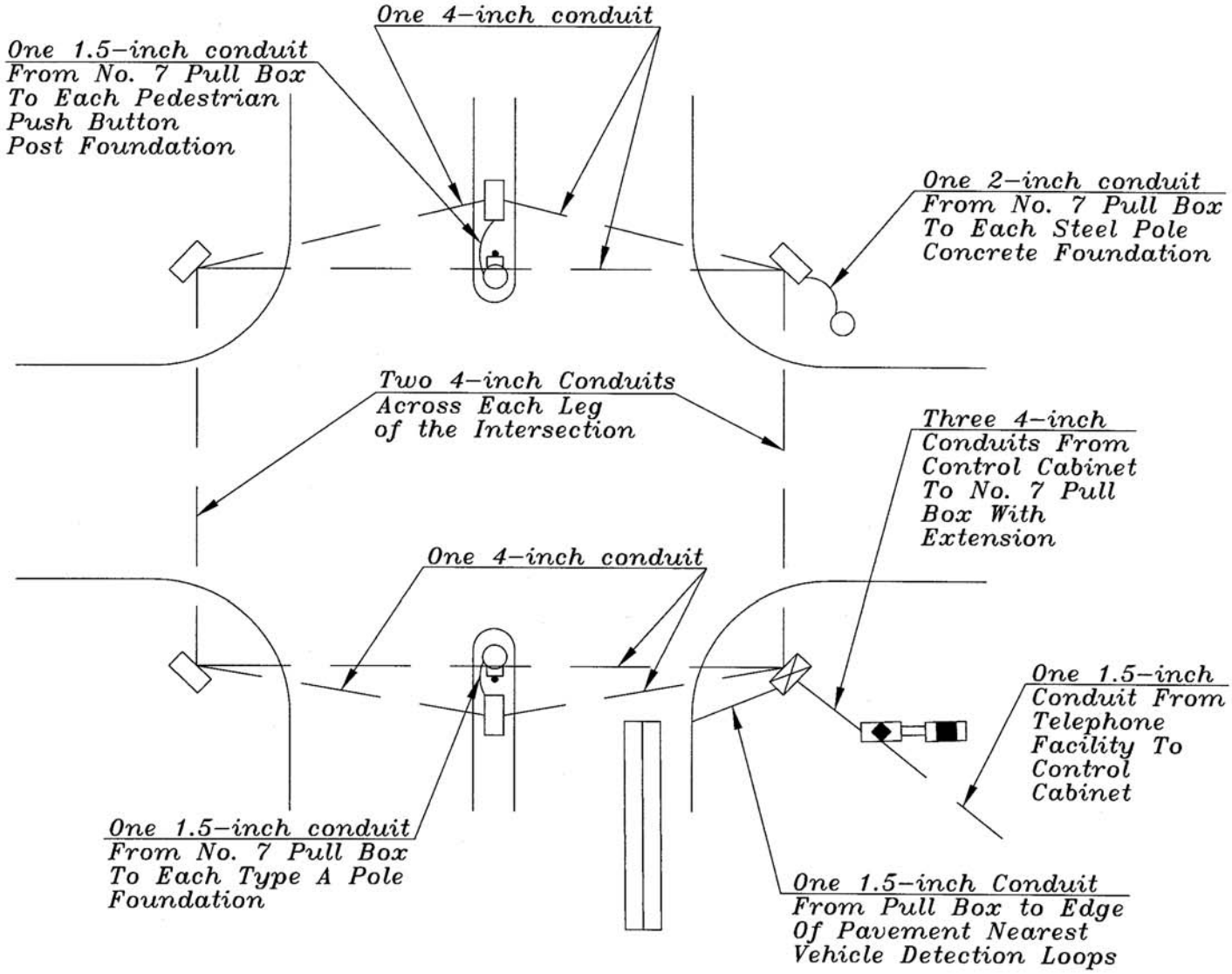
1. A No. 7 pull box with extension should be installed on the same corner as the traffic signal controller cabinet. A ¾ in. x 10 ft. ground rod shall be installed in the No. 7 pull box with extension adjacent to the controller cabinet. Two ground rod clamps shall be furnished for grounding the ground wire.

2. For all other corners, typically a No. 7 concrete pull box is installed, one on each corner.

3. When signal cable crosses the roadway, install No. 7 pull boxes in the median nose, adjacent to the pedestrian push button post.

4. Install No. 3 ½ pull boxes in medians for detection cable.

5. Pull boxes should not be located in drainage areas susceptible to water immersion or flooding.


One 4–inch conduit
One 1.5–inch conduit From No. 7 Pull Box To Each Pedestrian Push Button Post Foundation
One 2–inch conduit From No. 7 Pull Box To Each Steel Pole Concrete Foundation
Two 4–inch Conduits Across Each Leg of the Intersection
Three 4–inch Conduits From Control Cabinet To No. 7 Pull Box With Extension
One 4–inch conduit
One 1.5–inch Conduit From Telephone Facility To Control Cabinet
One 1.5–inch conduit From No. 7 Pull Box To Each Type A Pole Foundation
One 1.5–inch Conduit From Pull Box to Edge Of Pavement Nearest Vehicle Detection Loops

6. Pull boxes shall not be installed within concrete curb access. In addition, any pull boxes installed behind curbs shall be installed between the curb and the proposed/future sidewalk or beyond the proposed/future sidewalk (except when pull boxes are installed in a median.)

7. Any pull boxes installed along an uncurbed roadway should not be within the shoulder (minimum 10 feet from pavement edge).

8. Three feet of slack in the conductor cable, measured from the top of the pull box, shall be provided in each pull box.

D. ITS Improvements

1. In addition to the conduit run for low- and high-voltage traffic signal circuits, provide a second conduit run in a ring configuration under each leg of the intersection, for low-voltage fiber-optic cable in future ITS applications.

   a. Install 4-inch schedule 40, polyvinyl chloride, non-metallic conduit.

   b. Install a No. 7 pull box with extension at each corner.

   c. Install a #6 THW/XHHW wire for locating the conduit run.

2. Refer to special provisions regarding installation of fiber optic conduit and pull boxes.

3. Install 2-inch conduit to connect fiber optics pull box to traffic signal pull box on the cabinet corner.

10. OTHER TRAFFIC SIGNAL RELATED EQUIPMENT

A. Internally Illuminated Street Name Signs (IISNS)

1. An IISNS is provided for each approach to a signalized intersection.

2. Each IISNS for an intersecting street should be powered by a separate electric circuit, so that in the event of one circuit failure, the second IISNS will be illuminated (see Figure 5-1).

3. The IISNS is typically mounted to each traffic signal mast arm to the right of the signal head at the end of the mast arm.

4. The IISNS for each approach should indicate the cardinal direction and street name for the intersecting street (see Figure 10-1 below).

5. The size of the letters shall be:

   8" height for the street name
   5" height for suffixes
   3" height for block numbers

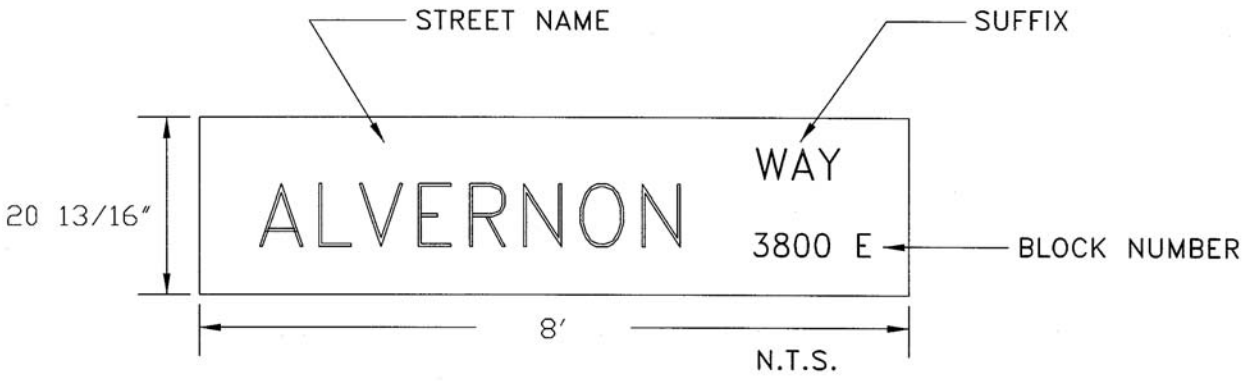


Figure 10-1
Internally Illuminate Street Name Sign (IISNS)

6. Legend letters and colors shall conform to the City of Tucson Engineering Division Special Provisions for the project.

B. Emergency Vehicle Pre-empt Systems

1. All City of Tucson traffic signal designs should include Emergency Vehicle Pre-emption Systems. These systems include sensor device, beacon and associated wiring and cabling.

2. Emergency Vehicle Pre-emption System installations shall conform to the City of Tucson Engineering Division Special Provisions for the project.

3. Beacons are installed on the top of the signal head at the mast arm tip.

4. Sensors are installed on the mast arm, six foot minimum from the mast arm tip.

11. OTHER TRAFFIC SIGNALS

All installation discussed below should conform with the Manual on Uniform Traffic Control Devices (MUTCD).

A. Intersection Control Beacons

1. An intersection control beacon is used only at an intersection to control two or more directions of travel. It consists of one or more signal faces directed toward each approach to the intersection, flashing circular yellow or circular red signal indications.

2. Intersection control beacons may be used at intersections where traffic or physical conditions do not justify conventional traffic control signals but crash rates indicate the possibility of special need.

B. Warning Beacons

1. A warning beacon may be used to supplement an appropriate warning or regulatory sign or marker, and consists of one or more signal sections of a standard traffic signal face with a flashing circular yellow signal indication in each signal section.

2. Typical applications of warning beacons may include:

   a. At obstructions in or immediately adjacent to the roadway.

   b. As supplemental emphasis to warning signs.

   c. As emphasis for mid block crosswalks.

   d. On approaches to intersections where additional warning is required, or where special conditions exist.

3. The condition or regulation justifying warning beacons should largely govern their location with respect to the roadway.

4. Warning beacons should be operated only during those hours when the condition or regulation exists.

C. Pedestrian Crossing Beacons

The following are some pedestrian crossing devices that are utilized within the City of Tucson.

1. **Yellow Pedestrian Activated Flasher Beacon.** These are installed to emphasize the location of a crosswalk as discussed under Warning Beacons, above. They are typically installed over the roadway on a mast arm in combination with appropriate warning signs.

2. **'HAWK' Crossing.** The 'HAWK' crossing method utilizes a red-yellow-red traffic signal head. When the signal is not activated, no signal indication is shown. When activated by a pedestrian, the signal shows a flashing yellow first, then steady yellow indication, which is followed by a steady red indication, during which the walk indication is provided for pedestrians. Following the steady red, the two red indications flash in an alternating sequence, during which a flashing DON'T WALK is indicated for the pedestrian. During the flashing red, drivers may proceed after stopping if it is safe to do so.

APPENDIX A

SAMPLE SIGNALIZED INTERSECTION DESIGN PLANS

APPENDIX B

GENERAL TRAFFIC SIGNAL NOTES AND RESPONSIBILITIES

GENERAL TRAFFIC SIGNAL NOTES:

1. All equipment / materials and construction shall meet or exceed the requirements contained in the current Pima County / City of Tucson "Standard Specifications for Public Improvements" and "Standard Details for Public Improvements", the Supplemental Specifications, the Special Provisions, and the plans.

2. All pedestrian push button assemblies shall meet ADA requirements. The signs that shall be used are identified in the 2000 MUTCD as R10-3b on page 2B-43.

3. Internally Illuminated Street Name Signs (IISNS's) shall be installed such that the bottom of the IISNS is no less that 17 feet above the roadway pavement or no less than 16 feet above the finished grade beyond the shoulder, bike lane or multi-use lane.

4. The exact location of each new pole foundation, pull box, controller cabinet foundation, and electric service pedestal foundation shall be approved by the Engineer prior to installation.

5. The top of the pole foundation shall be level with the finished grade.

6. Only new conduit and cable shall be installed.

7. All conduit shall be installed a minimum of 30 inches below finished grade.

8. Any conduit installed shallower than 30 inches below finished grade shall be encased in concrete per Specification No. 732-3.01 (G).

9. All conduits shall be cleaned by compressed air and a properly sized conduit piston or mandrel prior to cable installation.

10. Conduit installed under existing paved driveways that are not scheduled to be reconstructed as part of this project shall be installed by means of boring.

11. ITS / roadway lighting sleeves shall be installed under all intersecting side streets and driveways on all major roadway reconstruction projects, unless directed otherwise by the Engineer.

12. Pull boxes shall not be installed within concrete curb access ramps. In addition, any pull boxes installed behind curbs shall be installed between the curb and the proposed / future sidewalk or beyond the proposed / future sidewalk. An exception to this note would be pull boxes installed in a median. Any pull boxes installed along an uncurbed roadway shall be installed adjacent to, but not within, the shoulder.

13. A ¾ in. x 10 ft. ground rod shall be installed in the No. 7 pull box (with the extension) adjacent to the controller cabinet. Two ground rod clamps shall be furnished for grounding the ground wire.

14. The high voltage cables should be separated from the low voltage cables as much as possible.

15. A 14 AWG IMSA 19-1-1984 7-conductor solid wire cable shall be installed from each traffic signal terminal strip to the concrete pull box adjacent to the pole foundation leaving three feet of slack for each cable (measured from the top of the pull box) in the pull box.

16. A 14 AWG IMSA 19-1-1984 7-conductor solid wire cable shall be installed from each IISNS and luminaire to the concrete pull box adjacent to the pole foundation, leaving three feet of slack for each cable (measured from the top of the pull box) in the pull box. A 10 amp in-line fuse shall be installed for each luminaire and for each IISNS in the associated pull box.

17. Poles with pedestrian signals and push button stations shall use one 7-conductor cable for both the push button station and the pedestrian signal. The outer cable jacket shall be removed at the hand hole height. Two conductors shall be routed to the push button station and the remaining conductors shall be routed to the pedestrian signal.

18. All vehicle roadway detection loop cables shall be 14 AWG IMSA 51-5-1985 cable. Lead-In cables shall be 16 AWG IMSA 50-2-1984 cable. No splices shall be allowed in the roadway detection loop cable except at the pull box adjacent to loop.

19. The telephone interconnect cable and detector lead-in cable shall not be spliced.

20. The emergency vehicle pre-emption sensor cable shall be Opticom Detector Cable Model No. 138.

21. The conductors for the emergency vehicle pre-emption beacon shall be routed to the traffic signal head at the mast arm tip. The beacon shall be installed on top of the traffic signal head. The emergency vehicle pre-emption sensor shall be mounted on the mast arm using a special clamp located a minimum of 6 ft. from the mast arm tip.

22. The Belden coaxial cable shall be installed, unspliced, from the video camera mounting (attached to the luminaire mast arm) to the control cabinet.

23. The Special Provisions include information regarding the installation of fiber optic conduit and pull boxes, if these improvements are included in the project.

24. Detection loop sawcuts shall be flushed with water under pressure and then dried with air under pressure.

25. The Tucson Electric Power Company Public Improvement Coordinator (918-8359) shall be contacted by the Contractor to verify the location of the electric service connection at each intersection. The Contractor shall be responsible for excavating the trench and installing any necessary sleeves under sidewalks or driveways in which the electric service cable in conduit (CIC) is to be installed by TEP.

26. The Qwest Public Improvement Coordinator (884-2952) shall be contacted by the Contractor to verify the location of the telephone connection at each intersection.

27. The traffic signal operation at existing signalized intersections shall be maintained throughout the duration of the project.

RESPONSIBILITIES:

1. The Contractor shall install the following City supplied equipment and materials: traffic signal controller cabinet(s) with controller(s), and video detection system equipment. The Contractor shall supply and install the following equipment and materials as specified in the plans: Steel pole anchor bolts (with nuts and washers), concrete pole foundations with reinforcement (where specified), controller cabinet concrete foundation(s), concrete pull boxes, electrical conduit, ground rods and connectors, bare bond wire and all other conductors, poles, mast arms, traffic signals and mounting assemblies, pedestrian signals and mounting assemblies, pedestrian push button stations with signs, luminaires, photocells, internally illuminated street name signs, vehicle detection loops, electric service pedestal(s), concrete foundation(s), all auxiliary equipment, and all other appurtenances necessary for the operation of the traffic signal installation(s), except as modified in the plans.

2. The Contractor shall pick up and transport the controller cabinet(s), and video detection system from the City of Tucson Streets and Traffic Maintenance Division Yard to the intersection(s). Contact John Ramos (791-3191) at least 48 hours in advance of pickup.

3. The Contractor shall install each traffic controller cabinet on its foundation and route all of the conductors into the controller cabinet. The City of Tucson Streets and Traffic Maintenance Division staff shall terminate the conductors in the controller cabinet.

4. The Contractor shall carefully disassemble and salvage all existing traffic signal and street lighting equipment that is not to remain or be relocated. All of the equipment shall be returned to the City of Tucson Streets and Traffic Maintenance Division Yard. The contractor shall unload all the equipment. Contact Ray Quihuis (791-3191) at least 48 hours prior to delivering the equipment.