Traffic Signal Design Manual

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Oregon Department of Transportation
Technical Services
Traffic-Roadway Section
Traffic Standards Unit
http://www.oregon.gov/ODOT/HWY/TS/Pages/index.aspx

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1 INTRODUCTION

The material contained herein is for information purposes only and may be used to aid new employees and those unfamiliar with ODOT traffic engineering practices, in accessing and applying applicable standards, statutes, rules, and policies related to traffic signal operation and design.

There are two main manuals that shall be used to create Traffic Signal Plans and Specifications on the state highway system:

1. ODOT Traffic Signal Design Manual
2. ODOT Traffic Signal Drafting Manual

The ODOT Traffic Signal Design Manual focuses on the design aspects of traffic signals while the second manual focuses on the drafting of the completed design. Both manuals assume you have a basic understanding of the topics presented.

1.1 About Us

The Traffic Signal Standards Unit is responsible for maintaining and interpretation of the ODOT Traffic Signal Design Manual. This group is part of Traffic Engineering Services, which is a unit within the Traffic-Roadway Section.

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1.2 Availability

This manual is a web-only document, which can be accessed and printed in its entirety from the ODOT Traffic Signal Information web site:

http://www.oregon.gov/ODOT/Engineering/Pages/Signal-Design-Manual.aspx

1.3 Updates

This manual is updated continually and revisions will be made as necessary, typically on a yearly basis in June or July. The revised manual becomes effective on the official revision date (month/year format). All design work prior to final plans shall follow the requirements of the current version of this manual.

If you wish to receive notification of future revisions of this manual and other updates for ODOT traffic signal standards, subscribe to our e-mail notification system by e-mailing the Traffic Signal QC Engineer.

1.4 Change Requests

If you would like to suggest changes to the ODOT Traffic Signal Design Manual, please contact the Traffic Signal QC Engineer.

1.5 Document Revision Summary

1.5.1 Revision: December 2013

- Complete reformat of document
- New information on video detection
- New information on roadway design
- New procedure for Railroad Preemption Plan Sheet
- New information on operational approval
- New information on design approval

1.5.2 Revision: October 2014

- Minor revisions based on comments received during the draft manual release in December 2013

1.5.3 Revision: January 2016

Chapter 2 Design Approval Process:

1. Figure 2-1 (organization chart) – updated chart
2. Section 2.5 (Design Approval Process): Info on plan requirements at each milestone

Chapter 3 Signal Operation & Operational Approval:

3. Section 3.3.1 (ring and barrier diagram) – added bold note clarifying intent of the ring and barrier diagram; to clearly show the conflicts that require conflict monitoring.
4. New Section 3.3.3 (Flashing yellow left turn arrow with NOT-PED) – This section was added to describe the FYA not-ped feature and explain why it is NOT shown in the ring and barrier diagram.
5. Section 3.3.5 (not-ped overlap phases) – added a note to reference new section 3.3.3 (flashing yellow left turn arrow with NOT-PED) to make sure designers go to the right section for FYA not-ped info.
6. New Section 3.3.6 (Pedestrian Overlap Phases) – This section was added to describe pedestrian overlaps. Added new figure in this section.
7. Updated Figure 3-9 (ring & barrier diagrams: Multiple intersections using a single controller, example 1) – revised OLA designations from "," to "&" for consistency. Fixed lane use typo.
8. Updated Figure 3-10 (ring & barrier diagrams: Multiple intersections using a single controller, example 2) – revised OLA designations from "," to "&" for consistency
9. New Section 3.3.11 (dummy phases) – this section was added to describe dummy phases. Added two figures to this section showing a dummy phase.
10. Updated Figure 3-11 (ring & barrier diagrams: Multiple intersections using a single controller, example 3) – revised OLA designations from "," to "&" for consistency

Chapter 5 Signal Plan:

11. Section 5.2 (Vehicle signal head layout) – added two bullets, signal heads should be mounted overhead and they should be aligned vertically.
12. Added new section 5.2.3 (supplemental near-side signal heads) – added info to clarify and show examples of use of near side signal heads.
13. Section 5.2.5 (signal head louvers and cut-off visors) – added cut off visors to this section and a new figure
14. Table 5-3 (standard signal heads for right turn phases) – added 2 rows to the table to describe standard heads for signalized right turn slip lanes (Type 3R only, NOT type 2). Clarified that the opposing left turn CAN NOT be a permissive left turn if there is single receiving lane. Added figure 5-23 (signal head placement for right turn phases – Right turn slip lanes)
15. Table 5-3 (standard signal heads for right turn phases) – added a reference to the MUTCD section that prohibits a permissive opposing left turn movement and protected right turn movement to occur concurrently.

16. New Section 5.3.2 (Street name signs and guide signs – custom designed signs) – moved some info about custom signs into its own section for easier reference. Added info about max size of custom sign.
17. Section 5.6 (illumination) – hyperlinked lighting manuals to illumination webpage
18. Section 5.6 (illumination) – added new section for LED fixtures & changed standard from HPS to LED as per the Illumination Engineer
19. Section 5.6.2 (illumination wiring) – added a bullet point describing TC cable and a bullet describing bond wire
20. Section 5.9 (battery back-up) – deleted erroneous reference to Signal Policy and Guidelines (SP&G) – added information that was once contained in the SP&G.
21. Section 5.10.1 (Controller Cabinets/Location): Info on opening cabinet door off right-of-way
22. Section 5.13.1 (Conduit Size): 2" spare conduit for detection required between signal pole and first JB in the same quadrant. To allow for future retrofit of alternative detection.
23. Figure 5-17 (signal head types) – updated figure to include Type 1R and Type 1Y.
24. Figure 5-27 (signal head placement for right turn phasing) – updated the sign used with the Type 5 signal head (from OR22-14 to OR10-15)
25. Figure 5-31 & 5-32 (common signs used for traffic control) – updated sign AL/12: removed OR22-14 ("right turn yield to peds on green ball symbol") info and replaced with OR10-15 (turning vehicles stop for ped) info. Added sign AL/3T ('No trucks" R5-2) and sign AL/20 ("Except bus" OR3-7a)
26. Figure 5-33 (signs no longer used) – added OR22-14 to the list.

Chapter 6 Detector Plan:

27. New Section 6.3.2 (Overlap Phase Detection) – added this section discuss the need for overlap phase detection to be assigned to a parent phase.
28. Section 6.4 (standard detection layout) – revised this section to be more general and moved the chart into the Inductive loop detection section. Added a figure illustrating the standard layout
29. Section 6.6 (detector input file) – added "stretch" to CO (carryover) definition.
30. Section 6.6.1 (332S cabinet: 2070 controller with a C11 connector) – changed the 8 asterisks locations to include "count" as a function, as per Darren LAWRENCE.
31. Section 6.7.12 (Induction Loop Detection/Conduit): 2" spare conduit for detection required between signal pole and first JB in the same quadrant. To allow for future retrofit of alternative detection.
32. Section 6.7.12 (induction Loop Detection/Conduit): added info as per Region 4 - Regions may have a larger minimum conduit size than the statewide minimum – verify with Region.
33. Section 6.8.3 (Standard video detection zone layout) – revised this section to show new video detection standard layout. Added a figure illustrating the standard layout.
34. Section 6.10 (radar detection) – separated the radar and microwave detection information. Revised and added radar information. Added new radar detection standard layout. Added a figure illustrating the standard layout.
35. Section 6.12 (Use of multiple detection technologies at a single intersection) – added language to limit this to 2 max.

36. Figure 6-43 (camera labeling) and section 6.8.1 (camera placement and labeling) – fixed a typo (clockwise changed to counterclockwise)
37. Figure 6-52 (use of inductance loops and video detection at the same intersection) – updated illustration to reflect current standards for video detection placement.

Chapter 9 Details Plan

38. Section 9.3.3 (equipment on mast arm) – fixed a typo – should be rounded to nearest ½ foot, not 1/10 of a foot.
39. Section 9.3.5 (Luminaires) – changed standard from HPS to LED

Chapter 11 Temporary Signal Plan

40. Section 11.6.3 (Service Cabinet and Meter Base) – Reference to old standard details was removed and reference to revised standard drawing added.

Chapter 19 Specifications, Bid Items & Cost Estimate

41. Section 19.2 (Review & Approval of the special provisions) – added a reference to figure 19-4 as an example of a modification that requires review and concurrence of the technical expert.
42. Added new section 19.4 (letter of public interest finding) – this section was added to explain when and why this is needed.

Chapter 20 Cabinet Prints

43. Section 20.3 (procedure for producing cabinet prints) – revised this section based on the new procedure established in Sept 2014.
44. Section 20.4 (creating the cabinet print) – made a few revisions (file naming convention and added info about FINAL CABINET PRINTS location)
45. Chapter 20 (Cabinet Prints) – reformatted chapter to follow 332S cabinet print layout. Added info about 332S cabinet.

Chapter 23 Quick Reference

46. Chapter 23 (Quick reference) – Added video and radar detection information. Revised layout of detection/input file info.
47. Chapter 23 (Quick reference) – updated sign info (AL/12).
48. Chapter 23 (Quick reference) – added info for cabinet limitations (input, output and conflict monitor constraints)
49. Section 23.3 (loop detector information): added info as per Region 4 - Regions may have a larger minimum conduit size than the statewide minimum – verify with Region.
50. Section 23.6 (sign information): updated chart to include signs AL/3T, AL/20 and the revised AL/12.
51. Section 23.7 (junction box & conduit information): 2” spare conduit for detection required between signal pole and first JB in the same quadrant. To allow for future retrofit of alternative detection.
52. Section 23.13 (junction box and conduit information): added info as per Region 4 - Regions may have a larger minimum conduit size than the statewide minimum – verify with Region.
53. Chapter 23 (Quick reference) – added info about the checklists and hyperlinked examples

1.5.4 Revision: June 2017

1. Updated web link on cover page
2. General, minor wordsmithing on several areas (content and intent remain unchanged).

Chapter 1 Introduction

3. Section 1.1: About Us – Added Jeff Hayes contact information
4. Section 1.2: updated web link to manual
5. Section 1.3: changed updated frequency from twice a year to once a year
6. Section 1.3: added link to our subscribe/unsubscribe list for e-mail notification of changes and updates to the manual

Chapter 2 Design Approval Process

7. Section 2.1: updated Figure 2-1 (organization chart)
8. Section 2.2: added info about Roadway Design Exceptions for ADA pushbutton accessibility and link to section 5.4 for more info.
9. Section 2.5: added "temporary workzone" to list of other disciplines plans that could be helpful during review
10. Section 2.8: Added quick reference section electrical crew preferences form

Chapter 4 Starting the Design

11. Section 4.3.2: updated hwy number cross reference guide web link

Chapter 5 Signal Plan

12. General – added note at beginning to go to quick reference chapter for electrical crew preferences form
13. Section 5.1.2: added language to verify crosswalk closures (even existing closed crosswalks) have been approved by the STRE.
14. Section 5.1.3: added language that doesn't require curb ramps if there is no sidewalk, such as at rural intersections (specifies curb ramps are required if sidewalk is present)
15. Figure 5-1 Standard Closed Crosswalk Signing support and installation (TM490): updated figure to match current TM490
16. Section 5.1.2: changed clearance from barricade from 4' to 5' min as per TM490
17. Section 5.1.3: Added information related to new ADA requirements for ramp design and updated figure 5-4, figure 5-5, figure 5-6, and figure 5-7.
18. Added new section 5.1.4: information on Roadway ramp detail sheets and pole locations.
19. Section 5.1.4: Changed requirement for a two-phase pedestrian crossing configuration from "shall be staggered…" to "should be staggered". And added language about countdown heads mitigating the confusion associates with non-staggered two-phase pedestrian crossings.
20. Section 5.2.1: deleted bi-modal and one section signals from list of unique heads (now are listed on TM460)
21. Figure 5-17 Signal Head Types: updated to include new signal head types defined on TM460
22. Table 5-2 Standard signal Heads for Left Turn Phases: Added info for Type 3LCF and Type 3LBF signal heads.

23. Figure 5-27 Signal Head Placement for Left Turn Phasing: Updated figure to include Type 3LCF and 3LBF heads. Deleted illustration that showed using a type 4L signal head with an approach that does not have an exclusive left turn lane (this is not allowed by MUTCD section 4D.17 paragraph 06)
24. Figure 5-40 Common signs used for traffic control: Added "STRE approval required" for signs AL/3U and AL/3T (U-Turn Permitted and No trucks)
25. Section 5.4 (Pedestrian Signal Equipment Layout): completely revised with added information related to ADA pushbutton accessibility from technical bulletin TRS16-01(B). Additional info for two ramps sharing one turning space.
26. New section 5.4.8 Pushbutton located behind guardrail: Revised information allowing pushbuttons located behind guardrail.
27. Section 5.4.10 Indication Type: Changed "shall" to "Should" for upgrading all pedestrian signals for an entire intersection at the same time to allow more flexibility for ADA constraints.
28. Section 5.5.5: changed illumination requirements from "if warranted" to a default standard of including illumination on all mast arm and strain poles at an intersection.
29. Section 5.5.7: removed "signalized right turn slip lanes" from list of typical vehicle pedestal installations
30. Section 5.5: added info about pushbutton mounting (pedestals = yes, big poles =no) with reference back to section 5.4
31. Section 5.6: changed illumination requirements from "if warranted" to a default standard of including illumination on all mast arm and strain poles at an intersection.
32. Section 5.15.6: corrected typo for wiring of Type 6L head.
33. Section 5.6.1: deleted statement about contacting illumination engineer for new LED spec (02926) as it is now published.
34. Section 5.7: modified language for fire preemption for clarity
35. Figure 5-56 Standard Drawing TM470 Signal head wiring: updated to include Types 3LBF and 3LCF. Removed Type 4L
36. Updated Figures 5-57 thru 5-63 and corresponding text (wiring for signal head types) to match updated TM460

Chapter 6 Detector Plan

37. Fixed counterclockwise typos for radar and video camera labeling

Chapter 11 Temporary Signal Plan

38. Section 11.2 – added restriction to allow only one signal mast arm to be installed per intersection at day of turn on.
39. Section 11.6.5 – made reference to section 5.4 for pushbutton accessibility requirements
40. Figure 11-15 – fixed typo in lane use in the phase rotation diagram
41. New Section 11.7.3 Stop Line Location

Chapter 12 Flashing Beacon Plan

42. Section 12.4.6 added reference to new moveable bridges chapter
43. Section 12.2: added Standard Detail references for solar power RRFB to list

44. Section 12.6: deleted reference to an old (no longer accessible) standard detail DET4414

Chapter 13 Ramp Meter Plan

45. Removed references to TM497 (details have since been deleted from this drawing).
46. Removed references to TM497 (deleted) and replaced with TM492

Chapter 16 Railroads

47. Section 16.3: added language, "The Crossing Order must be completed prior to PS&E."
48. Section 16.6.1: added provision for allowing one 10 conductor 12 AWG gauge conductor cable instead of individual conductors at the Region Electrical Crew direction.
49. New section 16.4 Railroad Utility Permits

Chapter 17 Fire Signal Plan

50. Section 17.4.1: added a provision for flashing yellow operation on the mainline if the STRE Operational Approval documents the use. For example a unique application: the fire signal in downtown Roseburg on Douglas Ave uses Flashing Yellow due to the extremely close proximity to a traffic signal and is meant to approaching stop vehicles while the traffic signal clears the queue that blocks the fire entrance.
51. Section 17.4.3: Removed single circular green signal indication as an option for a confirmation light. Only option is a tattle-tail indicator due to the simplicity of a direct hardwire.
52. Section 17.4.5: revised information for Tattle-tail indicators and referenced DET4400

Chapter 19 Specifications Bid Items and Cost Estimates

53. Section 19.5.1: added clarification to power hook-up anticipated cost (includes conduit, trenching and wiring from the power source to the service)

Chapter 20 Cabinet Print

54. Section 20.1: added language requiring cabinet prints for temporary signals (for each stage/phase there is a change to interior components)
55. Section 20.4: changed format of prints from 8.5x11 to 11x17
56. Section 20.6: deleted requirement for TSSU to complete the conflict monitor diode card
57. Section 20.6.3: revised section to describe to designers how to complete the conflict monitor diode card
58. Section 20.6.5: fixed typo – A6 (not A4) is not monitored
59. Section 20.9: added Railroad preemption site specific constraints to list of info that should be on the intersection drawing.

Chapter 21 Construction Support

60. Added new section 21.4.1 for Field verification forms (Signal Pole and Signal Pole Foundation)

Chapter 23 Moveable Bridges

61. Added an entire new chapter

Chapter 24 Quick Reference

62. Added section 23.14: electrical crew preferences with forms.

1.5.5 Revision: January 2020

Chapter 1 Introduction

1. Section 1.1 - Changed Traffic Control Systems Engineer from Jeff Hayes to Sarah McCrea

Chapter 2 Design Approval Process

1. Section 2.3 – new section for Overhead Structures and Vertical Clearance Standards as per tech bulletin RD17-02(b).
2. Section 2.5 – minor modifications to the DAP plans information, percent completion for each stage, and name for 100% complete plans.
3. Section 2.5 – added information about the ProjectWise process and a new figure "Project Comment Log Sample".
4. Section 2.6 – added information about the ProjectWise process
5. Section 2.7 – added information about digital signatures

Chapter 4 Starting the Design

1. Section 4.1 – New section on Scoping, including information on the traffic signal asset management report and goals/priority Improvements.
2. Section 4.5 – Added information about the ProjectWise process.

Chapter 5 Signal Plan

1. Section 5.1 – Deleted reference to 1R preservation projects.
2. Section 5.1.2 – Completely revised to reference new guidance and process for crosswalk closures documented in the 2020 Traffic Manual Update.
3. Section 5.1.2 – moved general info about detailing vs. referencing with other discipline's plan sheets to chapter 19
4. Section 5.1.3 – added information about keeping the crosswalk distance short for railroad interconnected signals.
5. Section 5.2 – changed FYA standard signal head to type 3LCF as per memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 in all the locations necessary in this section.
6. Section 5.2.3 – Added info for supplemental signal heads for sun glare with a new figure
7. Section 5.4 – fixed reference section typo
8. Section 5.4 – Added reference to guiding documents: MUTCD, Oregon supplements, ADAAG, and PROWAG and deleted bullet item that pushbuttons should meet MUTCD section 4E-08 requirements.
9. Section 5.4 – changed turning space dimension from 4'x5' to 4.5' x 5.5' as per roadway section
10. Section 5.4.2 – Changed 10 foot minimum separation of buttons to 8 feet minimum.
11. Section 5.4.3 – Added information about priority of requirements/recommendations
12. Section 5.4.4 - Updated figure to include language that the entire pushbutton does NOT need to be included in the horizontal reach range area. Also fixed reference figure typo
13. Section 5.4.4 – added info for pushbutton parallel to crosswalk it serves.
14. Section 5.4.5 – Revised section to reflect new large pole foundation details shown in TM653 (now flat from foundation control point to edge of baseplate with a tolerance of 0"-1/4" between foundation and adjacent concrete or asphalt finish grade)

15. Section 5.4.6 – Added info about use of 8 foot minimum separation and buttons located in the 8 -10 foot separation range
16. Section 5.4.6 – revised figures for 4' minimum dimension for dimension between crosswalk striping and curb for diagonal ramp and added that obtaining this minimum measurement may not be possible with small radii.
17. Section 5.4.7 – added info about producing object (extension bracket) cannot extend more than 4" into the circulation path and a reference to RD720.
18. Section 5.4.9 – new section for info about the extended pushbutton press feature
19. Section 5.4.12 – new section for Audible pedestrian signals – reference to Traffic Signal Policy and Guidelines
20. Section 5.5.2 – New section for Overhead Structures and Vertical Clearance Standards as per tech bulletin RD17-02(b).
21. Section 5.5.3 – Added low voltage utility clearance guidelines with new figure
22. Section 5.10.1 – added info about maintaining the 5' minimum pedestrian clear circulation path when the controller cabinet door is open if possible.
23. Section 5.15 – new section added for Background/Reference information to allow for documentation that was contained in memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 about type 3LCF signal heads for FYA. Moved other historical only info into this section as well.

Chapter 6 Detector Plan

1. Revised entire chapter and section layout: Radar is the new default standard detection. Deleted info related to loops. Detector plan sheets are no longer required (all radar info is shown on the signal plan). Cabinet prints will now show detector zone and configuration information.

Chapter 7 Interconnect Plan

1. Section 7.1 – revised section to address central communication (now required for all traffic signals) and local communication (connection of multiple controllers in a corridor for signal progression).
2. Section 7.2 – updated text to state current controller type (ATC) and software (maxtime)
3. Section 7.3 – Revised allowable forms of communication as per ITS unit. Fiber optic is the preferred form. Other options include 4.9 GHz radio, cellular broadband and leased dedicated Ethernet. Twisted pair copper (VDSL) is no longer allowed for new installations.
4. Section 7.7.1 – removed outdated information and updated text to current controller type (ATC)
5. Section 7.7.2 – revised section to emphasize fiber optic installation
6. Section 7.7.4 – revised section to only show fiber optic wiring installation and added a new figure showing the fiber optic cable splice diagram created by the ITS unit.
7. Section 7.7.5 – deleted telephone connection section as per ITS unit.

Chapter 11 Temporary Signal Plan

1. Section 11.2 – added the 5th bullet about TPAR
2. Section 11.6.6 – changed section title to "Vehicle Detection". Added a statement that video and radar are the preferred method of detection. Added a statement that loop detection should be avoided if possible.
3. Section 11.6.8 – minor text modification for better readability

Chapter 12 Flashing Beacon Plan

1. Section 12.1 – updated table to include actuated system for Emergency Vehicles
2. Section 12.4.4 and 12.4.5 – added a reference back to section 5.4 for pushbutton placement and to locate the buttons where they are easily accessible for all intended users (peds and/or cyclists).
3. Section 12.4.7 – added a reference to Chapter 5 for pushbutton placement.
4. Section 12.4.8 – New section for actuated system for Emergency Vehicles

Chapter 13 Ramp Meter Plan

1. Figure 13-7 – Removed reference to TM497 (no longer exists). Removed loops from illustration.
2. Section 13.6 – Revised section to match changes made in chapter 6 (detector plan). Radar is new default standard. Deleted info related to loops.

Chapter 16 Railroads

1. Section 16.7.1 – revised pedestrian features to reference section 5.4.9 for extended pushbutton press feature.

Chapter 17 Fire Signal Plan

1. Section 17.1 – added a highlight box to alert designers that actuated flashing beacon systems for fire trucks are a good alternative to a traditional fire signal and reference to Chapter 12 for design info.
2. Section 17.3 – minor text modification for better readability
3. Entire chapter – changed tattle-tail to tattle-tale
4. Section 17.3.1 – This is a new section: Solutions For Existing Fire Signals Located at Intersections
5. Entire Chapter – clean-up of figure call-out notes for consistency throughout whole manual

Chapter 18 Standard Drawings and Details

1. Section 18.1 & Figure 18-1 – updated to text and figure to current method of listing standard drawings on plan sheets (no longer shown in the title block)

Chapter 19 Specifications Bid Items and Cost Estimate

1. Section 19.2 – added Specifications Engineer also is required to review and concur with special provision modifications that fall outside of the normal boiler plate instructions.
2. Section 19.3 - moved general info about detailing vs. referencing with other discipline's plan sheets to chapter 19
3. Section 19.3.5 – New section – added info about bid item for crosswalk closure supports.

Chapter 20 Cabinet Prints

1. Section 20.2 and Section 20.3 – changed timeframe for putting the cabinet print in the INCOMING subfolder from just before testing at TSSU to DAP (this will allow signal timers adequate time to review and comment on new sheet 7 which details the detection unit placement, zones, and zone configuration).
2. Section 20.5.2 – added info for SDLC (i.e. leave detector input location slots 1 thru 10 blank.
3. Section 20.5.8 – added information for 332s cabinet detector input termination using video, radar, or SDLC
4. Section 20.6 – fixed typos and incorrect microstation references
5. Section 20.6 – changed FYA standard termination from ped yellow to overlap as per memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 in all the locations necessary in this section.
6. Section 20.10 – new section added for Background/Reference information to allow for documentation that was contained in memos from the State Traffic Signal Engineer dated May 16, 2018 and July 23, 2018 about FYA.

Chapter 21 Construction support

1. Section 21.2 – added information for digital signatures
2. Section 21.7 – added information for digital signatures

Chapter 22 State Force Work

1. Figure 22-1 – updated to current title block

Chapter 24 Quick Reference

1. Deleted video and radar specific info and replaced with: Non-Invasive Detection Information, (consistent with Chapter 6).
2. Removed input file info for 170 and 2070 controllers

2 DESIGN APPROVAL PROCESS

The Traffic-Roadway Section has reviewed and approved traffic signal plan sheets for many years with the effort becoming formalized in the mid 2000's when ODOT decentralized the design functions of the agency. The main focus of the Traffic-Roadway Section's design review and approval is to identify and resolve any errors/omissions so that the design as shown in the plan sheets:

- is safe for the public
- meets the requirements of the operational approval documentation
- meets the requirements of the MUTCD and other applicable ODOT design, policy and guideline documents.
- is maintainable (ease of maintenance and economical)
- is constructible (staging, schedule, and economical)
- is readable and can be understood by those in the industry (drafting standards)
- contains clear, non-conflicting information
- results in zero to minimal construction change orders

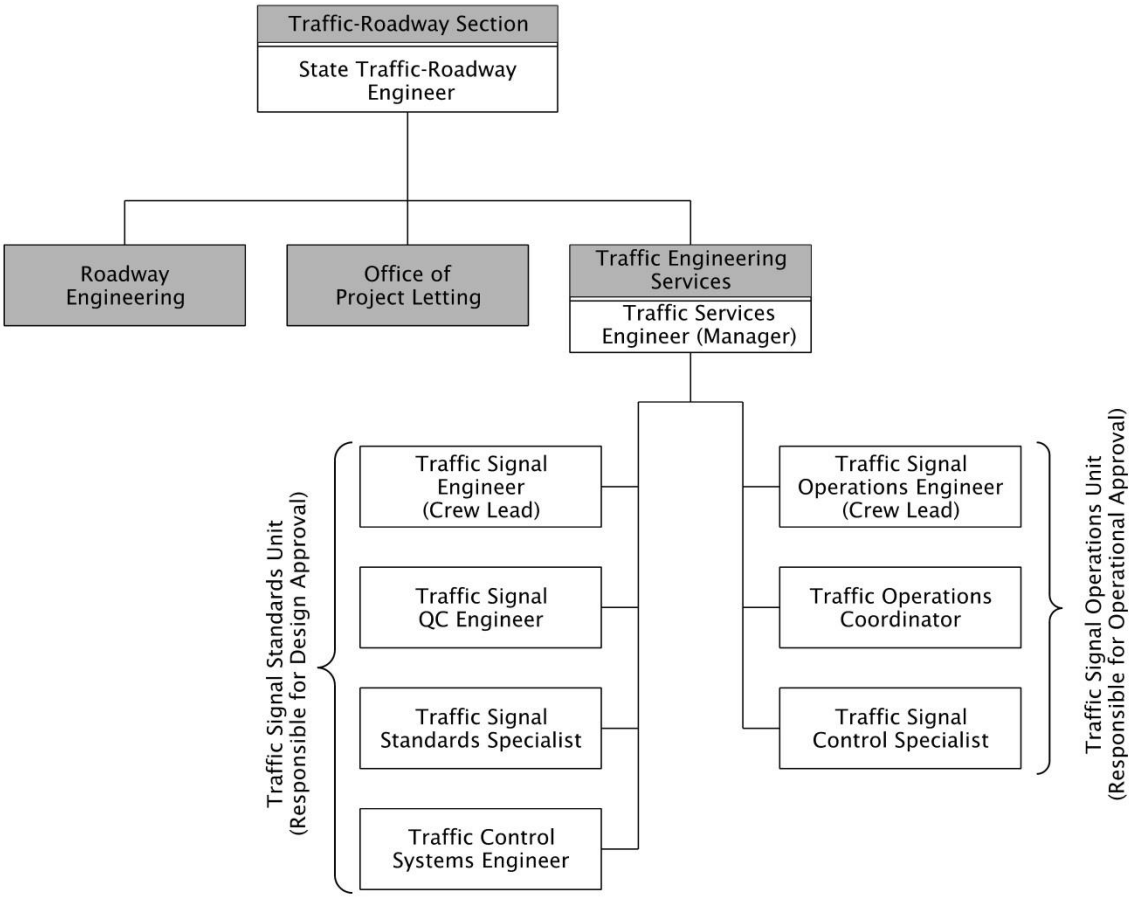
The Traffic-Roadway Section's design review will look at big picture issues as well as the details of the design, down to the conduit sizes and wire counts. The design review also includes a review of the signal operation details by the Traffic Signal Operations Unit. The operational review is coordinated by the Traffic Signal Engineer. As expected, reviews during the early phases of the design process will be more focused on big picture issues, becoming more focused on the details as design phase progresses. Typically a detailed review of the plans cannot be completed until the big picture issues are resolved, so it is important to address the big picture issues as early as possible.

Note: There are two separate types of approvals for traffic signal work – the Operational Approval and the Design Approval. See Chapter 3 for information on the Operational Approval.

2.1 Traffic-Roadway Organizational Structure

It is helpful to understand how the Traffic-Roadway section is organized and how the key positions will interact with the signal designer during the design review process. The organization chart below shows only the traffic signal related positions.

Figure 2-1 | Organization Chart



2.2 Design Exceptions, Non-Standard Design, and Experimental Design

All traffic control devices installed in the state of Oregon are required to conform to the Manual on Uniform Traffic Control Devices (MUTCD) and the Oregon Supplements as to the MUTCD as established by ORS 810.200 and OAR 734-020-0005.

The MUTCD, as well as this manual, contains Shall, Should, and May language which indicates what is required, recommended, and optional. Traffic design should not deviate from a Shall or Should statement unless it is prudent to do so, as per section 1A.13 of Oregon Supplement to the MUTCD.

Section 1A.13 of the Oregon Supplement to the MUTCD: "The decision to use a particular device at a particular location is typically made on the basis of an engineering study at the location. Thus, while this Manual provides standards for design and application of traffic control devices, the Manual is not a substitute for engineering judgment. It is the intent that the provisions of this Manual be standards for traffic control devices installation, but not a legal requirement for installation."

If the design or operation of a traffic control device must deviate from a Shall or Should statement, the deviation will be addressed by the Traffic-Roadway Section in the form of either an Operational Approval (see Chapter 3) or through the Design Approval process (see Section 2.6) depending on the nature of the deviation. The design exception process, used in other disciplines like roadway design, is NOT used for traffic design. However, new requirements for pushbutton accessibility are an exception and will require a Roadway Design Exception if they cannot be met. See Section 5.4 for detailed information.

Certain deviations may be considered experimental and require an additional approval from FHWA. All requests for FHWA experimental approval are processed by the Traffic-Roadway Section. See the ODOT Traffic Manual section 6.18 for more information on exceptions, deviations, and requests to experiment.

2.3 Overhead Structures and Vertical Clearance Standards

Contact the Region Mobility Liaison when any proposed project (new construction, reconstruction, preservation, or maintenance) adds a new or modifies an existing overhead structure (Truss Sign Bridge, Monotube Cantilever, Signal Mast arm, and Signal Strain Pole) regardless of meeting the existing minimum vertical clearance standards. In addition, contact the Region Mobility Liaison for any project that reduces the existing vertical clearance regardless of meeting the minimum vertical clearance standards. The Region Mobility Liaison will provide the appropriate coordination with the Region, and MCTD. This coordination should address not only project specific mobility requirements, but also any corridor level vertical clearance and mobility needs. Vertical clearance greater than 19'-0" for sign, VMS, and signal support structures are considered non-standard and require a design exception. The Traffic designer is to follow the procedures outlined in Chapter 14 of the HDM. The design exception

request process for increasing the vertical clearance greater than the above mentioned 19'-0" will need to consider safety, operations, and impact to other design features in order to support the approval of the design exception.

2.4 Project Types That Require Design Approval

There are four different types of projects which might contain traffic signal work that requires review and Design Approval of the Traffic-Roadway Section:

1. **Projects let for bid by ODOT**
   This is the typical method ODOT uses. The plans and specifications are developed within a project team. The work is reviewed and approved by the Traffic-Roadway Section before the project is let for bid.

2. **Projects let for bid by a local agency**
   The Local Agency, typically a City or County, lets the contract for bid. The ODOT Local Agency Liaison coordinates reviews of the plans and specifications within ODOT. The work is reviewed and approved by the Traffic-Roadway Section before the local agency is allowed to let the contract for bid.

3. **Projects by ODOT Permit**
   ODOT will issue a permit to work on State Right of Way. A common scenario is a developer wants to improve an area such as building a large retail store. This large retail store will impact the State Highway and typically some sort of mitigation is required. The ODOT District Office coordinates with the ODOT Region Traffic Engineer and the developer and issues a permit for construction once the work is reviewed and approved by the Traffic-Roadway Section.

4. **Projects by State Forces.**
   Plans and specification are created and given directly to State Forces for construction. Typically these projects are simple in scope such as upgrading to countdown pedestrian signals or changing left turn phasing. The project is developed similar to "projects let for bid by ODOT" described above, but considerably less formal. See Chapter 23 for more information on state force work.

2.5 Plan Sheets That Require Design Approval

Design Approval is required for each plan sheet that contains signal work. The Traffic-Roadway Section shall approve the following plan sheets for all ODOT owned **or** maintained traffic signals before the project is let for bid:

1. Permanent signals, both new installations and modifications to existing signals. This includes all components of a traffic signal: signal, detector, interconnect, details, railroad preemption, existing utilities, etc.
2. Temporary signals (excluding portable temporary signals)
3. Ramp Meters
4. Actuated flashing beacons (includes RRFB, Tunnel, and Bridge applications)
5. Flashing beacons mounted overhead
6. Pedestrian signals
7. Fire signals
8. Red light enforcement

Review and approval is NOT required for local agency owned **and** maintained traffic signals. However, federally funded local agency projects may request a courtesy review from the Traffic-Roadway Section for compliance with federal and state minimum requirements.

2.6 Design Approval Process

Plan sheets should be submitted to the Traffic Signal Engineer for review at all major project milestones; DAP (Design Acceptance Package), Preliminary, Advanced, and Plans-in-Hand. Plans may also be submitted for review independently of the project's major milestones or Project Leader's official schedule if it makes sense to do so. The design plans should progress in level of detail and completeness at each milestone. The requirements for each milestone, as detailed below, will enable efficient TRS reviews (faster turnaround, with fewer comments to address) and also should result in less re-work for the signal designer between reviews.

Use the Excel QA/QC Checklists (with hyperlinked examples) before submitting the plans for Traffic Standards Review. This will drastically reduce the number of comments to address during the review period!

1. DAP Plans (60% complete):
    a. Signal plan sheet
        i. Number of lanes & lane use (as per the completed Operation Approval)
        ii. Crosswalks/Crosswalk closures (as per the completed Operation Approval)
        iii. ADA ramps (i.e. basic style to be used to identify the amount of right-of-way needed to accommodate proper placement).
        iv. Normal Signal Phasing diagram (as per the completed Operational Approval)

v. Location of mast arm poles, strain poles, pedestals, controller cabinet, and service cabinet (used to identify the amount of right-of-way needed to accommodate proper placement).
vi. Location of potential commercial power source
vii. Existing and proposed right-of-way lines shown

b. Detector Plan Sheet
   i. Location and type of detection (loops, radar, video)
   ii. Detection Zones (for video or radar)
   iii. Loop numbers if applicable
   iv. Place holder for input file and/or loop wiring diagram

c. Identification of lane reductions occurring within ½ mile of the intersection and verification that the length before reduction can accommodate standard traffic control devices/signal operation (used to identify the amount of right-of-way needed to accommodate proper placement).

d. Identification of the basic temporary workzone strategy and need for temporary signals. If a temporary signal plan sheet will be required, the DAP requirements listed above for the signal plan sheet also apply to the temporary signal plans.

e. Placeholder signal plan sheets that will be needed with appropriate titles and intersection info (legend, detector plan, interconnect plan, existing utilities, details, removal, railroad preemption plan sheet, temporary signal plan, etc.)

2. Preliminary Plans (90% complete):
   a. The signal appurtenances should all be detailed with bubble notes for each plan sheet at this stage.
      i. signal heads, pedestrian heads, pushbuttons
      ii. regulatory signs
      iii. junction boxes
      iv. conduit
      v. wiring (signal, detector, and interconnect)
      vi. Illumination and photoelectric cell
      vii. fire preemption detectors
      viii. Crosswalk closure barricades
      ix. Detector layout and detector wiring diagram
      x. Fire preemption diagram
      xi. Right-of-way lines established
   b. Photometric analysis complete
   c. Railroad preemption plan sheet complete
   d. Place holder signal plan sheets for temporary/stage construction
3. Advance Plans (99% complete):
   a. Label all poles and pedestals on project
   b. Pole entrance chart completed
   c. Geotech report finished and referenced near pole entrance chart
   d. List of applicable standard drawings in the first sheet of the plan set
   e. TSSU No.
   f. Custom notes

   g. Temporary/Stage construction plan sheets detailed
4. Final Plans (100% complete)
   a. TRS Dwg. Numbers

The Traffic-Roadway Section is available at every step of the way during the design process to help answer questions, evaluate alternatives, and provide assistance.

For projects that are stored in ProjectWise, the designer should forward the distribution set at each project milestone to the State Traffic Signal Engineer. The Traffic-Roadway section will access the design documents from ProjectWise and provide review comments in the project's comment log. The Traffic-Roadway Section will inform the designer when all their comments have been entered in the comment log for the designer to address by the project milestone (or sooner).

For projects that are NOT stored in ProjectWise, plans may be submitted either electronically (preferred) or hard copy. If submitting electronically, the preferred format is a single PDF of the entire plan set. Other discipline's plan sheets for the project (temporary workzone, roadway, signing, striping, illumination, etc.) are helpful when reviewing the traffic signal plans. Once the review is complete, a list of comments is sent to the signal designer to be addressed by the next project milestone (or sooner).

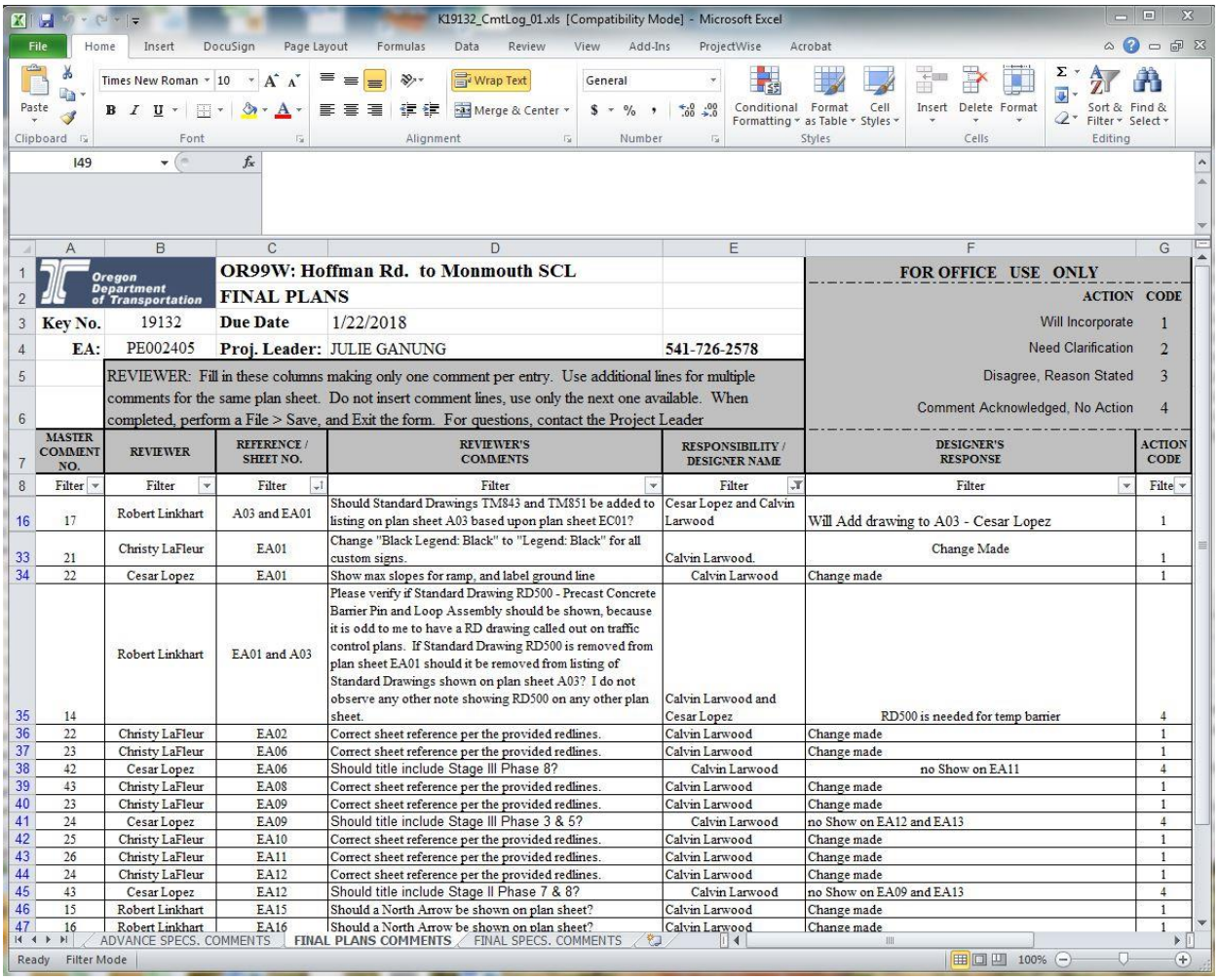
It is very beneficial to provide a design narrative along with the plan sheets. For complex projects or when the constraints/scope of the project requires non-standard design, the signal designer should set up a meeting with the Traffic-Roadway Section to discuss the project and constraints, as this can greatly reduce the amount of time needed for review and the number of comments/questions resulting from the review.

The standard time frame for the Traffic-Roadway Section review is two weeks, but this could be more or less depending on the workload/deadlines at the time. There is no limit to the number of reviews that are conducted and they may not correspond to the number of official major project milestone reviews; some projects may only require one (simple, small project) while some projects may require seven or more (complex, large project or projects with non-standard design).

Complex Project? Constraints requiring non-standard signal design?
Schedule a meeting with the Traffic-Roadway Section to discuss!

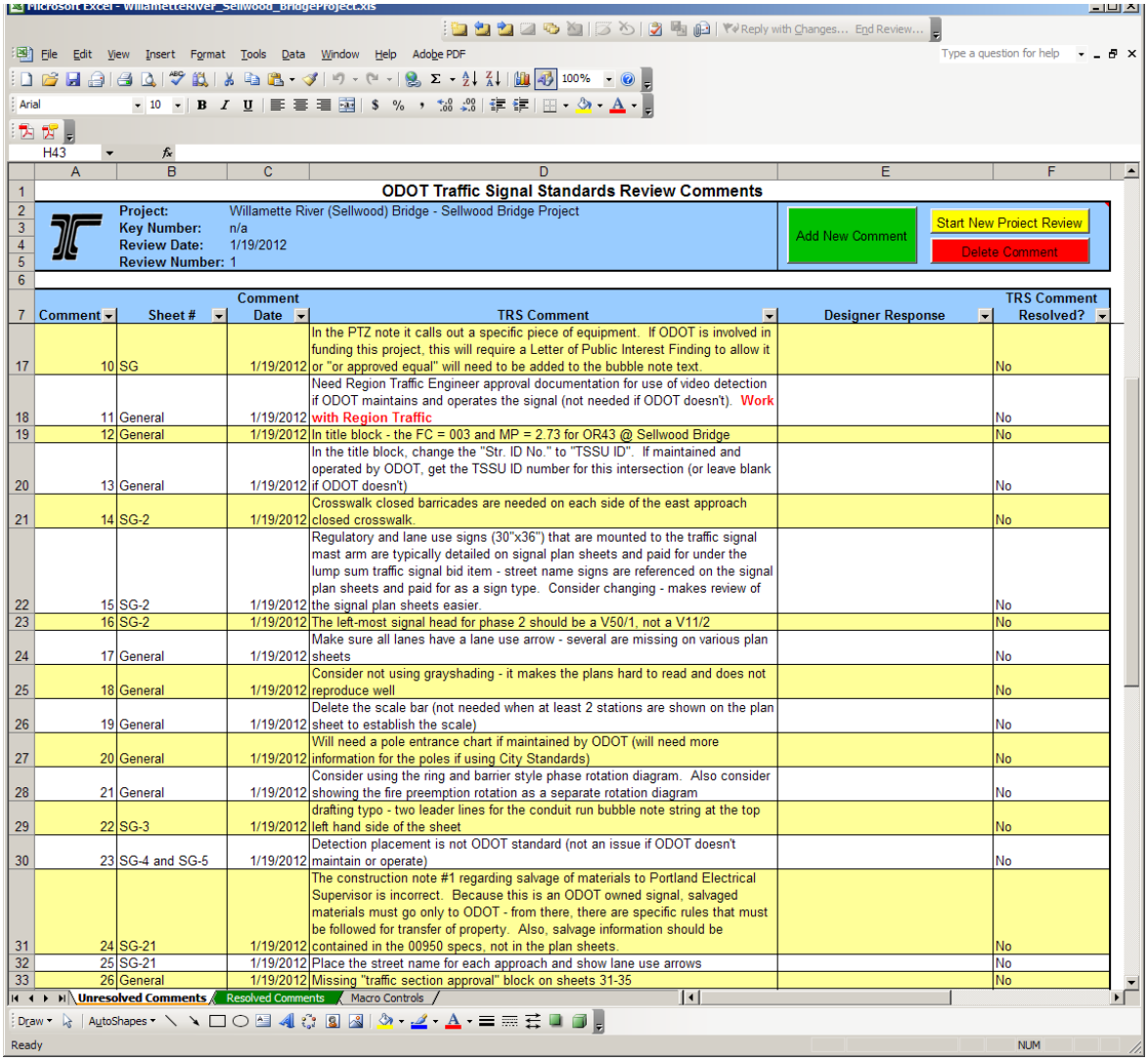
The comments from the Traffic-Roadway Section review are contained in either the project comment log or an excel spreadsheet that assigns a unique comment number to each comment made. See Figure 2-2 and Figure 2-3. Red line mark-ups of plan sheets are not done. Each comment will have a date and sheet number associated with it (or it will indicate "General" if the comment applies to multiple sheets). There is a column "Designer Response" that is for the signal designer to use to respond to each comment. When all of the Traffic-Roadway Section comments have been addressed by the designer, the updated plans need to be re-submitted to the Traffic-Roadway Section with the excel spreadsheet containing the designer response to the Traffic-Roadway Section comments. <u>All of the comments must be resolved to the Traffic Signal Engineer's satisfaction prior to getting the approval signature.</u>

Figure 2-2 | Project Comment Log Sample



	A	B	C	D	E	F	G
1	Oregon Department of Transportation		OR99W: Hoffman Rd. to Monmouth SCL			FOR OFFICE USE ONLY	
2			FINAL PLANS			ACTION	CODE
3	Key No.	19132	Due Date	1/22/2018		Will Incorporate	1
4	EA:	PE002405	Proj. Leader:	JULIE GANUNG	541-726-2578	Need Clarification	2
5		REVIEWER: Fill in these columns making only one comment per entry. Use additional lines for multiple				Disagree, Reason Stated	3
6		comments for the same plan sheet. Do not insert comment lines, use only the next one available. When completed, perform a File > Save, and Exit the form. For questions, contact the Project Leader				Comment Acknowledged, No Action	4
7	MASTER COMMENT NO.	REVIEWER	REFERENCE / SHEET NO.	REVIEWER'S COMMENTS	RESPONSIBILITY / DESIGNER NAME	DESIGNER'S RESPONSE	ACTION CODE
8	Filter	Filter	Filter	Filter	Filter	Filter	Filte
16	17	Robert Linkhart	A03 and EA01	Should Standard Drawings TM843 and TM851 be added to listing on plan sheet A03 based upon plan sheet EC01?	Cesar Lopez and Calvin Larwood	Will Add drawing to A03 - Cesar Lopez	1
33	21	Christy LaFleur	EA01	Change "Black Legend: Black" to "Legend: Black" for all custom signs.	Calvin Larwood.	Change Made	1
34	22	Cesar Lopez	EA01	Show max slopes for ramp, and label ground line	Calvin Larwood	Change made	1
35	14	Robert Linkhart	EA01 and A03	Please verify if Standard Drawing RD500 - Precast Concrete Barrier Pin and Loop Assembly should be shown, because it is odd to me to have a RD drawing called out on traffic control plans. If Standard Drawing RD500 is removed from plan sheet EA01 should it be removed from listing of Standard Drawings shown on plan sheet A03? I do not observe any other note showing RD500 on any other plan sheet.	Calvin Larwood and Cesar Lopez	RD500 is needed for temp barrier	4
36	22	Christy LaFleur	EA02	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
37	23	Christy LaFleur	EA06	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
38	42	Cesar Lopez	EA06	Should title include Stage III Phase 8?	Calvin Larwood	no Show on EA11	4
39	43	Christy LaFleur	EA08	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
40	23	Christy LaFleur	EA09	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
41	24	Cesar Lopez	EA09	Should title include Stage III Phase 3 & 5?	Calvin Larwood	no Show on EA12 and EA13	4
42	25	Christy LaFleur	EA10	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
43	26	Christy LaFleur	EA11	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
44	24	Christy LaFleur	EA12	Correct sheet reference per the provided redlines.	Calvin Larwood	Change made	1
45	43	Cesar Lopez	EA12	Should title include Stage II Phase 7 & 8?	Calvin Larwood	no Show on EA09 and EA13	4
46	15	Robert Linkhart	EA15	Should a North Arrow be shown on plan sheet?	Calvin Larwood	Change made	1
47	16	Robert Linkhart	EA16	Should a North Arrow be shown on plan sheet?	Calvin Larwood	Change made	1

Figure 2-3 | Excel Comment Spreadsheet Sample



ODOT Traffic Signal Standards Review Comments

Project: Willamette River (Sellwood) Bridge - Sellwood Bridge Project
Key Number: n/a
Review Date: 1/19/2012
Review Number: 1

Add New Comment | Start New Project Review | Delete Comment

Comment	Sheet #	Comment Date	TRS Comment	Designer Response	TRS Comment Resolved?
10	SG	1/19/2012	In the PTZ note it calls out a specific piece of equipment. If ODOT is involved in funding this project, this will require a Letter of Public Interest Finding to allow it or "or approved equal" will need to be added to the bubble note text.		No
11	General	1/19/2012	Need Region Traffic Engineer approval documentation for use of video detection if ODOT maintains and operates the signal (not needed if ODOT doesn't). Work with Region Traffic		No
12	General	1/19/2012	In title block - the FC = 003 and MP = 2.73 for OR43 @ Sellwood Bridge		No
13	General	1/19/2012	In the title block, change the "Str. ID No." to "TSSU ID". If maintained and operated by ODOT, get the TSSU ID number for this intersection (or leave blank if ODOT doesn't)		No
14	SG-2	1/19/2012	Crosswalk closed barricades are needed on each side of the east approach closed crosswalk.		No
15	SG-2	1/19/2012	Regulatory and lane use signs (30"x36") that are mounted to the traffic signal mast arm are typically detailed on signal plan sheets and paid for under the lump sum traffic signal bid item - street name signs are referenced on the signal plan sheets and paid for as a sign type. Consider changing - makes review of the signal plan sheets easier.		No
16	SG-2	1/19/2012	The left-most signal head for phase 2 should be a V50/1, not a V11/2		No
17	General	1/19/2012	Make sure all lanes have a lane use arrow - several are missing on various plan sheets		No
18	General	1/19/2012	Consider not using grayshading - it makes the plans hard to read and does not reproduce well		No
19	General	1/19/2012	Delete the scale bar (not needed when at least 2 stations are shown on the plan sheet to establish the scale)		No
20	General	1/19/2012	Will need a pole entrance chart if maintained by ODOT (will need more information for the poles if using City Standards)		No
21	General	1/19/2012	Consider using the ring and barrier style phase rotation diagram. Also consider showing the fire preemption rotation as a separate rotation diagram		No
22	SG-3	1/19/2012	drafting typo - two leader lines for the conduit run bubble note string at the top left hand side of the sheet		No
23	SG-4 and SG-5	1/19/2012	Detection placement is not ODOT standard (not an issue if ODOT doesn't maintain or operate)		No
24	SG-21	1/19/2012	The construction note #1 regarding salvage of materials to Portland Electrical Supervisor is incorrect. Because this is an ODOT owned signal, salvaged materials must go only to ODOT - from there, there are specific rules that must be followed for transfer of property. Also, salvage information should be contained in the 00950 specs, not in the plan sheets.		No
25	SG-21	1/19/2012	Place the street name for each approach and show lane use arrows		No
26	General	1/19/2012	Missing "traffic section approval" block on sheets 31-35		No

Don't forget to include the excel spreadsheet with designer responses when Re-submitting plans for review! This helps decrease the time needed for plan review.

2.6.1 ODOT Let Projects

For ODOT let projects the Project Leader or Consultant Project Manager will be in charge of the schedule and plan review distribution for each milestone. In this case, follow the process as stated by the Project Leader or Consultant Project Manager for plan review distribution. The signal designer should check with Traffic-Roadway Section to ensure the distribution has been received. For state force projects, the design phase

is not as formal as a standard STIP project and the signal designer will likely be in charge of the schedule for plan review distribution.

It is the signal designer's responsibility to make sure that a set of the plans makes it to the Traffic Signal Engineer for review; either by adding the Traffic Signal Engineer to the Project Leader's plan review distribution list or by sending the plan sheets to the Traffic Signal Engineer directly.

2.6.2 Non-ODOT Let Projects & Consultant Signal Designers

For non-ODOT let projects (local agency or development projects) and consultant designed plans (ODOT let project that is designed by a consultant) an ODOT point of contact will be responsible for plan review distribution of plans to other ODOT personnel. They are typically not responsible for maintaining the project development schedule, only coordinating the review period when the designer deems the plans ready for review. The main point of contact (Region Traffic, Local Agency Liaison, Project Leader, or District Office) will vary depending on the project type and which region and district the project is located in.

Submit the plans to the designated ODOT point of contact who will forward the plans to the Traffic Signal Engineer for review. The Traffic-Roadway Section will then submit comments back to the signal designer through the designated ODOT point of contact. Direct contact can be made to the Traffic-Roadway Section regarding the plan review and Traffic-Roadway Section comments; in fact, the designated ODOT point of contact may encourage direct contact regarding the technical details of traffic signal design rather than being a "middle man". However, the ODOT point of contact should always be kept in the loop of decisions made.

2.7 Getting TRS Drawing Numbers

Each signal related plan sheet is issued a unique TRS Drawing Number that is assigned by the Traffic-Roadway Section. This is how the plan sheets are archived. The sheet number directly relates to the age of the project; the lower the number, the older the plan sheet.

TRS Drawing numbers should be requested by the signal designer once the final number of plan sheets for a project is known and highly unlikely to change (typically near the end of the design process). For projects stored in ProjectWise, this is done by sending the Traffic Signal Engineer a link to the current signal plans in ProjectWise. For projects outside of ProjectWise, this is done by contacting the Traffic Signal Engineer and sending a PDF document (preferred) or hard copy of each plan sheet on the project that needs a drawing number. Drawing number requests are a high priority; they are processed as soon as possible, often within hours of the request.

2.8 Getting the Design Approval Signature

Each signal related plan sheet shall contain a signature block for “Traffic Section Approval”. When all comments on the signal plans have been resolved to the Traffic Signal Engineer’s satisfaction the final plans are either digitally signed by the Engineer of Record or printed on mylar and wet signed by the Engineer of Record.

When signing plans digitally, the Engineer of Record must add the digital signature field for the Traffic Section Approval Block before digitally signing the plans. Otherwise, the Engineer of Record’s signature will be invalidated. Once the plans have been digitally signed, send a link for the signed plans to the Traffic-Roadway Section for the approval signature.

When signing plans on mylar with a wet signature, the Engineer of Record will sign the plans and then send them to the Traffic-Roadway Section for the approval signature.

The approval signature is required to be either the Traffic Signal Engineer or person(s) that are authorized by the Traffic Signal Engineer (typically a member of the Traffic Signal Standards Unit). See Figure 2-4 for authorized signatures.

Figure 2-4 | Authorized Signatures

Scott Cramer

Katryn Johnson

Joe Searcy

2.8.1 ODOT Let Projects

For digitally signed plans, send a link for the digital signed plans to the Traffic-Roadway Section for approval digital signature. Once signed, the Traffic-Roadway Section will inform the signal designer.

For mylars with a wet signature, submit one set of sealed mylars to the Traffic-Roadway Section for the approval signature. Once signed, the Traffic-Roadway Section will return the mylars to the signal designer.

Follow the procedures as per the Office of Project Letting for getting the project finished and distributed.

2.8.2 Non-ODOT Let Projects

Submit two sets of sealed mylars to the Traffic-Roadway Section for the approval signature. Once signed, one set will be retained by the Traffic-Roadway Section for archiving and the other set will be returned to the signal designer for plan set distribution and non-ODOT archiving.

Not having an Authorized Signature on your plan sheets can delay the project bid let date

2.9 Review by Others

In addition to the review and approval from Traffic-Roadway Section, plan sheets should also be reviewed by Region Traffic, Region Electricians, the Construction Office, and any other interested parties (e.g. local agency, historic committees, etc.). Due to the flexibility for some design elements based on Region Electrical Crew preferences (as described in this manual), it is critical to coordinate with the Electrical Crew during the design phase to ensure maintenance concerns are addressed and documented. To accomplish this, download the Electrical Crew Preferences Documentation from Chapter 24 and follow the directions.

The signal designer is responsible for ensuring the plans are distributed to the appropriate parties for review, with one exception; a consultant signal designer working on ODOT let project or a project by permit (e.g. development project) where an ODOT point of contact has been established. The ODOT point of contact will be responsible for ensuring the plans are reviewed by the appropriate **ODOT** personnel.

While the Traffic-Roadway Section makes every attempt to produce comments that do not conflict with other ODOT review comments, it does happen. If other reviewer's comments conflict with the comments received from the Traffic-Roadway Section, it is best to discuss the issue with both parties to determine the appropriate action to take. The conflicting comments may have a simple resolution, such as an incorrect assumption of which standard should be applied to the project because a project narrative was not included with the plan review. Or

the conflicting comments may require more discussion to resolve, such as need to move a crosswalk location or change the signal phasing from what the operational approval requires.

A review by either the signal designer's crew lead or another designer is recommended for the following items, as they are not included in the Traffic-Roadway Section review:

- Quantities and cost estimate
- Special Provision Boiler Plates. Note that the Special Provision boiler plates are only checked and approved by the Traffic Signal Engineer (technical owner of the traffic signal specifications) if you have made any non-standard changes. The Traffic Signal Engineer only reviews and approves the portion of the special provisions where the non-standard change was made. See Chapter 19 for more information on Specifications.

3 SIGNAL OPERATIONS AND OPERATIONAL APPROVAL

3.1 Operational Approval

Traffic signal operational approvals come in two forms:

1. State Traffic-Roadway Engineer (STRE)
2. Region Traffic Engineer (RTE)

The SRTE can approve any operation on State Highways. The STRE has delegated some authority to the RTE. For more information on what design features require STRE or RTE approval, consult Chapter 5 of the ODOT Traffic Manual. The ODOT Traffic Manual also contains valuable information on many ODOT traffic policies, including the process for obtaining the necessary traffic signal Operational Approvals. The ODOT Traffic Signal Policy and Guidelines also contains information on signal operations and approval. These two documents can be viewed online at:

- http://www.oregon.gov/ODOT/Engineering/Docs_TrafficEng/Traffic-Manual-v2016.pdf
- http://www.oregon.gov/ODOT/Engineering/Documents_TrafficStandards/Traffic-Signal-Policy-Guidelines.pdf

The Region Traffic Section is responsible for processing any necessary signal operational approvals; all RTE approvals are completed by Region Traffic and all requests for STRE approval are submitted by Region Traffic to the STRE for completion. The signal designer is responsible for obtaining a copy of the Operational Approval and designing the signal according the requirements as stated within. Contact either the Region Traffic Section or the Traffic-Roadway Section to obtain a copy of the Operational Approval.

NOTE: The Operational Approval is NOT the Design Approval of the plans and specifications. See Chapter 2 for information on Design Approval.

Regardless who the operational approval is from, the signal designer needs this information before design work is started. Operational Approvals generally come in the form of a letter which will outline specific constraints and parameters to be used in the design of the traffic signal. They are accompanied by an engineering study requesting approval, and either the Preliminary Signal Operations Review (PSOR) form for minor changes or the Preliminary Signal Operations Design (PSOD) form for major changes. These forms provide a quick glance summary of the operational requirements, which is useful during the design process. The full engineering study is available upon request if more in-depth information regarding the operational requirements is desired. See section 3.10 for examples of Operational Approvals.

The Operational Approval letter typically contains the information listed below, as applicable to the project:

- Specific location (Highway, Milepoint, County)
- Number of lanes & lane use for each approach
- Normal Phase Rotation
- Crosswalk closures
- Traffic Signal Communications (Interconnect)
- Emergency preemption
- Railroad preemption
- Transit priority
- Other unique requirements (e.g. the signal at 1st and Main must be removed before the construction of a new signal at 2nd and Main)

NOTE: Failure to have an Operational Approval or failure to have a signal plan that matches the operational approval is a fatal flaw and will result in major delays to the project.

It is critical that the signal design, roadway geometry, signing, and striping at the intersection match the requirements shown in the Operational Approval. Any discrepancies between the design plans and the Operational Approval must be resolved by either a revision to the Operational Approval or by modifying the design plans.

3.2 Number of Lanes and Lane Use

The number of lanes and lane use needed for each approach of the intersection will be detailed in the engineering study and shown in the PSOR or PSOD form that accompanies the STRE or RTE approval letter. Depending on the type of project, projected traffic volumes, and phasing requirements, there are a couple of options:

- No change to the existing number of lanes,
- No change to the existing number of lanes, but a change to the existing lane use,
- Increase in the existing number of lanes; or
- Decrease in the existing number of lanes.

If changes to the number of lanes are necessary on the project, it is important to be in communication with the roadway designer early on in the process as the roadway design is the foundation of the signal design. Also, communication with the striping designer and the sign designer will be important.

If changes to existing lane use (but not to the existing number of lanes) are necessary on the project, it is important to be in communication with the striping designer and the sign designer early on in the process as these types of changes usually necessitate the need for a striping plan and a signing plan.

3.3 Normal Phase Rotation

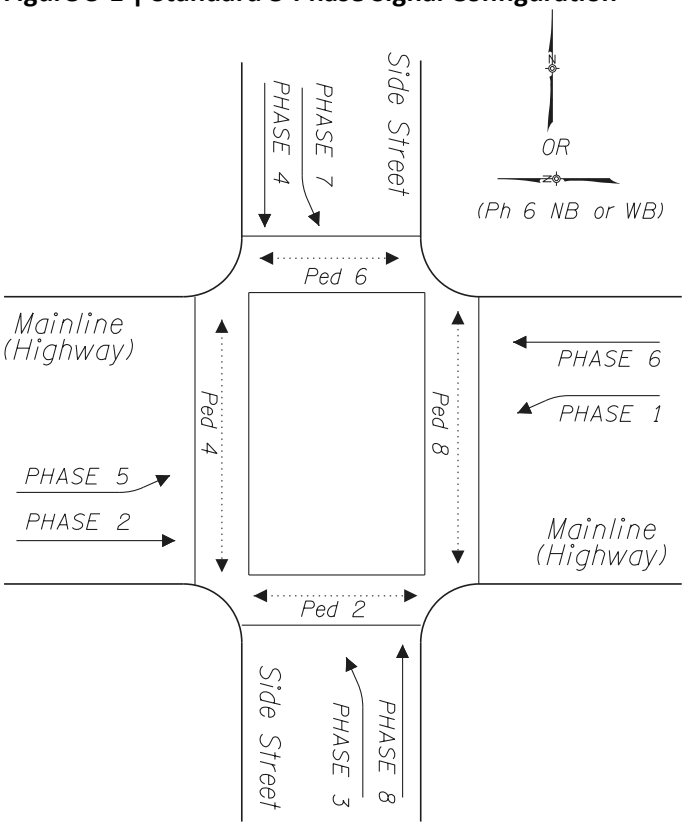
In order to design a traffic signal, a basic understanding of traffic operations and phasing is required. The phasing and operation of the traffic will also be shown on the plan sheets. For more detailed information, the following resources should be consulted:

- Traffic Signal Operations Engineer,
- Region Traffic Operations Engineer; and
- ODOT Signal Timing Policy.

The phasing of the traffic signal is shown on the signal plans. Figure 3-1 shows a typical 8-phase signal configuration and Figure 3-2 shows the corresponding ring & barrier diagram. Typical 8-phase signal configurations have the following characteristics:

- Protected left turns are odd numbered phases (ø1, ø3, ø5, and ø7).
- Through movements and permissive right (or left turns) are even phases (ø2, ø4, ø6, and ø8). Typically, phase 6 is mainline northbound (or westbound).
- Pedestrian phases are even phases corresponding to the compatible through phase (ped 2, ped 4, ped 6, and ped 8).
- The main line through phases are 2 and 6, with corresponding left turn phases 1 and 5. The sum of the phases for each mainline approach equals 7 (2+5=7, and 1+6=7).
- The side street through phases are 4 and 8, with corresponding left turn phases 3 and 7. The sum of the phases for each side street approach equals 11 (4+7=11, and 3+8=11).

Figure 3-1 | Standard 8-Phase Signal Configuration



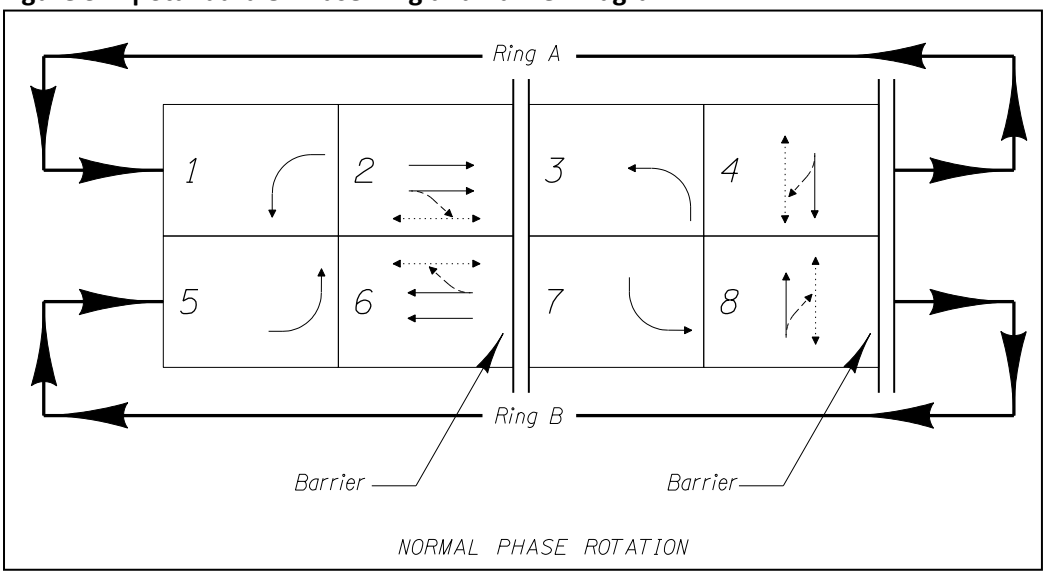
3.3.1 Ring and Barrier Diagram

Modern U.S. practice for signal control organizes phases by grouping them in what is called a ring and separating the crossing or conflicting traffic streams with time between when they are allowed to operate, either by making the movements sequential or adding a barrier between the movements.

A ring consists of two or more sequentially timed and individually selected conflicting phases arranged so as to occur in an established order. In Ring A of the Normal Phase Rotation diagram shown in Figure 3-2, phase 1 must terminate prior to phase 2, which must terminate prior to phase 3, which must terminate prior to phase 4, which must terminate prior to returning to phase 1. The majority of traffic signals use two rings.

Barriers assure there will be no concurrent selection and timing of conflicting phases for traffic movement in different rings. Both ring A and ring B cross the barrier simultaneously to select and time phases on the other side. These barriers separate the mainline phases (ø1, ø5, ø2, and ø6) from the side street phases (ø3, ø7, ø4, and ø8). In this example, phase 2 and 6 must terminate at the same time before the next phases (ø3 and ø7) can be serviced. Similarly, phase 4 and phase 8 must terminate at the same time before the next phases (ø1 and ø5) can be serviced. There is no barrier between phases 1 & 5 and 2 & 6; therefore, phase 1 and 5 do not have to terminate at the same time. If phase 1 terminates prior to phase 5, the next phase in Ring A may be serviced (phase 2), resulting in phase 2 and 5 being serviced together. Using this same logic, compatible phases can be determined. For example: phase 1 may operate concurrently with phase 5 and phase 6 (but not with phase 2 which is in the same ring as phase 1, and not with any phases located beyond the barrier: 3, 4, 7 & 8), phase 2 may operate concurrently with phase 5 and phase 6 (but not with phase 1, 3, 4, 7, & 8), phase 8 may operate concurrently with phase 3 and phase 4 (but not with phase 7, 1, 2, 5, & 6)

Figure 3-2 | Standard 8-Phase Ring and Barrier Diagram



When reading a ring and barrier diagram, vehicular movements drawn with solid lines do not have any conflicting movements associated with them. In Figure 3-2 that would be phases 1, 3, 5, 7, and thru movements for phase 2, 4, 6, 8. Vehicular movements drawn with large dashed lines have conflicting movements associated with them that require the motorist to yield during a green indication (permissive movement). In Figure 3-2 that would be the right turn movement for phases 2, 4, 6, and 8 (the conflicting movement that the right turn must yield to is the associated pedestrian phase). Pedestrian movements are drawn with small dashed lines with dual arrow heads, because pedestrians can move either direction in a crosswalk. Barriers are indicated by dual vertical lines.

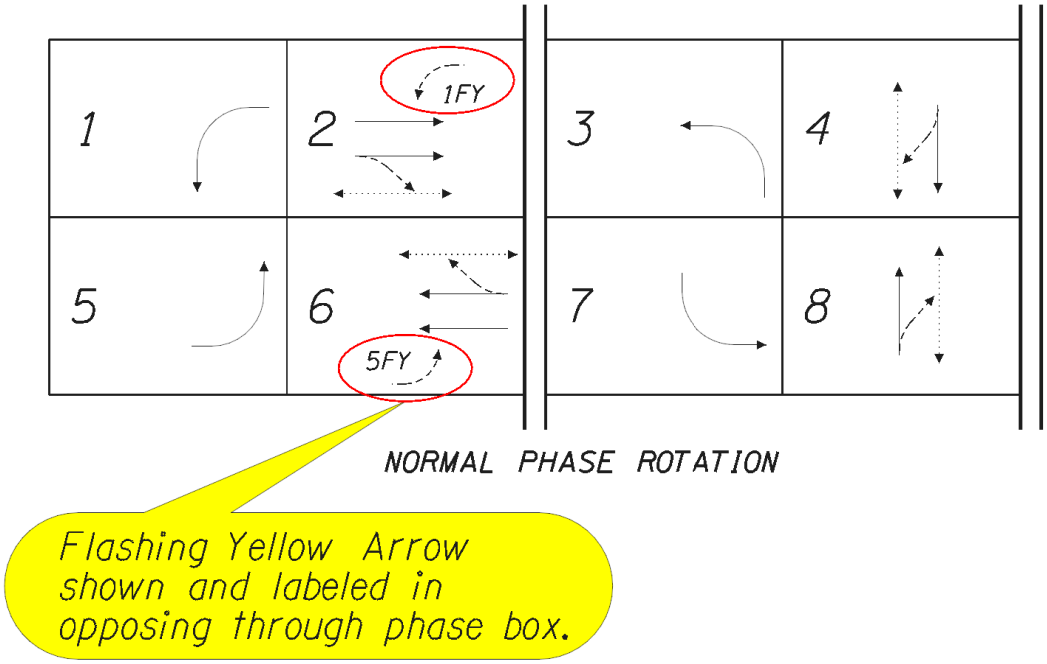
Depending on the operational requirements of the traffic signal, there can be many variations to the phasing and signal timing, and some of these variations might change by time-of-day or day-of-week. It is important to obtain the current STRE or RTE approval and to work with the Region Signal Operations Engineer regarding proper phasing. If the project has a signal that will have multiple signal timing configurations based on time-of-day/day of week, only the ring and barrier diagram that will be used the majority of the time is shown on the plan sheet (multiple normal phase rotation diagrams are NOT shown on the plan sheet).

NOTE: The main purpose of the Ring and Barrier diagram is to clearly show which movements are compatible and which movements require conflict monitoring. This diagram is critical for developing proper signal timing and the proper conflict monitor configuration.

3.3.2 Flashing Yellow Left Turn Arrow

The flashing yellow arrow display is the current standard for protected/permissive left turn movements. The permissive phase is shown in the opposing through phase box and labeled "FY". See Figure 3-3.

Figure 3-3 | Ring and Barrier Diagrams: Flashing Yellow Left Turn Arrow



3.3.3 Flashing Yellow Left Turn Arrow with NOT-PED

Flashing yellow arrow with NOT-PED refers to timing that restricts the permissive left turn (flashing yellow arrow) from being served if the pedestrian phase crossing the lane used by the permissive left turn is active (active ped phases options include: 1.) the WALK indication only, 2.) the WALK indication and a portion of the FLASHING DON'T WALK indication, or 3.) the WALK indication and the entire FLASHING DON'T WALK indication). For example, if pedestrian phase 2 is displaying the WALK indication (or FLASHING DON'T WALK indication), the phase 1 left turn indication will display a solid RED arrow.

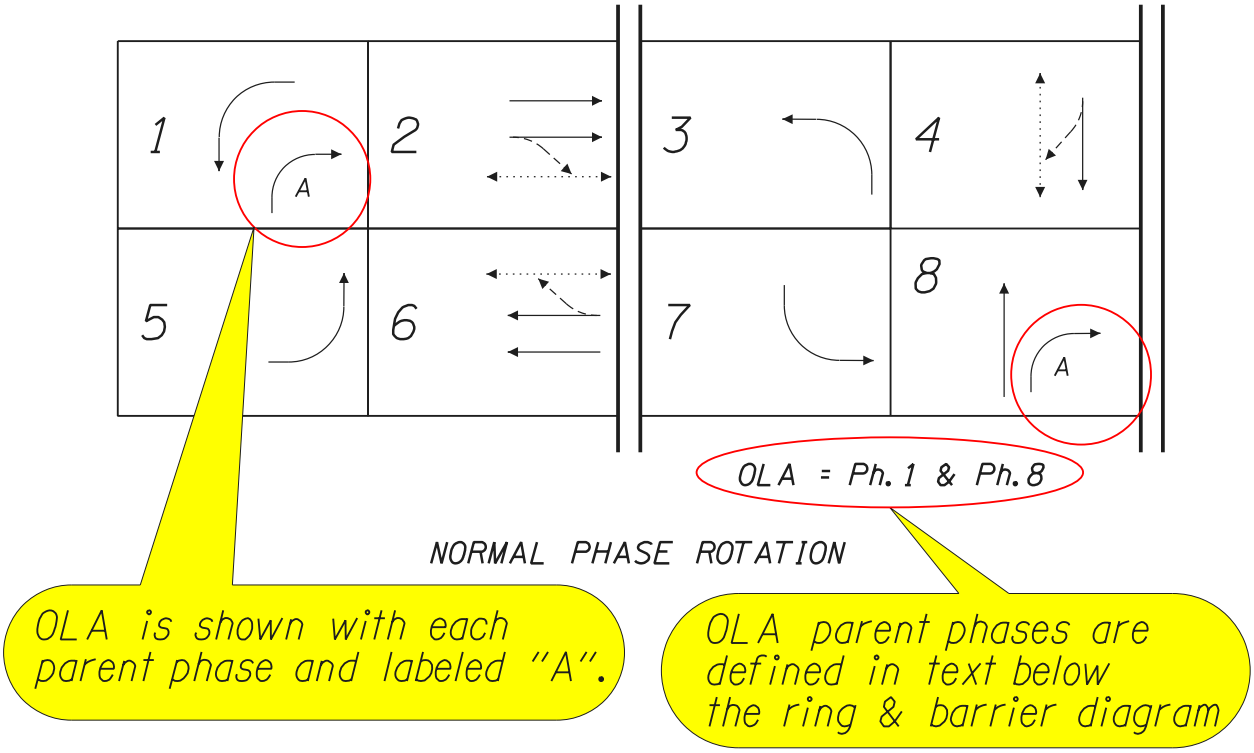
The flashing yellow arrow NOT-PED timing feature is NOT shown in the ring and barrier diagram as it is not a conflict that results inappropriate signal operations if the flashing yellow arrow and pedestrian phase are served together (MUTCD section 4D.17 paragraph 04 allows a permissive left turn phase and the pedestrian phase crossing the lane used by the permissive left turn to be active at the same time). See Section 3.3.2 for how to show the ring and barrier diagram.

3.3.4 Vehicle Overlap Phases

Overlap phases are typically associated with right turns and become beneficial when right turn traffic volumes are high. They may also be used in other circumstances to address unique intersection geometry or improve signal timing efficiency.

An overlap phase is assigned to "parent phases" such that whenever the parent phase is green, the overlap phase is also green. For example, the parent phases for a right turn overlap are the adjacent thru phase (side street thru phase 8) and the non-conflicting left turn phase (mainline left turn phase 1). It is shown in each parent phase box and labeled with the appropriate letter (A, B, C, D, etc.). Below the ring and barrier diagram in text, the overlap parent phases are listed. See Figure 3-4.

Figure 3-4 | Ring and Barrier Diagrams: Overlap Phases



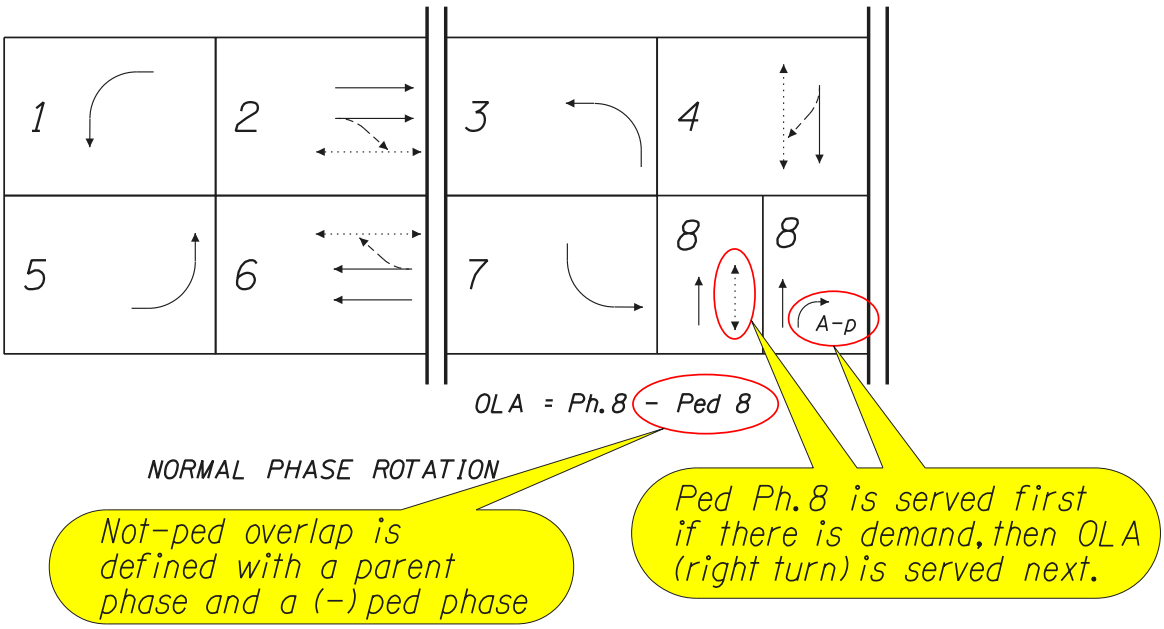
3.3.5 Not-Ped Overlap Phases

Another common overlap phase is called a "not-ped" overlap. This is used with a right turn overlap when there is a conflicting pedestrian phase (the pedestrian phase located to the right of the right turn lane). The new traffic signal software allows the controller to easily separate the pedestrian phase from the right turn overlap, resulting in no conflicting phases and enabling the use of a simpler signal indication.

Not-ped overlaps are shown by separating out the two possible conditions in the ring and barrier diagram. Below the ring and barrier diagram in text, the non-ped overlap phase is defined. See Figure 3-5.

Note: A not-ped overlap phases is NOT the same as a not-ped used with flashing yellow arrow. See Section 3.3.3 for information about flashing yellow arrow with not-ped.

Figure 3-5 | Ring and Barrier Diagrams: Not-Ped Overlap Phases



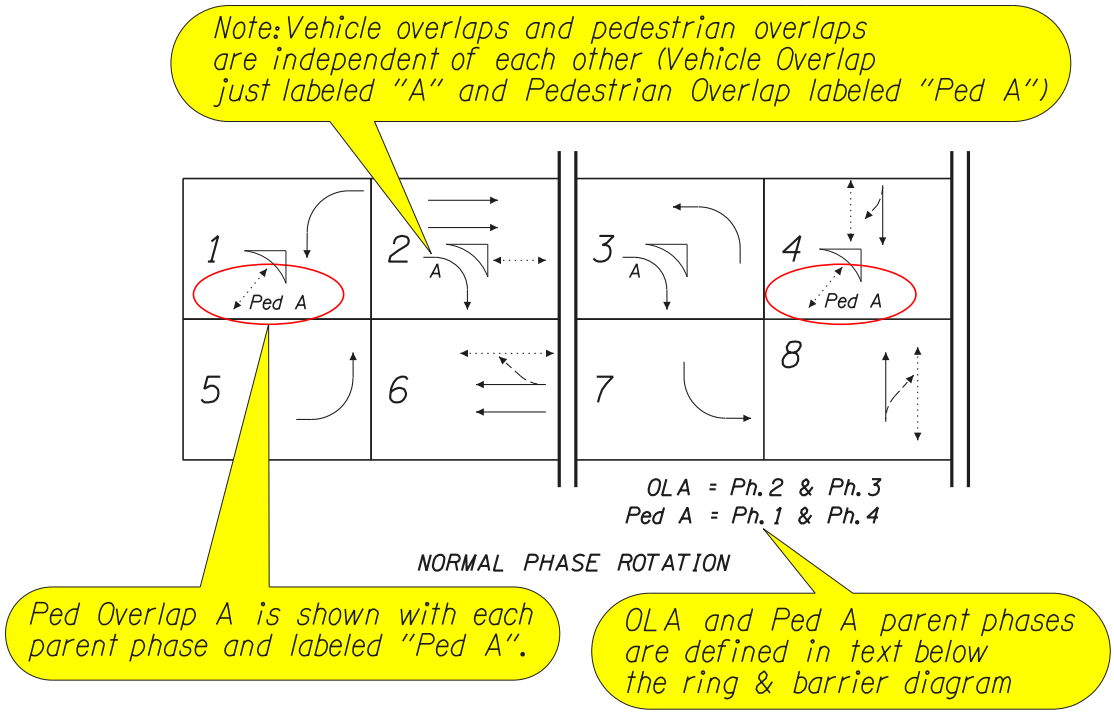
3.3.6 Pedestrian Overlap Phases

Pedestrian overlap phases are typically used when the geometry of the intersection allows the pedestrian crossing served by 2 (or more) phases, which can decrease the amount of wait-time for the pedestrian.

Similar to the vehicle overlap phase, the pedestrian overlap phase is assigned to "parent phases" such that whenever the parent phase is green (and for actuated ped systems, the push button has been activated), the overlap pedestrian phase is also active. As shown in Figure 3-6 below, the parent phases for a pedestrian overlap that crosses a signalized right turn lane are the non-conflicting mainline left turn phase (phase 1) and the non-conflicting side street thru phase (phase 4).

The pedestrian overlap is shown in each parent phase box and labeled with the appropriate letter (Ped A, Ped B, Ped C, Ped D, etc.). Below the ring and barrier diagram in text, the Pedestrian overlap parent phases are listed. See Figure 3-6.

Figure 3-6 | Ring and Barrier Diagrams: Pedestrian Overlap Phases



3.3.7 Split Phases/Exclusive Phases

Split phasing describes an operation where all movements on one approach are served prior to all movements on the opposing approach. This is typically used if the geometry of the intersection, traffic volumes and/or crash history creates a conflict with normally non-conflicting movements. Split phasing requires STRE Operational Approval. Use of split phasing requires specific signal indications depending on the lane use. See Chapter 5 for signal head layout examples.

Split phases may be shown as either sequential without a barrier or sequential with a barrier. See **Figure 3-7**. However, there are cases where exclusive phases shall be shown with a barrier to avoid confusion. See **Figure 3-8**.

Figure 3-7 | Ring & Barrier Diagrams: Exclusive Phases that can be shown with or without a barrier

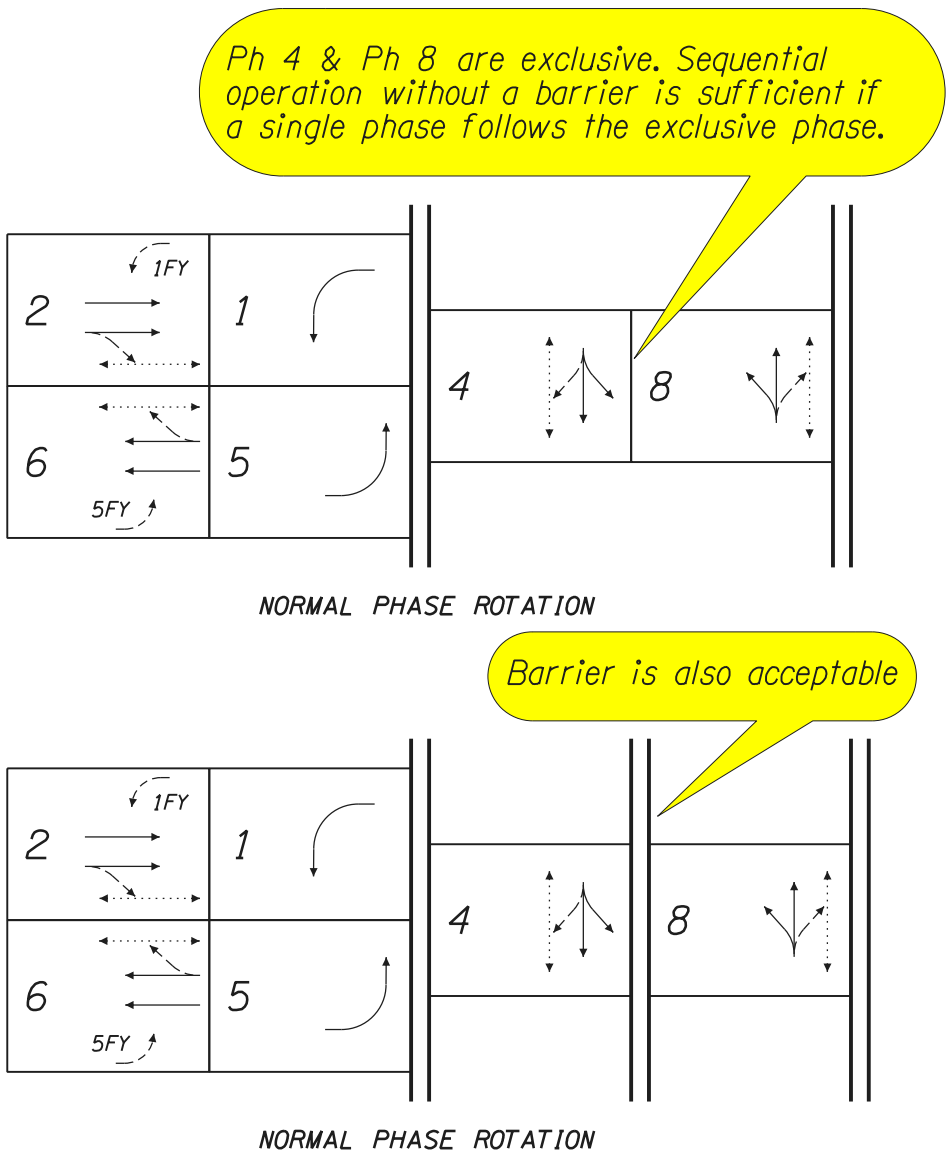
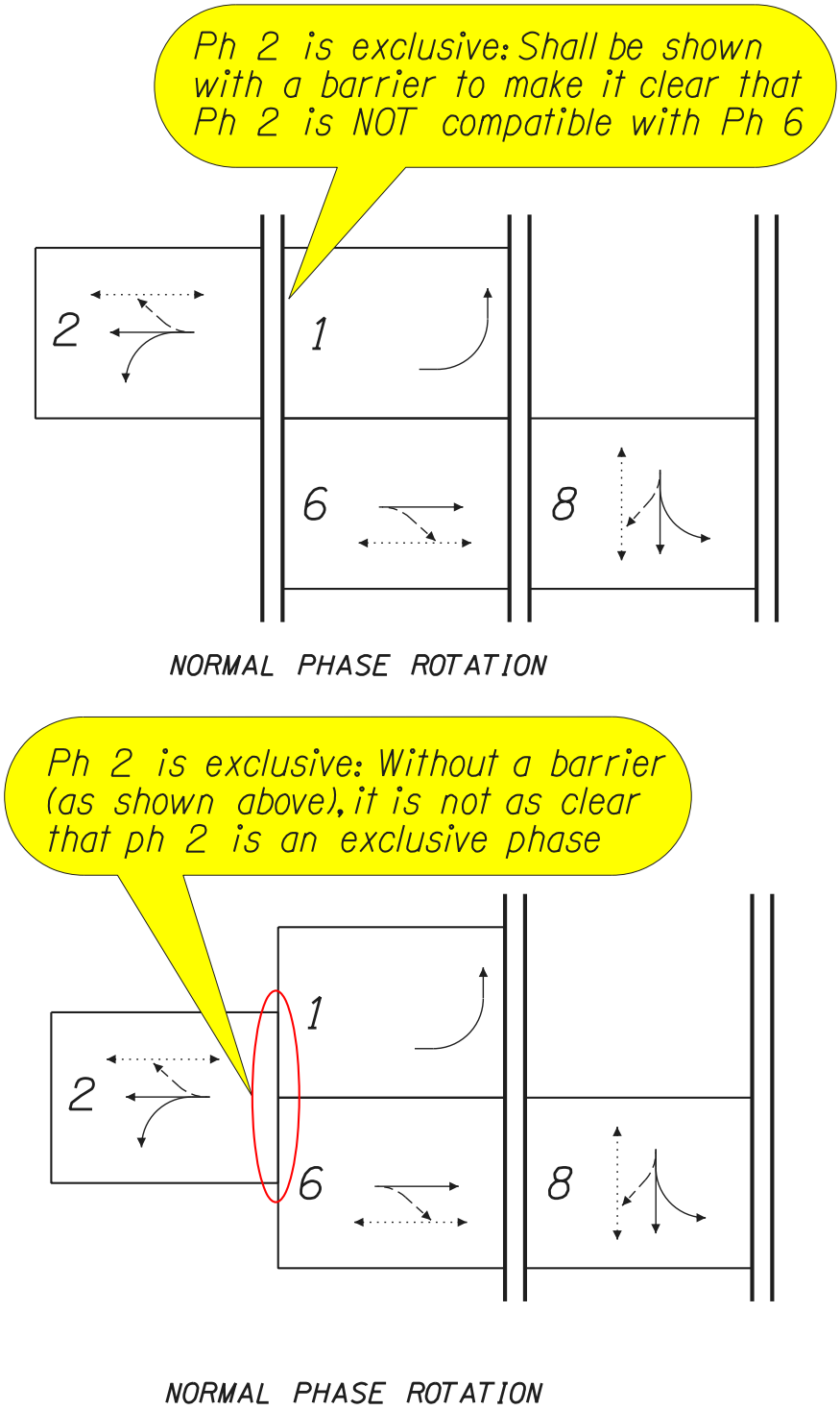


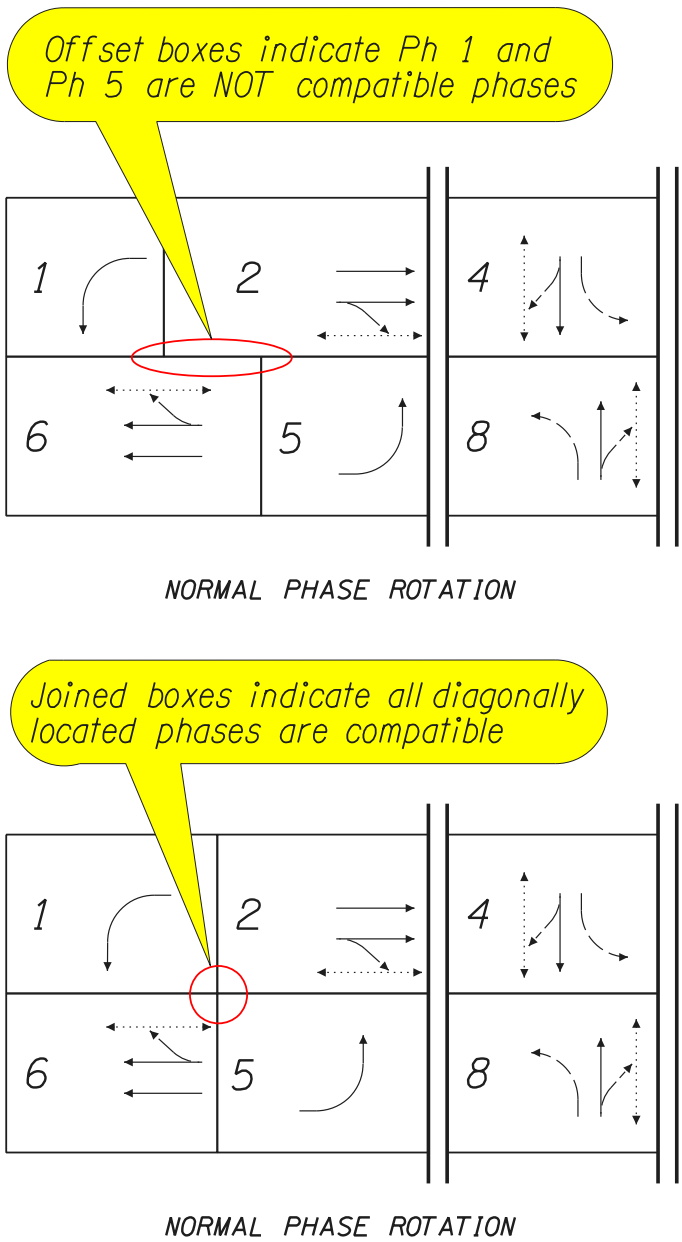
Figure 3-8 | Ring & Barrier Diagrams: Exclusive Phases that shall be shown with a barrier



3.3.8 Incompatible Left Turn Phases

Opposing left turn phases are typically compatible, however if the intersection geometry cannot accommodate the truck turning templates from opposing left turns concurrently, then the left turning phases must be separated from each other (either by split phasing the approaches, See 3.3.7, or by lead-lagging the left turn phases and maintaining separation between them). If the lead-lag method is used, it is shown by a physical separation of the ring and barrier phase boxes. See **Figure 3-9**.

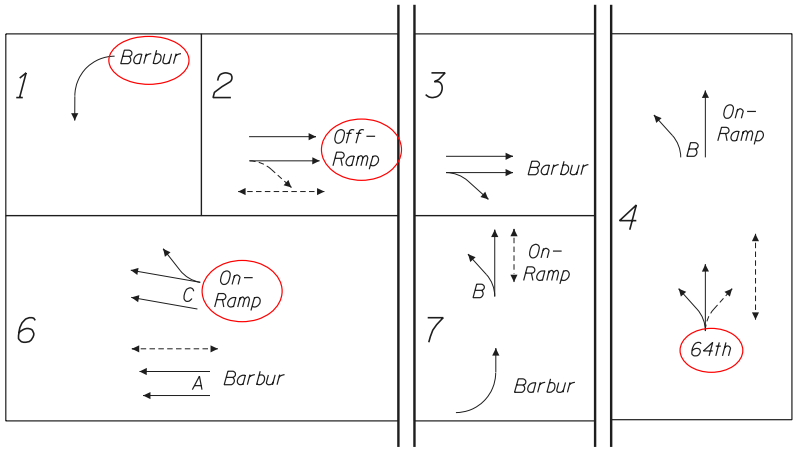
Figure 3-9 | Ring & Barrier Diagrams: Incompatible Left Turn Phases



3.3.9 Multiple Intersections using a Single Controller

Two intersections are sometimes operated with a single controller if the intersections are very close together. The intersection of a divided highway typically operates like two very closely spaced intersections using a single controller. The ring and barrier diagram should combine both intersections into one ring and barrier diagram, with each intersection's cross street labeled in the phase rotation boxes. See **Figure 3-10**, **Figure 3-11**, and **Figure 3-12**.

Figure 3-10 | Ring & Barrier Diagrams: Multiple Intersections Using a Single Controller, Example 1



OL A = Ph. 6
OL B = Ph. 4 & Ph. 7
OL C = Ph. 6

NORMAL PHASE ROTATION

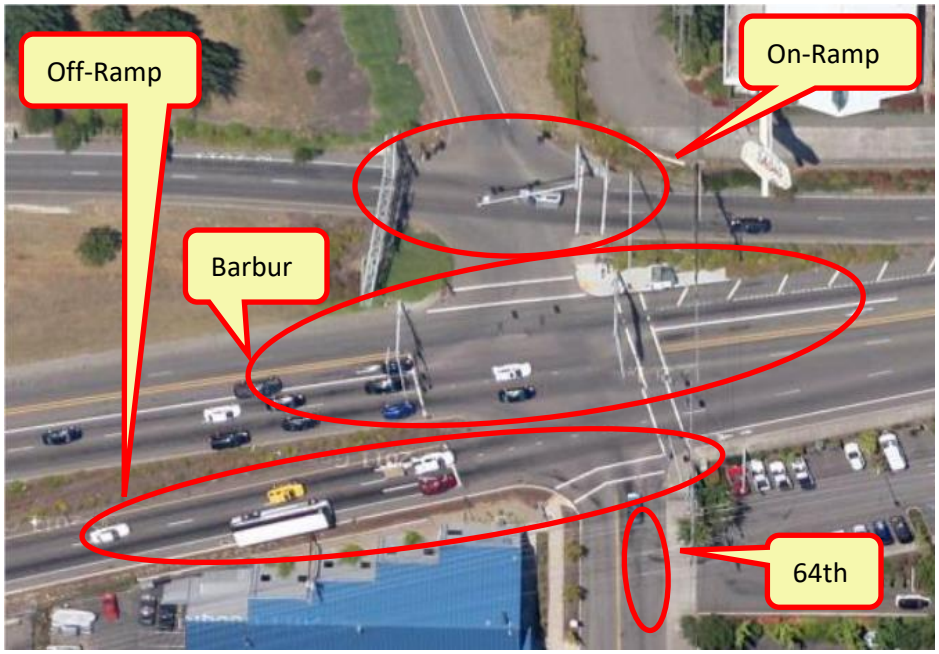
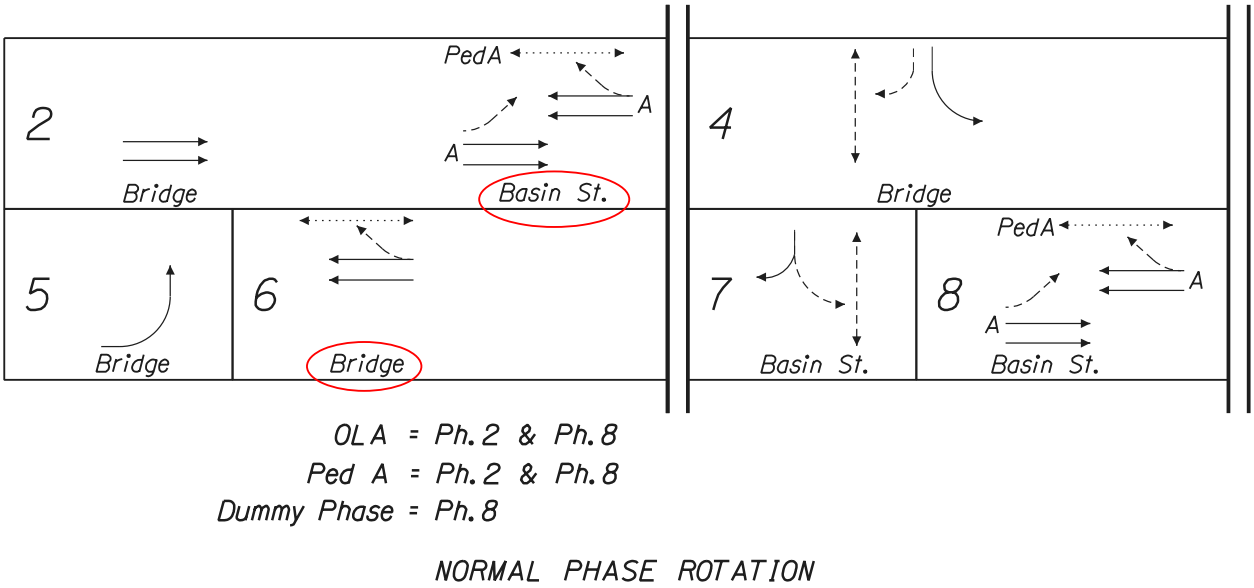


Figure 3-11 | Ring & Barrier Diagrams: Multiple Intersections Using a Single Controller, Example 2



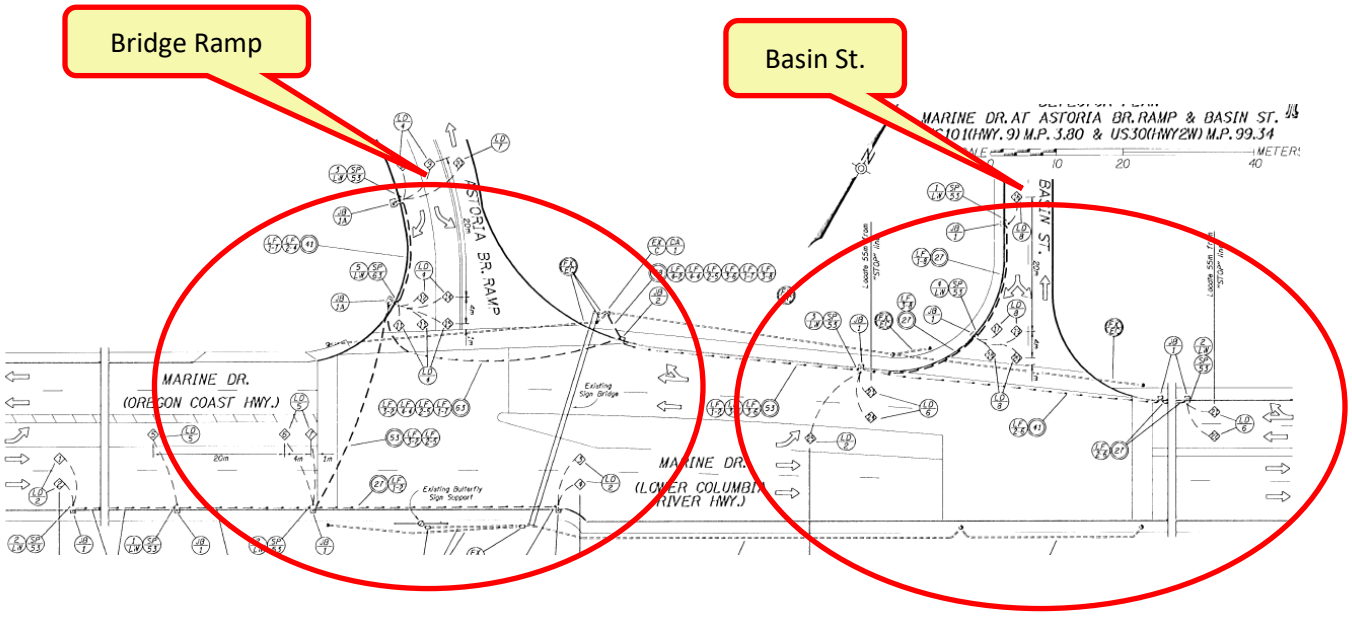
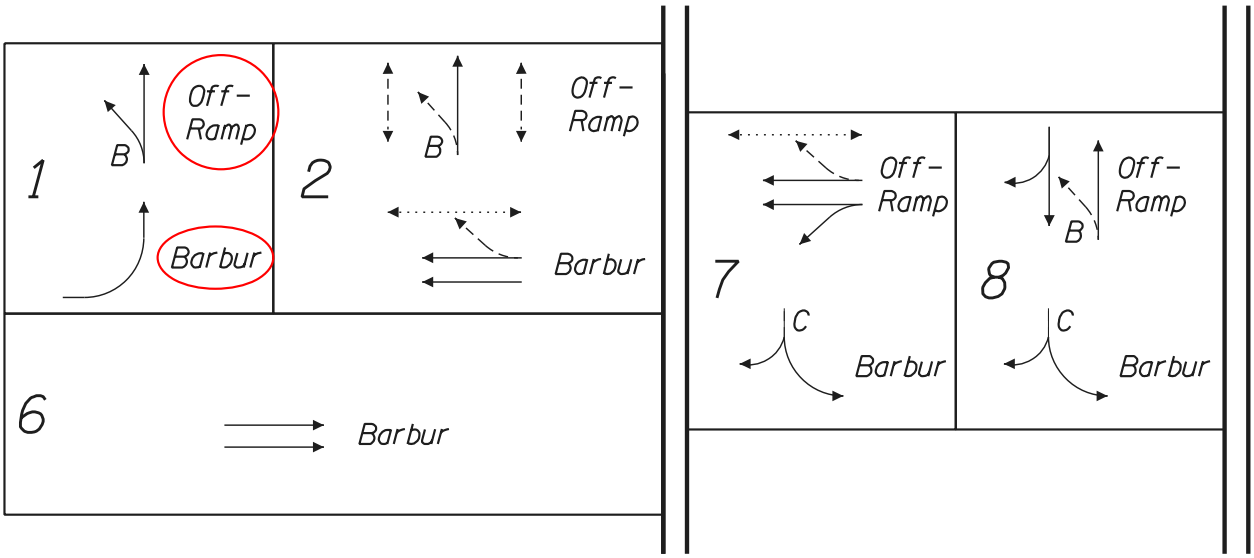
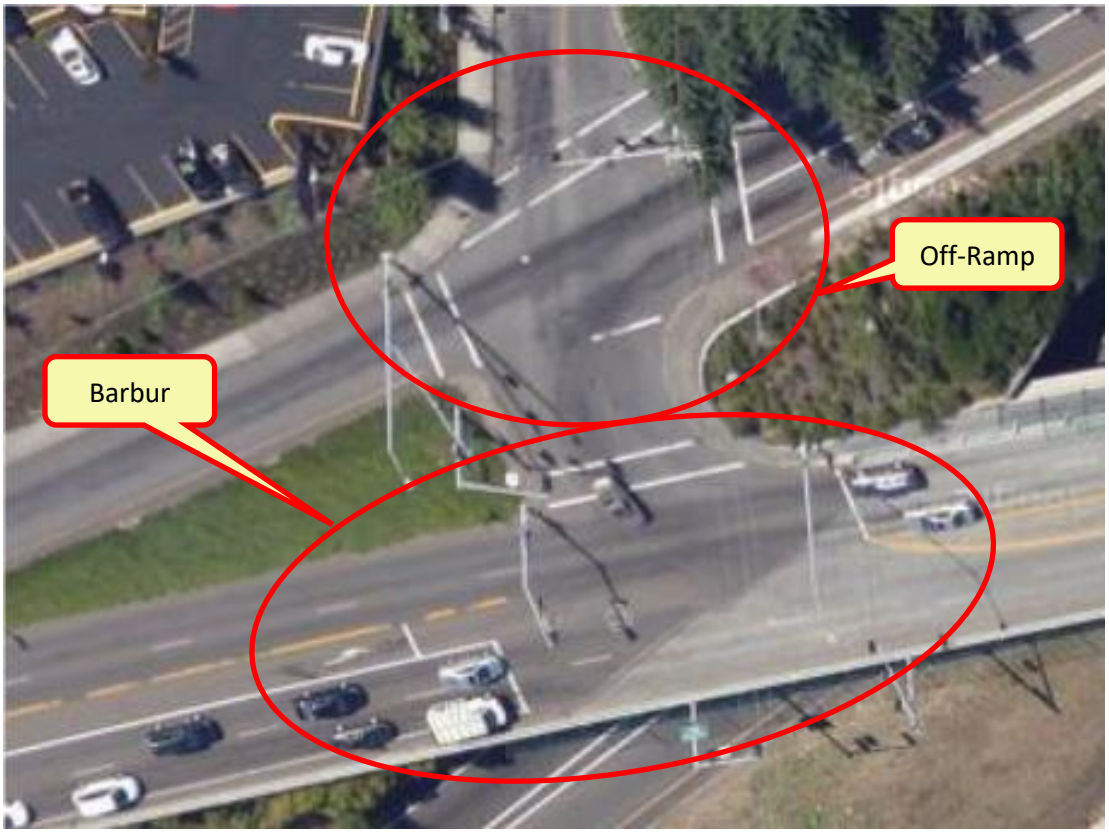


Figure 3-12 | Ring & Barrier Diagrams: Multiple Intersections Using a Single Controller, Example 3



OLB = Ph. 1 & Ph. 2 & Ph. 8
OLC = Ph. 7 & Ph. 8

NORMAL PHASE ROTATION



3.3.11 Dummy Phases

A dummy phase is defined as a phase that does not have an output, but is still used in the controller software to achieve a certain operation. Typical applications are complex geometry with overlaps (see Figure 3-13) and one-lane, two-way temporary traffic signals (see Figure 3-14). The movements (or all-red time clearance time, in the case of a one-lane, two-way temporary traffic signal) are shown in the appropriate phase block. Below the ring and barrier diagram in text, the dummy phases are listed. See Figure 3-13 and Figure 3-14.

Figure 3-13 | Ring & Barrier Diagrams: Dummy Phases, Example 1

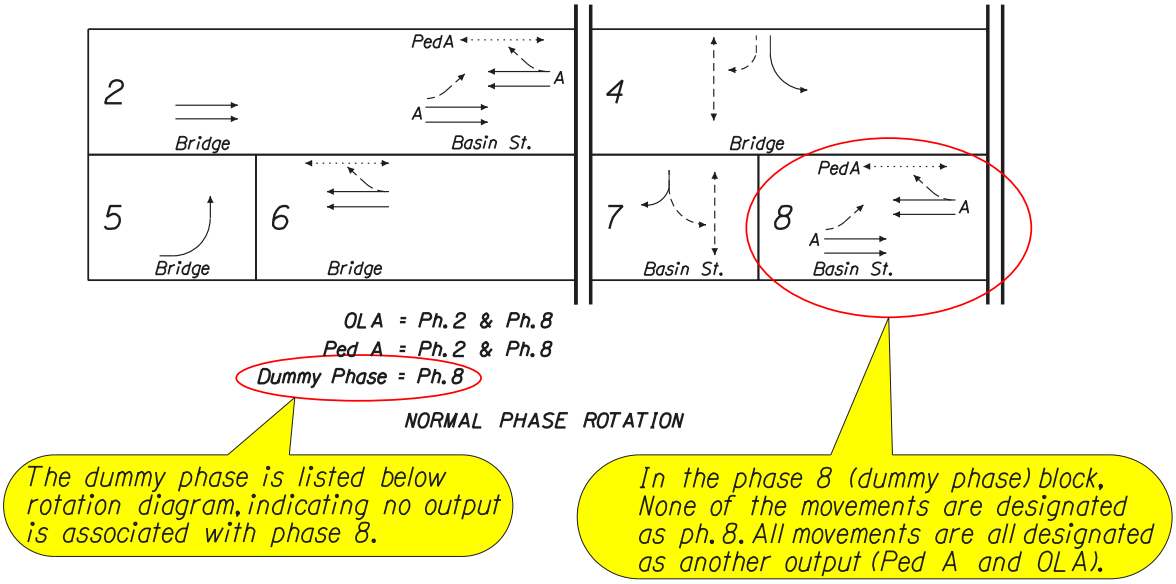
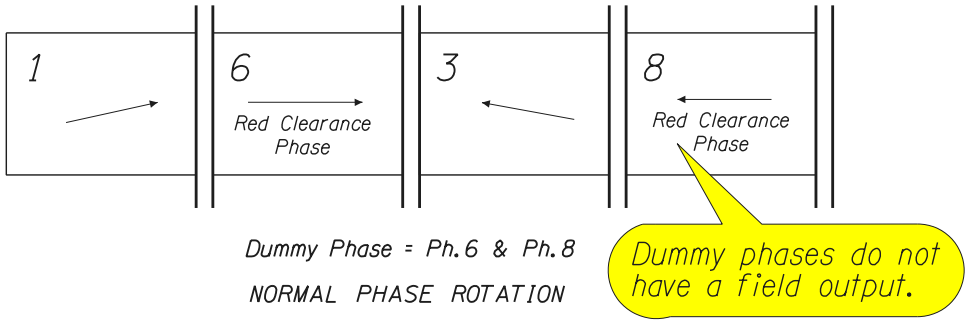


Figure 3-14 | Ring & Barrier Diagrams: Dummy Phases, Example 2



Note:
With current software, dummy phases may not be required to provide a red clearance interval (This phasing was used with older software that had limited red clearance timing, which necessitated a dummy phase in order to provide the proper amount of red clear time). Confirm with the Region Signal Timer.

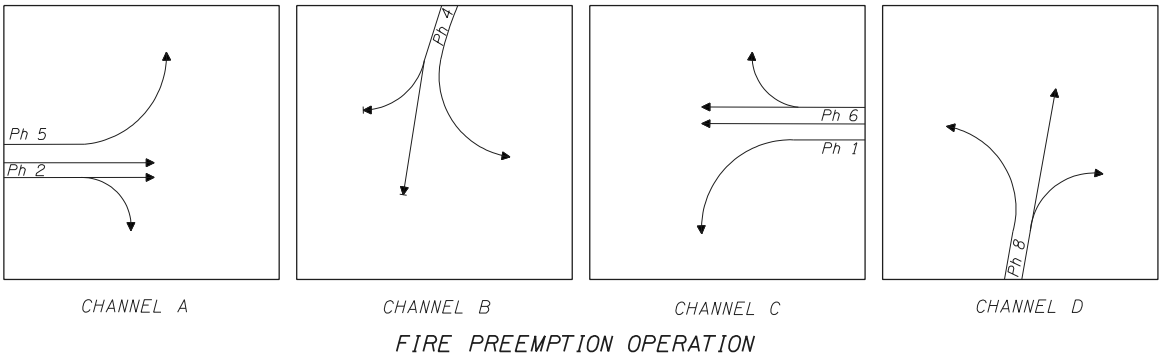
3.4 Emergency Preemption

When an emergency service provider is granted permission (by ODOT) to use emergency preemption, the traffic signals within the geographic area of service will require emergency preemption. The majority of ODOT signals are within areas requiring emergency preemption. To check if an area has permission to use emergency preemption, contact the Traffic Signal Operations Engineer.

Emergency preemption alters the normal phasing of the traffic signal to allow green indications for an emergency vehicle (typically fire or ambulance) approaching the intersection. This is shown on the signal plan sheet. Figure 3-15 below shows the standard channel assignments for fire preemption operation:

- Channel A = phase 2 & 5
- Channel B = phase 4 & 7
- Channel C = phase 6 & 1
- Channel D = phase 8 & 3

Figure 3-15 | Standard Fire Preemption Channel Assignments

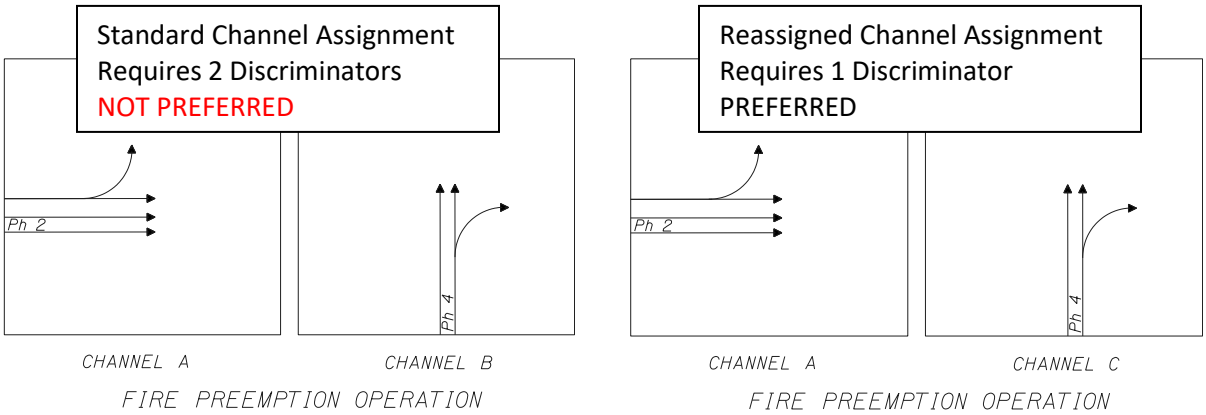


When reading a fire preemption operation diagram, all vehicular movements are drawn as solid lines, indicating that that movement is protected (no conflicting movements requiring the motorist to yield). Pedestrian phases are not serviced during preemption.

There are times when non-standard channel assignments are preferred, such as an intersection that requires use of only two channels. See Figure 3-16. This is due to the termination layout for the fire preemption discriminators located inside the controller cabinet. Each discriminator is able to monitor up to two channels. One discriminator is always used for Channels A & C, and one discriminator is always used for Channels B & D. To save the expense of installing two discriminators for only two channels (using the standard channel assignments), the phases assigned to the channels will be reassigned in the controller software, thus only requiring one discriminator. For example, if an intersection only had phase 2 and phase 4 (downtown, one-way grid system), channel A should be assigned to phase 2 and Channel C should be reassigned

to phase 4 (uses 1 discriminator) vs. Channel A being assigned to phase 2 and Channel B being assigned to phase 4 (standard channel assignment, uses 2 discriminators).

Figure 3-16 | Two Channel Fire Preemption Channel Assignments



3.5 Railroad Preemption

If a signalized intersection is located within 215 feet of a rail crossing, rail preemption is required. If a signal requires rail preemption, a Rail Crossing Order is needed. The rail crossing order will state specific design and operational requirements that must be met.

Rail preemption alters the normal phasing of the traffic signal to allow pedestrians to clear the intersection and vehicles to clear the tracks prior to the train arrival. This is the highest order of preemption and takes precedence over all other forms of preemption. See Chapter 16 for more in-depth discussion on rail preemption operation and how it is depicted on the plan sheets.

3.6 Transit Priority

In large metropolitan areas, there may be a need to accommodate transit priority on the traffic signal within the geographic area of service.

Transit priority does not have the ability to alter the normal phasing of the traffic. Instead, transit priority just alters the cycle of the normal phasing, typically by either extending or delaying green time for the appropriate approach to allow minimal to no delay for the transit vehicle. Because transit priority does not alter the normal phasing, the operation is NOT shown on the plan sheets (only contained within the signal timing sheets).

3.7 Crosswalk Closures

It is ODOT policy to provide pedestrian crossings for all approaches at a signalized intersection unless an engineering study and STRE approval deem a crosswalk closure is necessary. Often, the need to close a crosswalk is due to unusual roadway geometry, certain lane use (such as dual turn lanes), certain signal phasing (such as a single point urban interchange), and/or crash

history. Closing a crosswalk requires posting signs in a specific way. The details for this signing are typically shown on the signal plan. See the crosswalk section in Chapter 5 for more information.

3.8 Traffic Signal Communications

Closely spaced signals in a corridor typically require central or local communications for the signals to function in a coordinated manner or to use responsive/adaptive signal timing. When communications are required, either an interconnect plan or communication plan is needed. See the Chapter 7 for more information.

3.9 Other Unique Requirements

Other requirement may be listed on the operational approval, specific to the project. Some unique requirements in the Operational Approval include the following:

- Audible pedestrian signals
- Right turn slip lane control (yield, stop or signal control)
- Non-traversable medians/island to restrict/channel turn movements
- Advanced Flashing Beacons on signs
- U-turns

3.10 Examples of Operational Approvals

Several examples of operational approvals are included below for your reference.

Figure 3-17 | Example 1: STRE Approval

FILE

INTEROFFICE MEMO

TECHNICAL SERVICES
Traffic-Roadway Section
Office Phone: (503) 986-3568
Fax Phone: (503) 986-3749

DATE: April 6, 2012

TO: Dan Dorrell, P.E.
Region Traffic Operations Engineer

File Code: Hwy 25 MP 0.62

FROM: Bob Pappe, P.E., P.L.S.
State Traffic/Roadway Engineer

SUBJECT: **Traffic Signal Modification**
Redwood Highway (US199) at Ringuette Street
City of Grants Pass
Josephine County

We have reviewed your request to modify the traffic signal at the intersection of Redwood Highway at Ringuette Street. The modifications at this intersection are in response to a comprehensive mitigation strategy for the removal of the traffic signal at the intersection of Redwood Highway at Fairgrounds/Union Road. The requested signal modifications at Redwood Highway at Ringuette Street include:

1. Adding dual left turn lanes on the south approach by converting the existing center through lane to a through/left option lane.
2. Adding pedestrian crosswalk across the west approach, so that all pedestrian crossings will be provided.
3. U-Turns in both the east and west direction for all vehicles.

Under delegation order TSB-05, I approve this request. The approval is based on our review of the materials you submitted. The design and operation shall be according to requirements stated in the attached Approved Signal Operations Design.

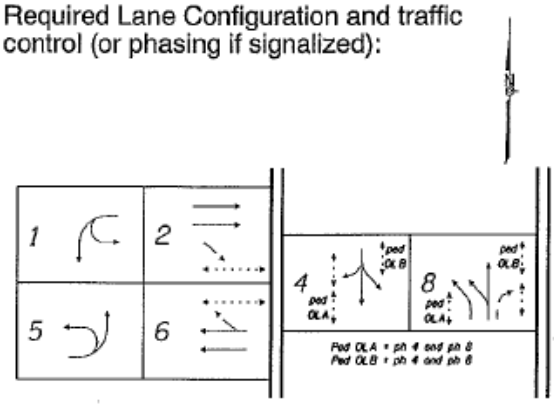
If you have any concerns or questions regarding this approval, please contact Doug Bish at 503-986-3594.

Attachment
KLJ/
Electronic Copies to:
Frank Reading, Reg. 3 Manager
Ron Hughes, Reg. 3 Interim Traffic Manager
Raymond Lapke, Region 3 Traffic
Mike Morris, Region 3 Tech Center
Mark Thompson, Region 3 Tech Center
Jason Sheadel, Region 3 Tech Center
Trenton Glick, Region 3 Traffic White City
William Fitzgerald, Region 3 White City Jerry Marmon, District 8 Manager
Scott Cramer, Traffic Standards

Approved Signal Operations Design

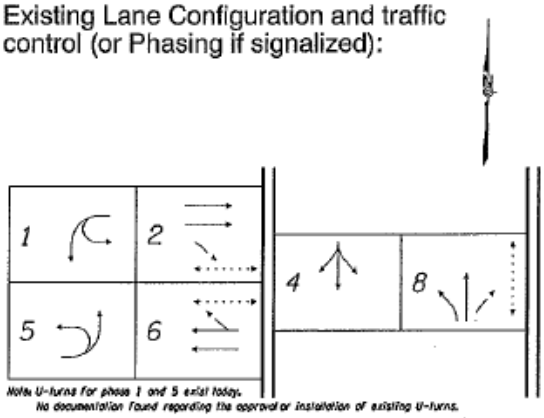
(See Engineering Report, STE Approval Letter, and/or RTE Approval Letter for more in-depth information)

Required Lane Configuration and traffic control (or phasing if signalized):



NORMAL PHASE ROTATION

Existing Lane Configuration and traffic control (or Phasing if signalized):



NORMAL PHASE ROTATION
Adopted from T.M.S. DWG NO. 12773

STE Approved Features, RTE Approved Features, and other Requirements:

1.) Dual left turn lanes on the south approach by converting the existing center lane through lane to a through/left option lane
2.) Adding a pedestrian crosswalk across the west approach, so that all pedestrian crossings will be provided
3.) Ringuette Street will continue to operate as split-phase
4.) U-turns in both the east and west direction for all vehicles.
5.) Modifications to intersection at Redwood Hwy at Fairgrounds/Union Road required as per the Approved Signal Operations Design for Redwood Hwy at Fairgrounds/Union Roads.

General Requirements:

1.) Lane configuration, phasing, and other requirements shall be designed according to this Approved Signal Operations Design.
2.) The design and operation will be according to the Manual on Uniform Traffic Control Devices (2009 Edition), ODOT's Traffic Signal Policy and Guidelines, and ODOT's Traffic Signal Design Manual.
3.) State Traffic Engineer's Office must approve the final signal design plans.

Location:	US199 @ Ringuette Street
Hwy Name & No.:	Redwood Hwy, No. 25
Mile point.:	0.62
County:	Josephine
City:	Grants Pass

DATE	INFORMATION / HISTORY	APPROVED BY
5/27/2011	Engineering study and RTE request for approval of U-turn	RTE
12/16/2011	Engineering study and RTE request for approval of dual left	RTE
12/16/2011	PSOD and RTE request for approval of west approach crosswalk	RTE
4/6/12	STE approval letter and ASOD	STE

Figure 3-18 | Example 2: STRE Approval - Preliminary Signal Operations Design (PSOD)

INTEROFFICE MEMO

TECHNICAL SERVICES
Traffic-Roadway Section
Office Phone: (503) 986-3568
Fax Phone: (503) 986-4063

DATE: June 28, 2011

TO: Dennis Mitchell, P.E.
Region 1 Traffic Engineer

File Code: Hwy 081 MP 2C4.45

FROM: for Bob Pappe, P.E., P.L.S.
State Traffic/Roadway Engineer

SUBJECT: **Traffic Signal Modification**
SE McLoughlin Blvd/SE Tacoma St NB Ramp Terminal
Pacific Highway East MP 2C4.45
City of Portland
Multnomah County

We have reviewed your request to modify the existing signal at the intersection of SE Tacoma Street at SE McLoughlin Boulevard. This project will add protective/permissive left turns on SE Tacoma Street and re-open the northbound approach to provide access to a proposed Park & Ride facility. Under the Letter of Delegated Authority, I approve this request.

This approval has the following conditions:

- The design and operation of the signal must adhere to the **Manual on Uniform Traffic Control Devices** (2009 edition), ODOT's **Traffic Signal Policy and Guidelines** and ODOT's **Traffic Signal Design Manual;**
- The lane configuration and signal phasing of the intersection shall be designed according to a signed Preliminary Signal Operations Design report provided by your office;
- Obtain an intergovernmental agreement with TriMet to mitigate the vehicle queue that extends from the Johnson Creek Boulevard/SE 32nd Avenue intersection to prevent 95th percentile from spilling into the SE Tacoma Street/SE McLoughlin Boulevard northbound ramp terminal.
- Obtain an intergovernmental agreement with the City of Portland to develop signal timing solutions that prevent vehicle queues from extending into the deceleration portion of the SE McLoughlin Boulevard exit ramps.
- This office must approve the final signal design plans. It is advised that this office be consulted throughout the design phase.

If you have concerns or questions regarding this approval, please contact Don Wence at 503-986-3576.

Electronic Courtesy Copies To:

Kate Freitag, Region 1 Traffic
Scott Cramer, Traffic Standards

MGK/tc

Preliminary Signal Operations Design

Use this form for projects involving new signals or significant modifications to an existing signal.

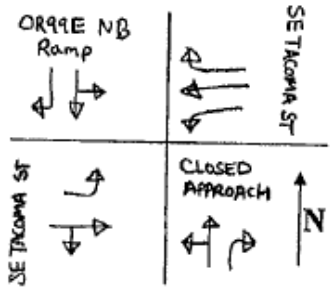
Location: SE Tacoma Street / SE McLoughlin Boulevard Northbound Ramp Terminal Hwy No: 091BQ M.P.: 2.64.45 Date: 10/9/2010

Existing Traffic Information

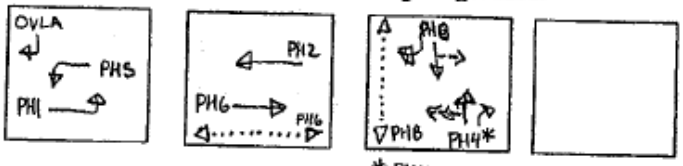
Existing Traffic Control

- ☐ 2-way STOP
- ☐ All-way STOP
- ☒ Signalized

Existing Lane Configuration



Existing Vehicle and Pedestrian Phasing if signalized:



* PH4 CURRENTLY DOES NOT OPERATE TODAY DUE TO THE CLOSED APPROACH

Opening Day Volumes (AM/PM)

RT (202/244) TH (0/0) LT (64/95)	RT (396/138) TH (533/420) LT (0/0)
(56/75) LT (324/685) TH (0/0) RT	(0/0) LT (0/0) TH (0/0) RT

Future Volumes (AM/PM)

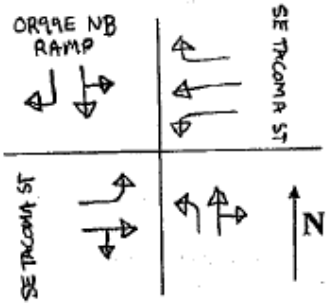
RT (NA/300) TH (NA/5) LT (NA/140)	RT (NA/150) TH (NA/520) LT (NA/20)
(NA/100) LT (NA/820) TH (NA/15) RT	(NA/110) LT (NA/5) TH (NA/50) RT

Other Relevant Information: TRI-MET IS REQUIRED TO MITIGATE THE SPILLBACK QUEUE FROM THE JOHNSON CREEK BLVD / SE 32ND AVE INTERSECTION TO OBTAIN MODIFICATION APPROVAL. SIGNAL TIMING PRIORITY FOR THIS SIGNAL IS GIVEN TO THE PREVENTION OF UNSAFE QUEUES ON OR99E MAINLINE AND OR99E RAMPS.

Preliminary Signal Operations Design

Recommended Signal Design

Recommended Lane Configuration



Pedestrian Crosswalks

☐ All Crosswalks Provided

☒ Following Crosswalks Closed: EAST AND NORTH LEGS

Other Required Features

☐ Signal interconnect to _____

☐ Phone drop or cellular network router

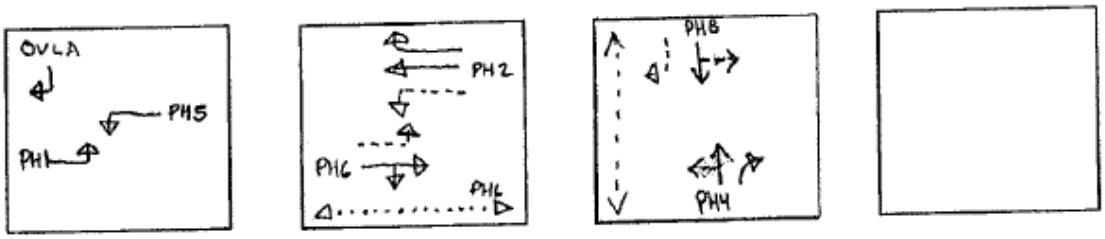
☐ 2070 Controller

☐ Audible/accessible pedestrian signals

☐ RR Pre-emption

☐ Other _____ _____

Recommended Phasing



Notes regarding right turn lane control: RIGHT-TURN ON RED IS PERMITTED FOR ALL APPROACHES PENDING INTERSECTION SIGHT DISTANCE ANALYSIS. THE SOUTHBOUND APPROACH RIGHT-TURN LANE HAS AN OVERLAP PHASE WITH THE EB APPROACH LEFT-TURN

Primary considerations used to determine left turn phasing: FLASHING YELLOW LEFT-TURN PHASING WILL NEED TO HAVE ATLEAST THE MINIMUM STOPPING SIGHT DISTANCE FOR THE DESIGN SPEED OF SE TACOMA STREET.

Design Vehicle info: (to be confirmed with Roadway Engineer) ☐ "Design for" ☒ "Accommodate"

☒ WB - 67 ☐ WB-50 ☐ other_____

Recommended by: Kathleen M. Freitag
Region Traffic Operations Engineer

Figure 3-19 | Example 3: RTE Approval - Preliminary Signal Operations Review (PSOR)

Preliminary Signal Operations Review

Use this form for projects involving only minor modifications or replacement-in-kind of existing signals.

Note to the Designers

Unless a Preliminary Signal Operations Design Report is needed, this form may be used to support the operational aspects of the signalized intersection. It should be completed prior to beginning design work on signal or detector plans. The form should be completed by the designer and signed by the Region Traffic Operations Engineer. The adequacy of existing operational elements (phasing, lane configuration, crosswalks, etc.) is documented by the completion of this form. Minor signal improvements may be specified on this form, but significant modifications (phasing changes, lane configuration changes, etc) are expected to necessitate the use of a Preliminary Signal Operations Design Report. Some geometric features such as curb lines and crosswalk locations can dramatically affect the layout of the signal appurtenances so these should be confirmed with the Region Traffic Operations Engineer as well as other Roadway engineers early in the design process. Failure to show that the necessary communications and decisions have been reached prior to submitting the plans for review may result in delays of approval or the return of plans without review.

Name of Intersection (Major Line): US-101

(Cross Street): Lewis St/Casino Entrance

ODOT Hwy. Number: 9 Mile Point: 236.26

The phasing and lane configurations proposed in these plans are believed to offer the most desirable operations given the project constraints. The Region Traffic Operations Engineer has reviewed the following operational elements of the proposed design and found them to be acceptable.

- Phasing and lane configuration
- Crosswalks (existing open or closed conditions)
- Overlap phasing
- Emergency vehicle and RR preemption systems
- ADA accommodations, i.e. audible pedestrian, ramp design, etc.

Minor changes to the existing signal operations include: Ø1+5 switched from protected to permissive/protected

Comments:

Signature of Region Traffic Operations Engineer

1-21-11
Date

prelim signal operations/review form.doc

Traffic Roadway Section
8/2010

4 STARTING THE DESIGN

4.1 Scoping

Scoping is the very first step to forming and funding projects. The formal scoping process involves multiple disciplines working together and requires the signal designer and signal operations staff to provide a detailed assessment of needs, requirements, risks, and associated cost estimate for all traffic signal work within the defined project limits. A Project Leader will coordinate the scoping effort and each Region will have specific processes and forms that should be used.

When scoping traffic signal work, the following guidance should be used:

- Note any Operational Approvals that are required
- Verify the condition rating of existing traffic signals (See Section 4.1.1)
    - Signals with a condition rating of less than 70% should be scoped for complete replacement.
    - Signals with a condition rating of 70% or greater may be scoped for modifications in lieu of complete replacement.
- Signal work that requires extensive modification (e.g. moving three out of four poles, replacing/rerouting majority of conduit, etc.) should be scoped for complete replacement regardless of the condition rating.
- Verify existing signals meet current statewide goals (see Section 4.1.2)
    - Signals that do not meet current statewide goals and priority improvements should be scoped to include every listed upgrade.

Scoping notes should clearly identify if any of the statewide goals listed in the table in Section 4.1.2 are needed for <u>any</u> of the signals in the project limits but will NOT be addressed by the project. When this occurs, notify the State Traffic Signal Engineer via e-mail with a link to the scoping notes so that this data can be tracked in the Traffic Signal Asset Management program.

Scoping for projects usually takes place several years before the DAP design work begins. As such, it is important to clearly document the design features, assumptions, and judgement used in the scoping notes to ensure they are useful for future reference. It is highly recommended to provide a basic sketch of the proposed design(s) or to clarify assumptions used (in addition to text only descriptions that are provided in the scoping notes). Sketches may not be necessary for all scoping projects, but they can help other disciplines better visualize how the traffic signal equipment impacts their features, improve the accuracy of the cost estimate, and convey design information more efficiently than text only. See Figure 4-1 and Figure 4-2.

Figure 4-1 | Scoping Sketch Example 1

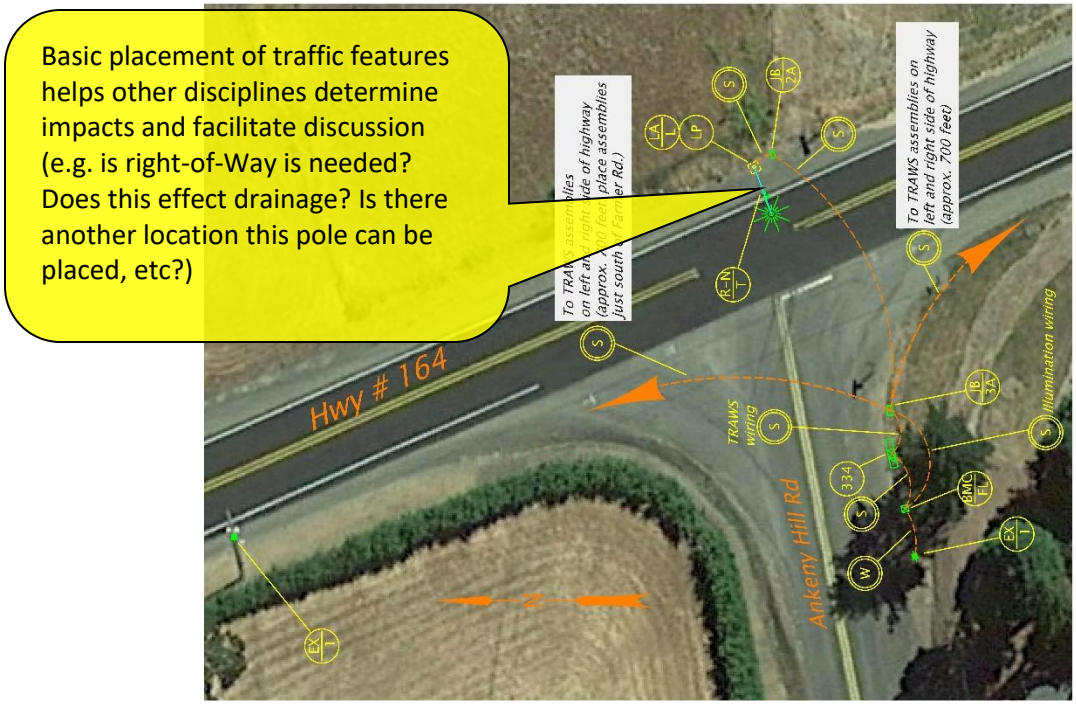
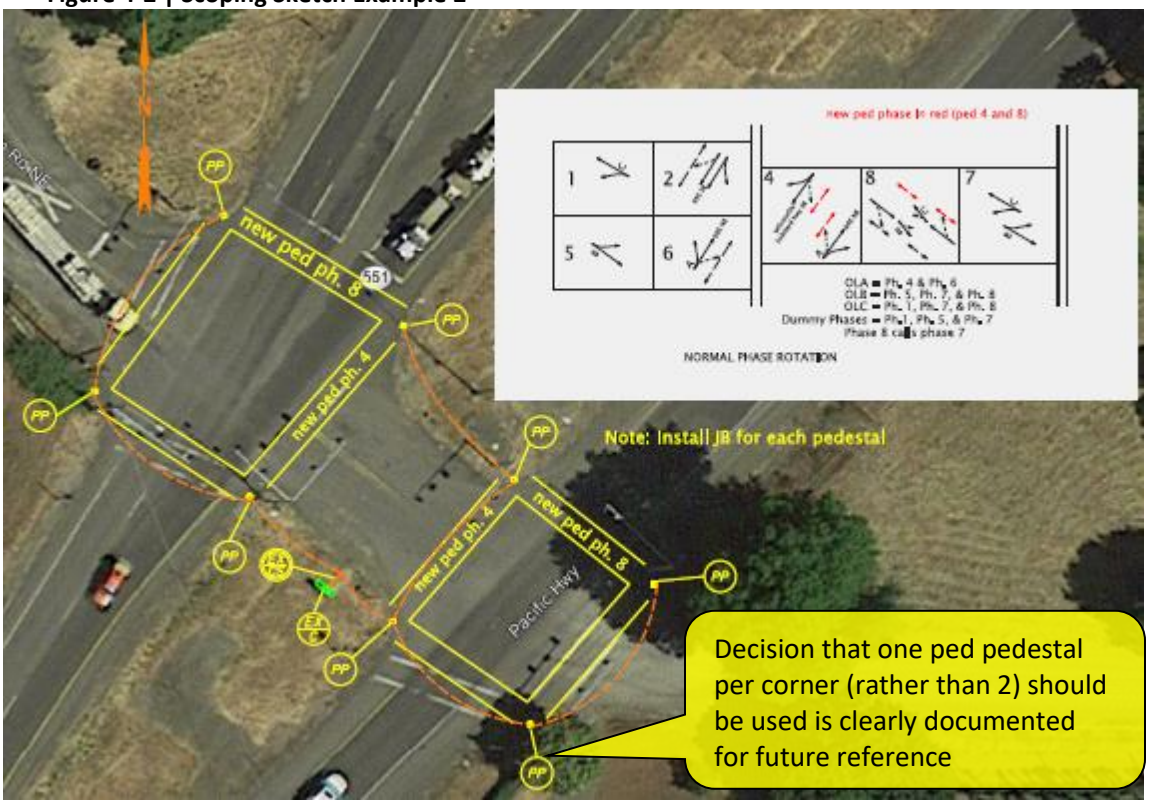


Figure 4-2 | Scoping Sketch Example 2



4.1.1 Traffic Signal Asset Management

The Traffic Standards Unit produced the first traffic signal condition report in 2017. This report is updated every year in September. It contains a condition rating for every ODOT owned or maintained traffic signal expressed as a percentage (from 0% to 100%) with three classification categories:

- Fair or Better (70% +)
- Poor (50-69%)
- Very Poor (49%)

You can find the condition reports on the ODOT Traffic Signal website: https://www.oregon.gov/ODOT/Engineering/Pages/Signals.aspx

4.1.2 Statewide Goals, Priority, and Implementation

Planning traffic signal upgrades and replacement requires consideration of many factors, such as crash data, operational data, annual maintenance costs, planning documents, etc. Completing all of the recommended upgrades listed in the table below in one project is desirable, but may not be possible due to limited funding. Therefore, each upgrade has been prioritized (High, Medium and Low), assigned a goal date for completion, given associated design impacts, and reasons for the goal to help assist in decision making. The Region Traffic Engineer/Manager should determine how the priorities are implemented and secure funding as necessary to meet the goal dates.

Statewide Goals			Goal Completion Date	Potential Design Impacts	Reason for Goal
High Priority	1	Change existing controller cabinet with a PDA1 to a 332S cabinet	2021	May require a signal rebuild to properly address all impacted features	Safety: PDA1 is fire hazard
	2	Change existing controller (170, 2070, etc.) to an ATC controller	2022	N/A	Safety and operations: 170 and 2070 controller software is unsupported and unmaintainable
	3	Change existing "words" or non-countdown pedestrian signals to countdown LED modules	2032*	Likely to require a signal rebuild to address ADA issues	Safety: FHWA Crash Reduction Countermeasure
	4	Replace existing loop detection with non-invasive detection (radar or video)	2030	May require a signal rebuild to address conduit issues	Safety and operations: See Chapter 6 & FHWA Every Day Counts 4 Initiative (ATSPM)
	5	Replace existing copper interconnect with fiber optic and install network communication	2030	May require a signal rebuild to address conduit issues	Safety and operations: FHWA Every Day Counts 4 Initiative (ATSPM)
	6	When required, install Type 7 signal heads at railroad interconnected signals	2025	May require a signal rebuild to address structural issues	Safety: clears the RxR tracks faster during a preemption
	7	Change existing 8" lens vehicle signals to 12" lens	2030	May require a signal rebuild to address structural issues	Safety: FHWA Crash Reduction Countermeasure
	8	Add backplates or change existing backplates to reflectorized backplates for the vehicle signals	2030	May require a signal rebuild to address structural issues	Safety: FHWA Crash Reduction Countermeasure
Medium Priority	9	Change existing ¼" pushbuttons and H-frame to standard mounts & buttons	2032	Likely to require a signal rebuild to address ADA issues	Accessibility and uniformity
	10	Change existing controller cabinet (336, 336S, 337) to a 332S cabinet	2030	May require a signal rebuild to properly address all impacted features	Operations, uniformity, and lower maintenance costs (less labor, less materials)
	11	Condition rating of signal is 70% or greater	2055	May require a signal rebuild depending on deficiencies	Lower maintenance costs (less labor, less materials)
Low Priority	12	Replace 4 bolt base vehicle signal poles (mast arm and strain poles) with 8 bolt mast arm poles. Note: strain poles no longer an option for permanent traffic signals due to new 75' mast arm length.	2055	Likely to require a signal rebuild to address all poles at an intersection	Lower maintenance costs (less labor, less materials)
	13	Change existing power service (RPS & service/meter base mounted to poles, etc.) to BMC/BMCL service	2050	May require a signal rebuild to properly address all impacted features	Lower maintenance costs (less labor, less materials)
	14	Install battery back-up at railroad interconnected traffic signals	2030	May require a new controller cabinet, which then may require a signal rebuild to address all impacted features	Safety: allows preemption sequence to occur during a power outage (note: power outage of an extended duration is historically a very low risk).

*Note: the MUTCD Table I-2 specifies a 2013 compliance date

4.2 Starting the DAP Design

Before starting the design, follow the simple check-list below. Design work should not begin until every item on the check list is complete. Starting a design with incomplete check-list items usually results in wasted time through unnecessary rework.

- Operational Approval is complete (See Chapter 3),
- Standards applied to the project are known (See Section 4.3), and
- Applicable background information has been compiled (See Sections 4.4 through 4.5)

The signal designer should also take a few moments to plan out what design work will be required:

- Will there be any unique details that are not covered in the Standard Drawings? The most current standard drawings (updated every 6 months in January and July) should be reviewed for any changes that may affect the design. If unique details are anticipated, these details will need to be included in plan set. See Chapter 9 and Chapter 18 for more information.
- Will any existing signal equipment need to be removed? If equipment will be permanently removed, where will ODOT want that equipment stockpiled? Check with the Region Electricians.
- Will a temporary signal be needed for any stage of construction? Existing signals need to remain in service until the re-built signal is turned on and certain lane use configurations should not be open to traffic unless they have proper signalized control (e.g. dual turn lanes). Check with the Roadway Designer and Workzone Traffic Control Designer. See Chapter 11 for more information.

4.3 What Standards Will Be Used?

This question MUST be answered before starting the design and specifications. Failure to determine which standards will be used could result in complete failure of the project. In extreme cases, plans and specification will not be approved for construction and the entire project might be terminated. Every traffic signal within the state of Oregon, regardless of jurisdiction, is required to meet the minimum standards as stated in current, adopted editions of the Manual on Uniform Traffic Control Devices (MUTCD), the Oregon Supplement to the MUTCD, and the National Electric Code. There are levels of standards that apply to signal design:

- **Full ODOT design standards and specifications**
  This is typically required for any project on the State Highway System. If ODOT will maintain and operate the traffic signal this is always the case. Full ODOT standard consists of the ODOT Traffic Signal Design Manual, the ODOT Traffic Signal Drafting Manual, and the ODOT Traffic Signal Policy and Guidelines.

- **Partial ODOT design standards and specifications**
  This is typically allowed if a Local Agency will maintain and operate the traffic signal on the State Highway for ODOT. This is also the case where ODOT will maintain and operate a traffic signal owned by a Local Agency. The portions of the design and specifications that are not full ODOT standard are negotiated in the Inter-Governmental Agreement (IGA) or directly with the Traffic-Roadway Section during the Design Approval Process. Generally the variance to ODOT Standards is minor, such as the use of interior illuminated lane use signs.

- **Full Local Agency design standards and specifications**
  This standard only applies to local agency owned and maintained traffic signals. As stated above, if the local agency will maintain and operate an ODOT owned traffic signal then some of the local agency standards might be allowed through negotiation.

4.4 Intergovernmental Agreements (IGA) and Jurisdictional Transfers

An Intergovernmental Agreement (IGA) is a legally binding document that defines the obligations of each party involved in a project. An IGA is typically needed for a state highway intersection with a local county road or city street. Depending on the scope and nature of the project there could be a lot of responsibilities to define, some of which have a direct impact on the design of traffic signal, for example; Maintenance responsibility (what design standards should be used), signal timing responsibility (what type of controller and type of detection should be used), and aesthetics (what decorative treatments are to be used).

Jurisdictional transfers allow agencies to legally redefine who has ownership of the roadway (typically changing from ODOT owned to local agency owned). They are rare, but if one is being considered on the project, it is imperative that Jurisdictional Transfer Agreement is complete and final prior to any design work. The fundamental question of what design standard should be used cannot be answered until then.

Unfortunately, the IGA or the jurisdictional transfer is sometimes processed simultaneously with the design the traffic signal. If this is the case, it is highly recommended that the signal is designed according the applicable standards that CURRENTLY apply, not to the standards that are ANTICIPATED. It is VERY risky to design according the anticipated standards, as past history has shown IGAs and especially jurisdictional transfers often do not go forward as expected given the many negotiated factors and political nature. Also, the Traffic-Roadway Section review and design approval process becomes more onerous and may cause delays to the project due to the uncertainty of the proper standard that should be applied.

Designing a signal according to anticipated standards is risky. This will result in wasted time and effort should the IGA or Jurisdictional Transfer fall through.

4.5 Background Information to Gather

4.5.1 As-Built Drawing Archive (Filenet)

As-built plan sheets should be downloaded from the internet at the Traffic Signal Standards Website under "Drawing Archive". There is also a "Getting Started Guide" for help in using the database.

http://www.oregon.gov/ODOT/Engineering/Pages/Signals.aspx

When searching for drawings, it is often best to search with the Highway Number. Also, leave the search as generic as possible (while still specific enough to return less than 200 entries). This is because many of the more specific fields are not consistently populated for all intersections entered in the database. Searching these specific fields may result in missing certain drawings.

4.5.2 Electronic Information

Prior to the field verification discussed in Section 4.5.3 below, it is good to get familiar with the project area using the available electronic sources of information: ODOT digital video log and Google/Bing maps. This can help the signal designer zero in on issues/questions to address during the field verification, resulting in an efficient use of time when on-site. Note that ODOT uses a unique numbering system for all the highways; use the Cross-Reference Guide link below to find the ODOT highway number.

ODOT Highway Number Cross-Reference Guide:
http://www.oregon.gov/ODOT/Data/Documents/Routes-to-Highway-Cross-Reference-Table.pdf

ODOT Digital Video Log: http://www.oregon.gov/ODOT/Data/Pages/index.aspx

4.5.3 Field Verification

Field verification is the one of the most important steps in the process of designing a traffic signal or signal modification and should not be skipped. Thousands or tens of thousands of dollars can be saved during the construction phase of the project by simply making a field visit during the design phase and verifying the existing conditions. Seeing the actual site with you own eyes is more valuable than just looking at photos or a base map because photos and drawings only

provide limited perspective and can be incomplete or misleading.

A field visit is ALWAYS cost effective and well worth the effort. At least one field visit should be done during the design phase.

When conducting the field visit, bring a camera and take a lot of photos. These photos will be very helpful throughout the design and construction support phase the project. If in doubt, take a photo; something that seems insignificant now may prove to be extremely useful in the future (it may save an additional trip in the field to re-verify or might be useful data in resolving a construction claim). Some tips for taking good photos (depending on the scope and nature the project, some may not apply):

- Take photos of the same area from different perspectives
- Get specific, micro detail photos – inside of junction boxes (conduits and wire), inside the controller cabinet (front and back), existing signal equipment and attachments.
- Get "bigger picture" photos – each approach (approximately 500' feet back from the intersection), each quadrant of the intersection, slopes, utility locations (the ones that are visible)

Measurements can also be very helpful, especially if the project has limited or no survey information (depending on the scope and nature of the project, some may not apply):

- Existing conduit sizes and number of wires (these measurement are critical if attempting to re-use them or add additional wire)
- Push button and pedestrian head mounting heights (if the project will be adjusting or adding ADA ramps)
- Sight distance measurements

Other useful information to gather in the field includes:

- Posted speed in the vicinity
- Location and nature of any accesses/streets that are close by
- Potential locations for all of the signal hardware (poles, pedestals, & cabinets)
- Power source location (typically nearest transformer)
- The driver's perspective – drive each approach, note any sight distance issues (depending on the time of year, vegetation may block sight distance when leaves return).
- Information on the signal pole

4.6 Background Information from Others

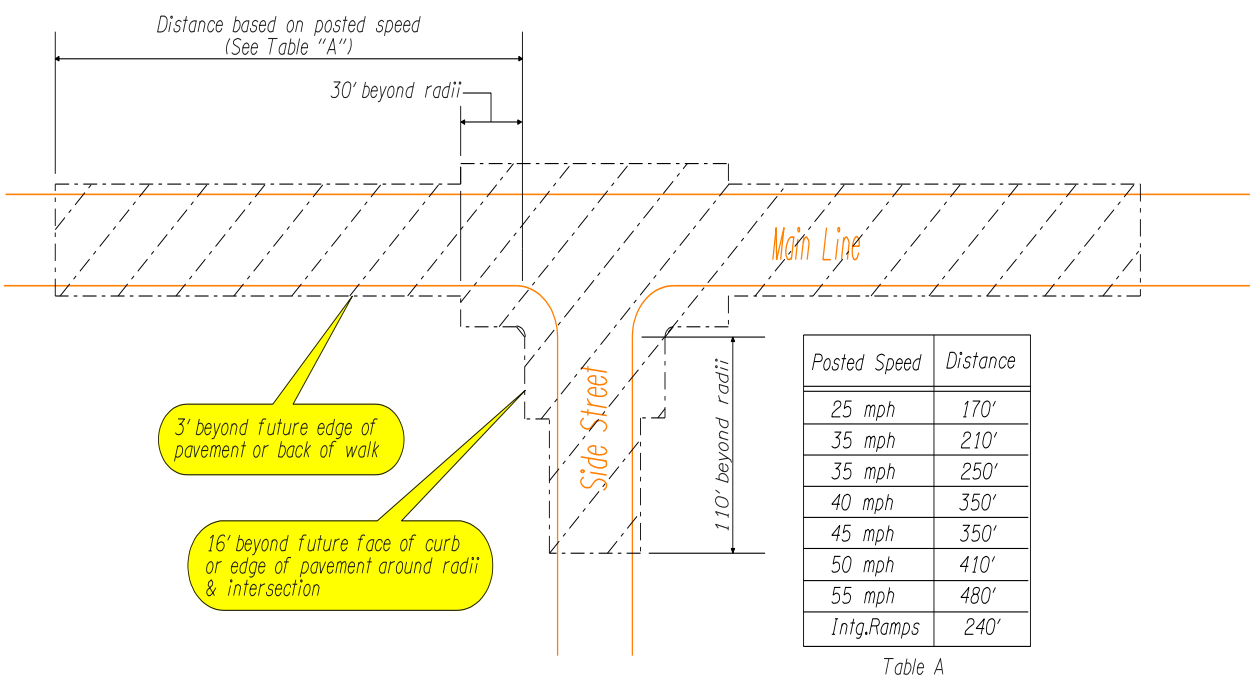
4.6.1 Base Map and Survey Information

Survey data is needed on most projects. To determine the amount and type of survey needed, the scope of the design must be defined. Below are a few examples:

- Replacement of existing loops – Typically as-built plans and field visit are all that is needed.
- Rebuild of detection system – Typically as-built plans and field visit are all that is needed. If utilities appear to be an issue a simple survey is needed.
- Installation of pedestrian signal poles, vehicle pedestals, controller cabinets, service cabinets – A simple survey is needed
- Installation of SM or STP poles – Full survey is needed with geotechnical report

Figure 4-3 below shows the recommended minimums for a survey within the intersection area. If the intersection has not yet been surveyed or additional information is required, this figure will help guide you in getting the necessary data.

Figure 4-3 | Survey Needs For Typical Traffic Signal



Posted Speed	Distance
25 mph	170'
35 mph	210'
35 mph	250'
40 mph	350'
45 mph	350'
50 mph	410'
55 mph	480'
Intg.Ramps	240'

Data to collect within the survey area shown in Figure 4-3:

- Underground utilities less than 18’ deep in the 16’ wide survey areas around the radii (pole foundation conflicts)
- Underground utilities less than 3’ down in the 3’ wide survey areas beyond edge of pavement or back of walk (conduit and junction box conflicts)
- Above ground utilities and wire attachment heights in 16’ wide survey areas around the radii (mast arm and span wire conflicts)
- Power poles with transformers (potential power source). Note: this may be located outside of survey area
- All Striping within survey area: lane lines, centerline, fog lines, crosswalks, stop bars, legends
- Any existing signal features within survey area: controller cabinet, poles, junction boxes, loops, etc.

4.6.2 Roadway Design

If the project is rebuilding the roadway, then there will be a roadway design base map. It is critical that the signal design is based on what will be built in the field. The Signal Designer must communicate with the Roadway Designer from the start of design through final plans and specifications. Since the Roadway Designer’s final product is the base for the Signal Designer to start their design, it is easy to see using outdated roadway base maps will result in total failure of the traffic signal design.

4.6.3 Geotechnical Report

If new SM or STP poles are proposed, then a geotechnical report is required to determine the foundation depths. Standard loading, not actual loading, is shown in the Standard Drawings for the poles and is what is used to determine foundation depth.

As soon as the pole locations are defined, contact the Region Geo/Hydro Manager for a foundation investigation of the proposed site. This information will need to be incorporated into the pole entrance chart for the pole foundations.

4.6.4 Utility Hook-ups

New signals require a connection to commercial power and may require other connections (e.g. telephone). Or the project may involve moving existing utilities. The signal designer must coordinate with the Region Utility Specialist when locating the power supply and any other utility connections as early as possible in the design process.

4.6.5 Rail Crossing Order

If a rail crossing order is required for an intersection, it will be processed simultaneously with the design the traffic signal. The final Rail Crossing Order will be issued prior to letting the project. The signal designer will provide a sealed Railroad Preemption Plan

Sheet during the early stages of the design (DAP or Preliminary Plans) for inclusion into the Rail Crossing Order. See Chapter 16 for more detailed information.

4.7 Signal Design Project File

A project file for the signal designer's personal use should be created and maintained for the project in ProjectWise. It should contain all of the supporting documentation, calculations and major decisions related to the traffic signal design and construction. The items listed below, if applicable, are typically included in the signals file:

- Project narratives
- Operational Approval letters
- Photometric Data for Illumination
- Calculations for:
  - Wire size
  - Wire fill
  - J-Box Size
  - Wire count
  - "AH" for strain poles
- Cost estimates (itemized breakdown for each bid item, total bid item cost, and anticipated item cost)
- E-mails and memos concerning design decisions
- Photos
- Field verification information
- Geotechnical report
- Rail crossing order
- Pole submittals and shop drawings
- Manufacturer's cut sheet or submittals
- Correspondence between project managers, consultants or contractors
- Existing as-builts

Other documentation related to signals, such as special provision boiler plates, review comments and their resolution, etc. will be also created and maintained in ProjectWise, but will not be stored in the signals file. They will be stored in the appropriate file as designated by the ProjectWise standards.

Good record keeping can save time and effort when issues/questions arise during the design, construction, or even maintenance phase.

5 SIGNAL PLAN

This chapter will discuss all the design elements that are shown on a sign plan sheet, in order of the recommended process for designing a new traffic signal.

There are many ways to build a traffic signal. In this chapter, there is flexibility for some design elements based on the Region Electrical Crew preferences. It is critical to coordinate with the Electrical Crew during the design phase to ensure maintenance concerns are addressed and documented. To accomplish this, download the Electrical Crew Preferences Form from Chapter 24 and follow the directions.

5.1 Roadway Design

The signal design work starts with the roadway base map and geometric design. It is important to review the roadway geometric design and work with the roadway designer early on in the process, as fundamental roadway features such as the number of lanes, the lane use, horizontal/vertical alignment, and the crosswalk ramp locations all have a direct impact on how the signal will be built.

If the scope of the project is minor, such as changing from protected only left turn phasing to protected/permitted phasing, there likely won't be a roadway base map or survey data to work from. In these cases, you will need to work from the most current as-built plan sheet. Of course, field verification is essential when working only from an as-built drawing.

5.1.1 Number of Lanes and Lane use

The Operational Approval for the traffic signal will show the required number of lanes, lane use, and signal phasing. The roadway design must match what is shown in the Operational Approval. Any discrepancy between the roadway design and the Operational Approval must be resolved, either by amending the Operational Approval (typically requires an additional engineering study) or by correcting the roadway design.

5.1.2 Pedestrian Crosswalks Closures

The Operation Approval for the traffic signal will indicate where the signalized pedestrian crossings are located and will identify any crosswalk closures. Crosswalk closures will normally be approved in a separate approval letter where the requirements for closure treatments will be specified. Closure treatments will normally be required in both visual and detectable formats. Sign OR 22-7 is the standard visual treatment for a crosswalk closure; this sign will nearly always be required at crosswalk closure at a signalized intersection. The crosswalk closure support shown in Standard Drawing TM240 is a typical treatment to meet the requirements for a detectable barrier, but other treatments may be used such as a buffer strip, a railing, or bollards with chains. A detectable barrier will nearly always be required when there is a sidewalk

at a closed crosswalk. See the Traffic Manual for additional information on crosswalk closures.

Crosswalk closure supports (TM240) and "CROSSWALK CLOSED" signs (OR22-7) used at signalized intersections are typical shown on the signal plan sheet, NOT on the signing plan sheet. Crosswalk closure supports are no longer included in the traffic signal lump sum bid item; use bid item in specification 00902 (see Chapter 19).

It is likely that a project will also include crosswalk closure supports for unsignalized intersections. These are typically shown on the signing plan sheet and will use the same 00902 specification and bid item. Coordinate with the sign designer to determine the EOR for the 00902 specifications and ensure the bid item quantity is correct.

Verify that all crosswalk closures (even existing closed crosswalks) have been approved by the State Traffic-Roadway Engineer. If there is no documented Operations Approval for the closure, either the crosswalk must be opened OR a request for closure will need to be submitted by Region Traffic.

Follow the requirements stated in the crosswalk closure Operational Approval! If these requirements are not met, the crosswalk closure will not pass ADA inspection.

5.1.3 Selecting & Locating Pedestrian Ramps for Proper Crosswalk Alignment

Each signalized crosswalk shall:

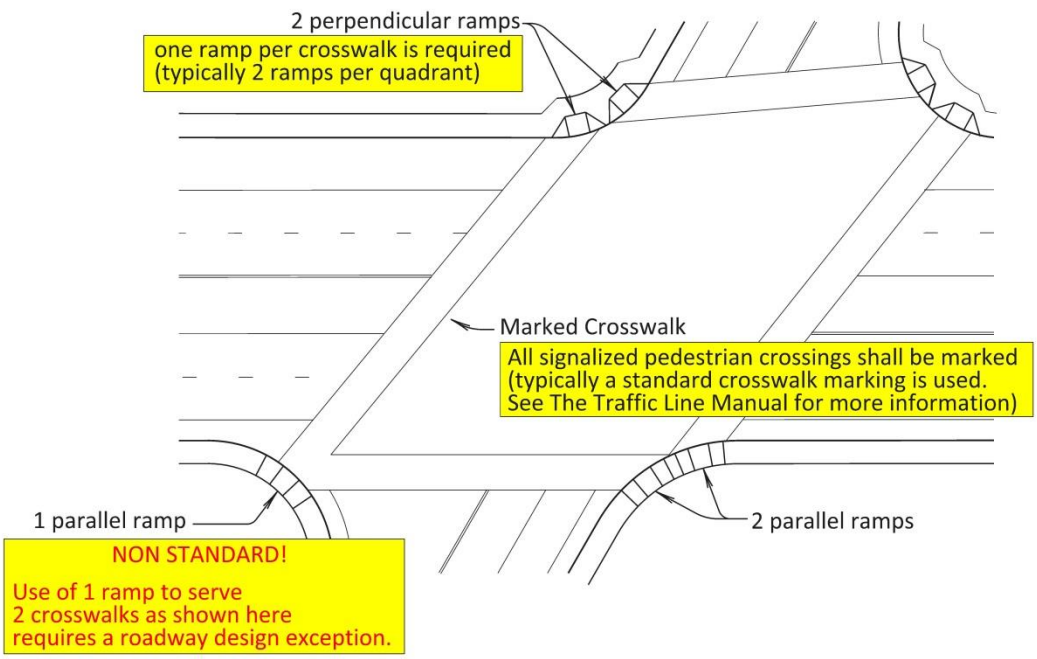
- Be marked with appropriate crosswalk pavement markings as per the ODOT Traffic Line Manual.
- Have a separate curb ramp at each end of the crosswalk if sidewalk is present. If no sidewalk is present, (i.e. rural locations and interchange ramps), a level landing area in lieu of curb ramps should be used. **Note that a Roadway Design Exception is required if a single curb ramp is used for more than 1 crosswalk.**

When locating ramps and crosswalks, consult the latest Roadway Section Standard Drawings for current sidewalk ramp configurations and discuss with the roadway designer. The roadway designer is responsible for the ramp design, but the signal designer should be involved in the selection and placement of the ramps as the following signal design features are dependent on ramp type and placement:

- Crosswalk alignment and stopping location for vehicles (affects line of sight, signal timing parameters, and detection system)
- Location of signal poles
- Location of signal pedestals
- Location of pushbuttons

Figure 5-1 shows the standard requirements of ramp installation.

Figure 5-1 | Standard Ramp Requirements for Signalized intersection



There are two main objectives for proper crosswalk alignment:

1. To maximize the visibility of the pedestrian and maintain a good line of sight between the pedestrian and the motorist. The way to accomplish this is to move the crosswalk as close to intersection as possible (as opposed to crosswalk located beyond the intersection radii). Figure 5-2 illustrates this crosswalk placement. This configuration should be used if the signal timing plan can accommodate the longer crossing time without resulting in unacceptable delay.

2. To reduce the amount of exposure the pedestrian has in the intersection. The way to accomplish this is to place the crosswalk perpendicular to the travel lanes, resulting in the shortest path for the pedestrian and the most efficient signal timing. Figure 5-3 illustrates crosswalks this crosswalk placement. Having the shortest path is a very important consideration when the traffic signal is interconnected to a rail crossing, as it may not be feasible or cost prohibitive to obtain extra seconds from the rail equipment to accommodate the Pedestrian Clear Out Interval (PCOI). However, this configuration does not really meet the first objective (especially for the side street right turning vehicles which will be able to pick up quite a bit of speed before the crosswalk).

As Figure 5-2 and Figure 5-3 illustrate, these two objectives will often times be in conflict with each other and the benefits of having crosswalks pulled into the intersection will need to be balanced with the path of the crosswalk. Figure 5-4 is a good compromise if the pedestrian crosswalk timing has a large impact on the effectiveness of the signal timing plan (typically in a highly congested corridor with system timing and a high frequency of pedestrian phase activations) and line of sight to the pedestrian can be maintained. Coordinate with Region Traffic concerning the needs of the pedestrian signal timing.

Selection and placement of ramps shall be done with the assistance of the roadway designer to determine the ramp type that best addresses all ADA and geometric design issues, while still addressing the signal design needs.

Figure 5-2 | Crosswalk Example 1

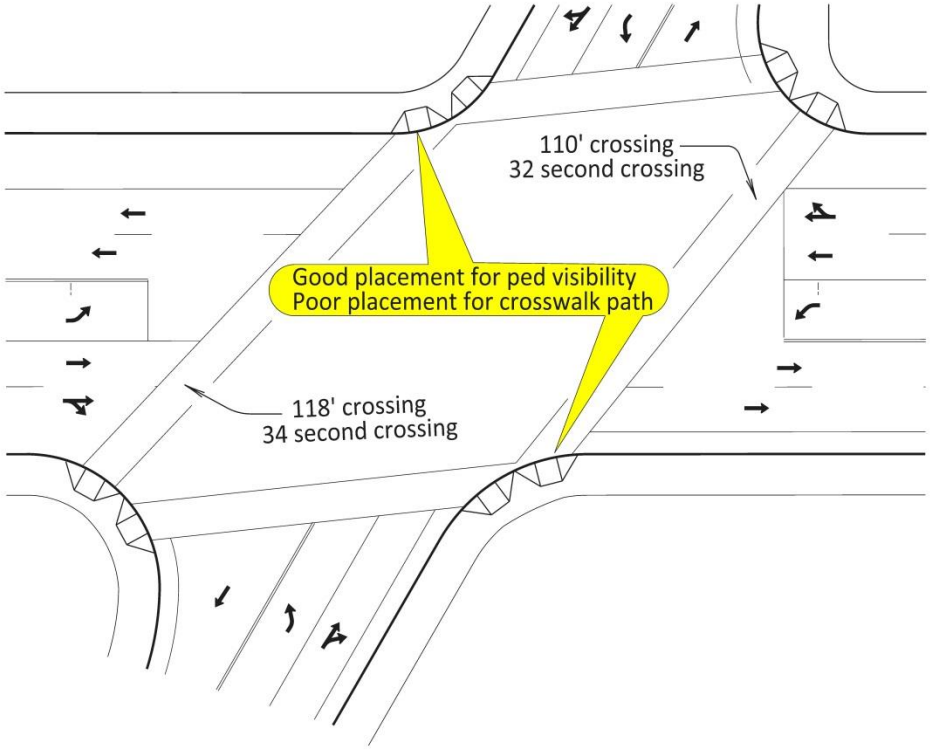


Figure 5-3 | Crosswalk Example 2

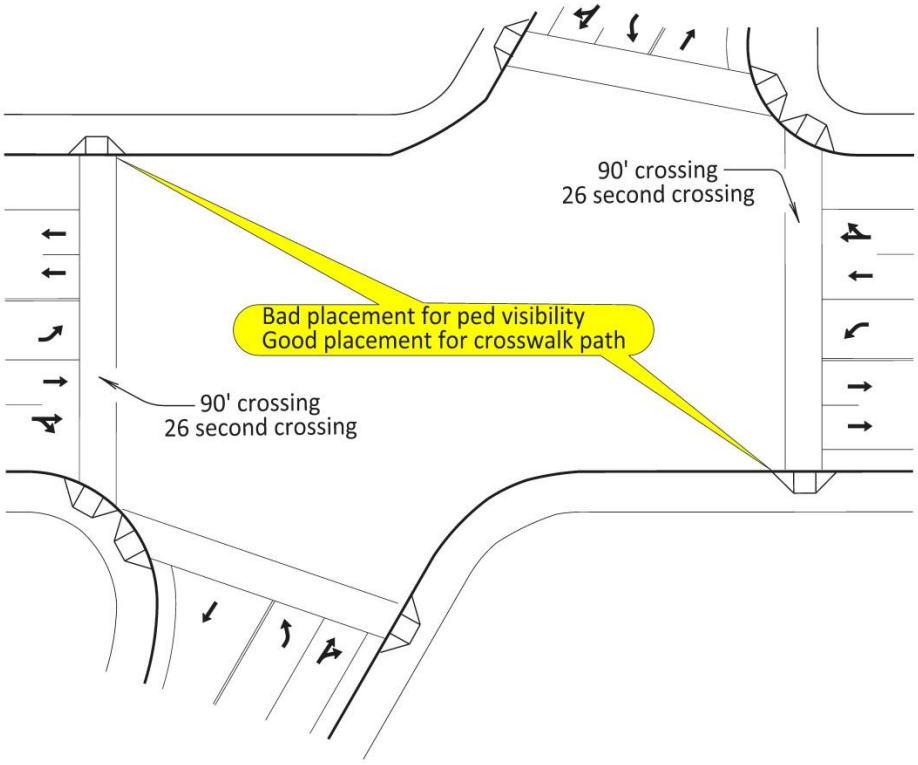
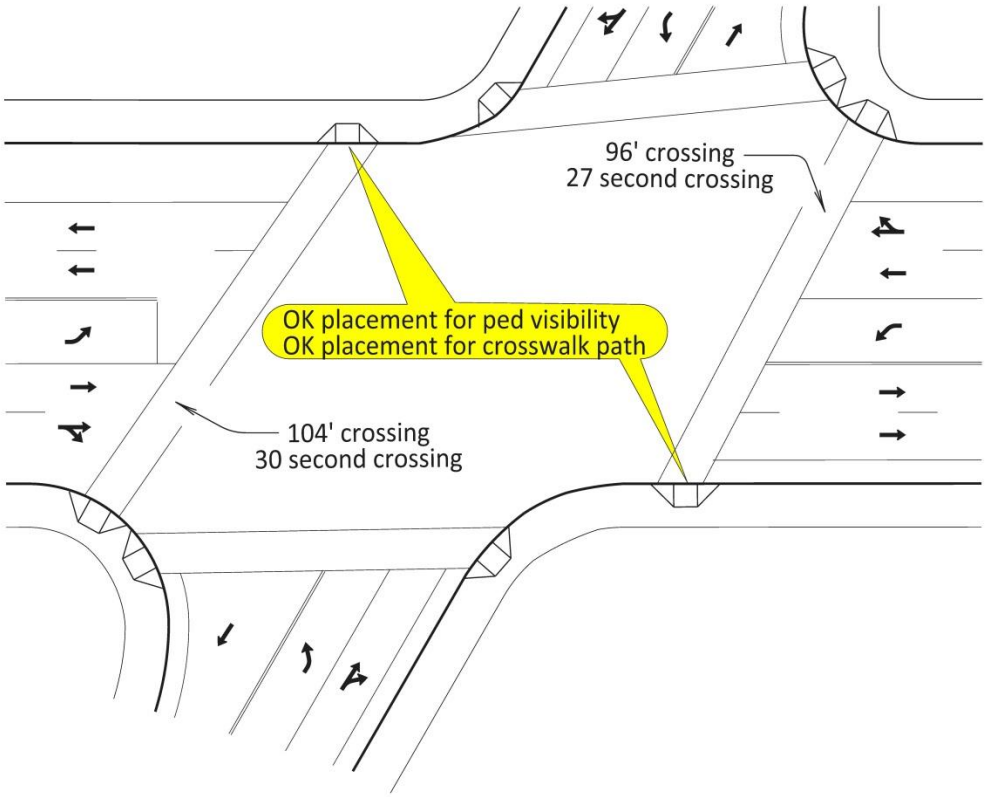


Figure 5-4 | Crosswalk Example 3



5.1.4 Signal Pole, Pedestal, and Pushbutton Posts

As per Technical bulletin RD17-01(B), ADA sidewalk curb ramp detail – minimum requirements in construction plans, Roadway Designers are required to show full detail of each ramp in the contract plans. This includes showing the exact location and critical elevations for signal poles, pedestrian pedestals, pushbutton posts and pushbutton locations. See Roadway Standard Details DET1720 and DET1721 for examples of ramp details. The Signal Designer will need to work closely with the Roadway Designer during ramp design, following the guidance in Section 5.4 to provide accurate pole and pedestal locations. The signal plan sheets should reference the ramp detail plan sheets.

5.1.5 Raised Median Islands and Crosswalk Alignment

Raised median islands are recommended by the ODOT Highway Design Manual and Oregon Highway Plan based on the highway classification (i.e. Statewide NHS routes) and to address certain safety, operational, and access concerns. The type of end treatment for the median island at signalized intersections should be carefully considered as it directly impacts the design of the pedestrian equipment (pushbuttons and pedestrian indication requirements) and signal phasing (number of pedestrian phases and potential phase restrictions due to truck turning radii).

Two-Phase Pedestrian Crossing

If a two-phase pedestrian crossing is required (according to the operational approval) the crosswalk configuration should be staggered with enough distance such that each phase of the pedestrian crossing is clearly defined. The pedestrian indications for the first phase of the crossing should not be visible to pedestrians using the second phase of the crossing (and vise-versa). See Figure 5-5 and Figure 5-6. This eliminates the potential confusion of which signal indication pertains to which crossing and the pedestrian crossing on an incorrect indication. Louvers and programmed heads are not an option for pedestrian indications. Count down heads can eliminate the confusion associated with non-staggered two-phase crossings (if the time for each of the two-phases is the same), but non-staggered two-phase crossings should be avoided when possible. Pushbuttons for each phase should also be separated and clearly indicate which crossing they apply to, preferably located on the same pedestal as the applicable pedestrian indication.

Figure 5-5 | Two-Phase Pedestrian Crossing (Staggered Crosswalk Alignment) Example 1

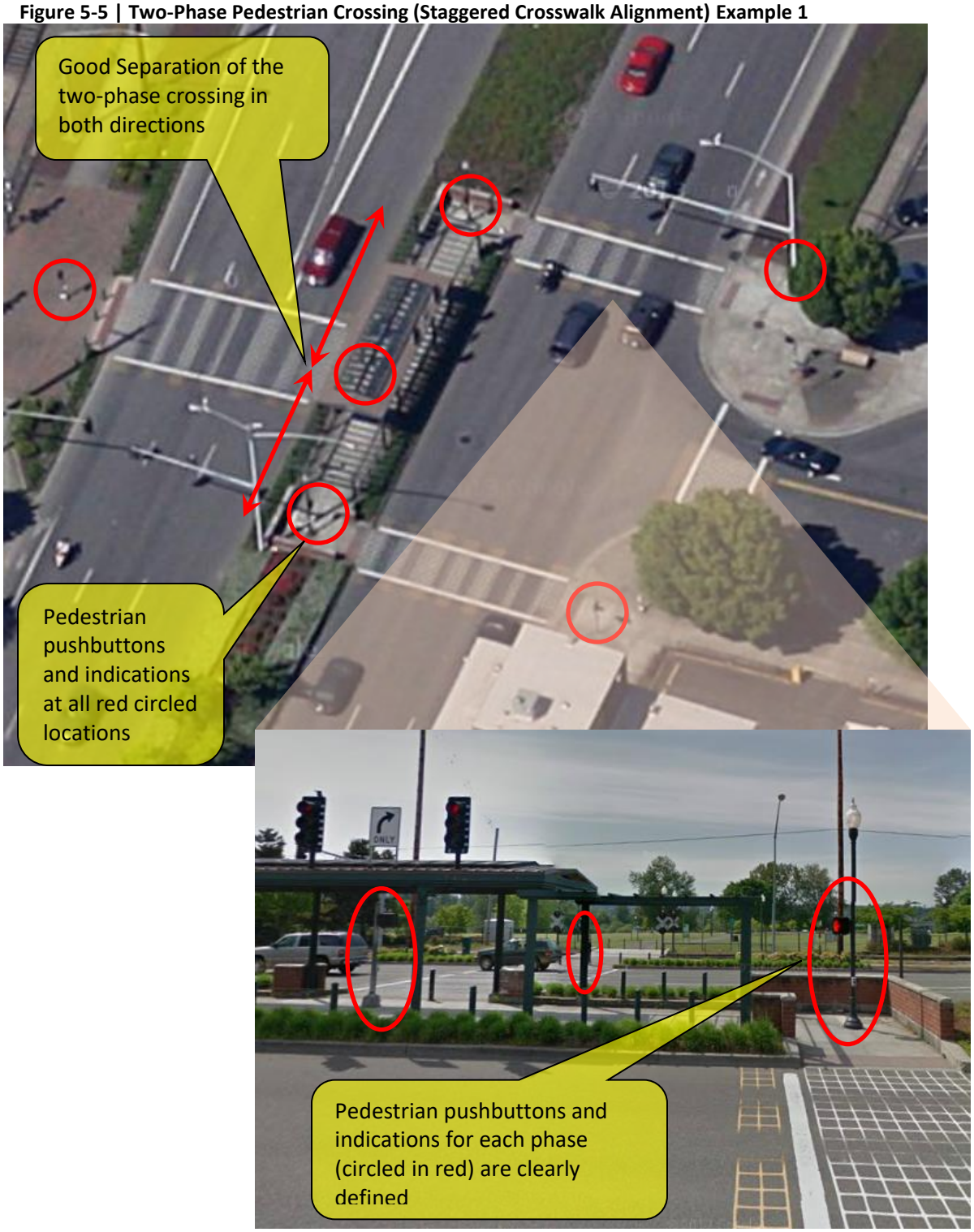
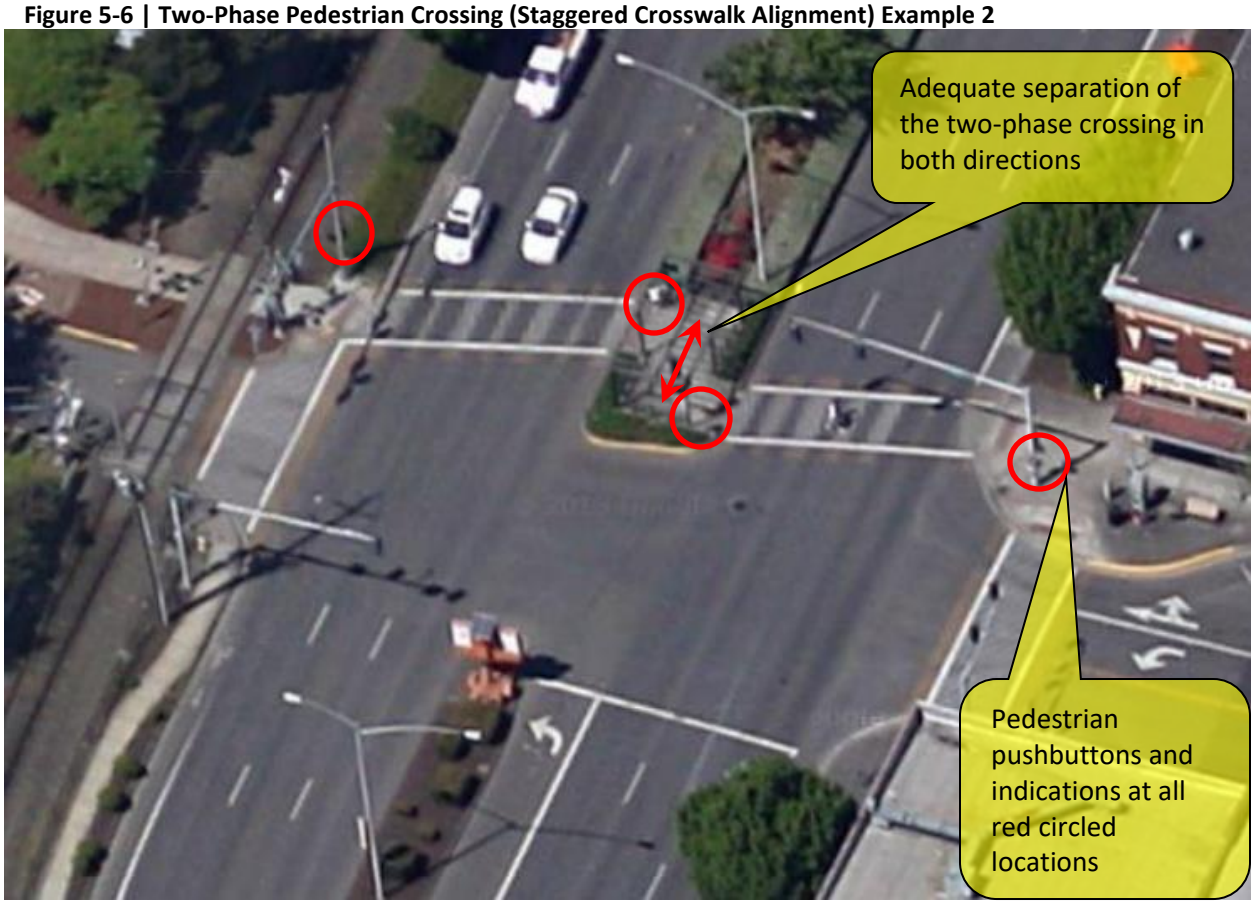


Figure 5-6 | Two-Phase Pedestrian Crossing (Staggered Crosswalk Alignment) Example 2



Single Phase Pedestrian Crossing

If a two-phase pedestrian crossing is NOT required (according to the Operational Approval) the crosswalk should be aligned as per section 5.1.3 with a median that ends prior to the crosswalk. This eliminates the need for a pushbutton located in the median as the design provides clear direction to the pedestrian that they will be crossing the entire crosswalk in one stage. See Figure 5-7 and Figure 5-8. Pushbuttons in the median, as shown Figure 5-9, in shall NOT be installed for a single phase pedestrian crossing where the raised median ends prior to the crosswalk (pedestrians should not be encouraged to take refuge where there is no pedestrian refuge).

Figure 5-7 | Single Phase, One Stage Pedestrian Crossing (Recommended Crosswalk & Median Design) Example 1

Figure 5-8 | Single Phase, One Stage Pedestrian Crossing (Recommended Crosswalk & Median Design) Example 2

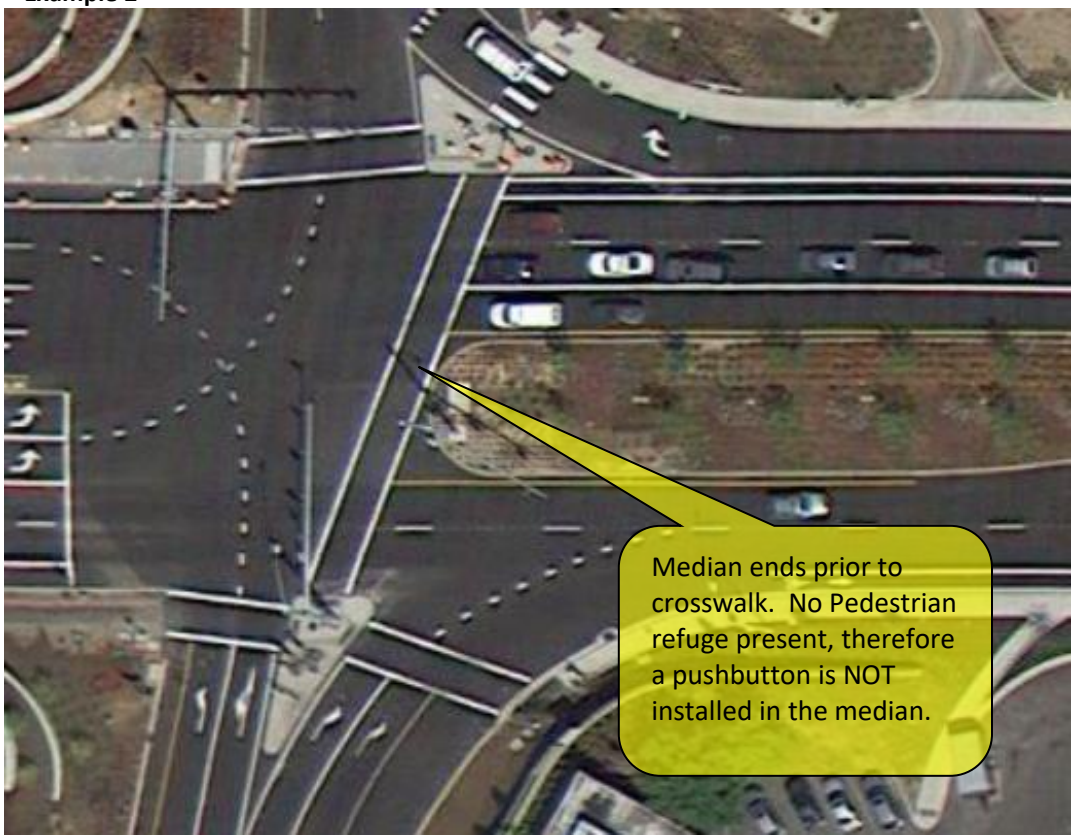
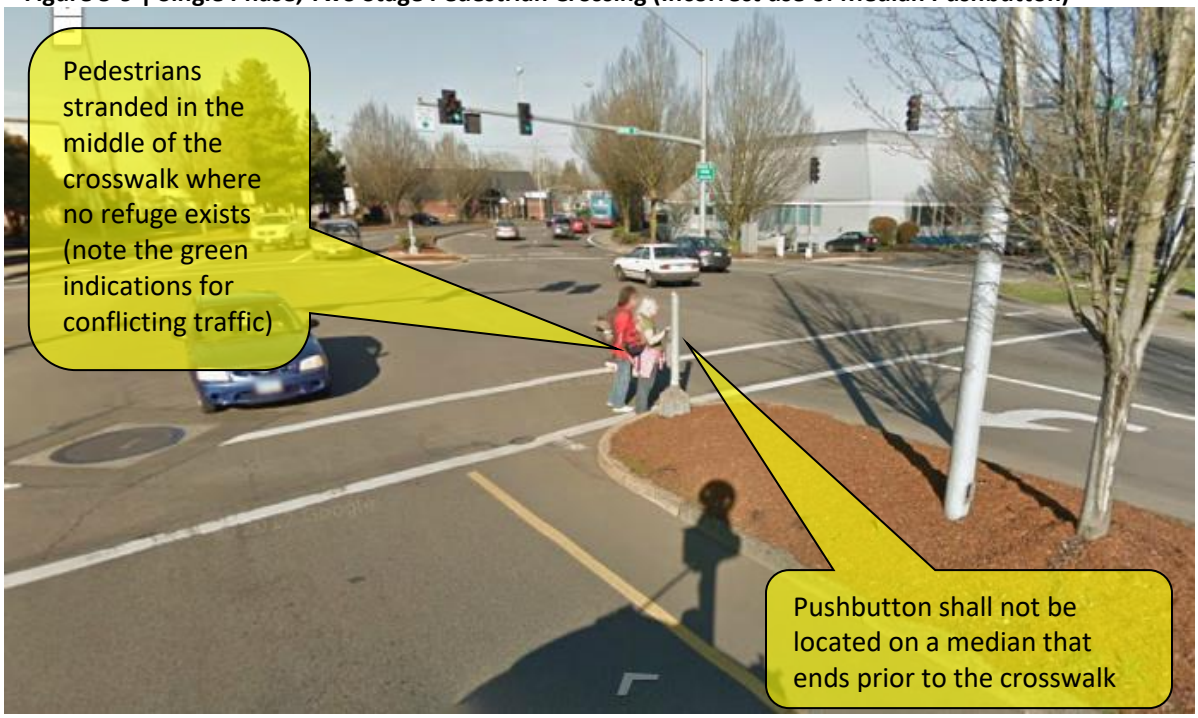


Figure 5-9 | Single Phase, Two Stage Pedestrian Crossing (Incorrect use of Median Pushbutton)

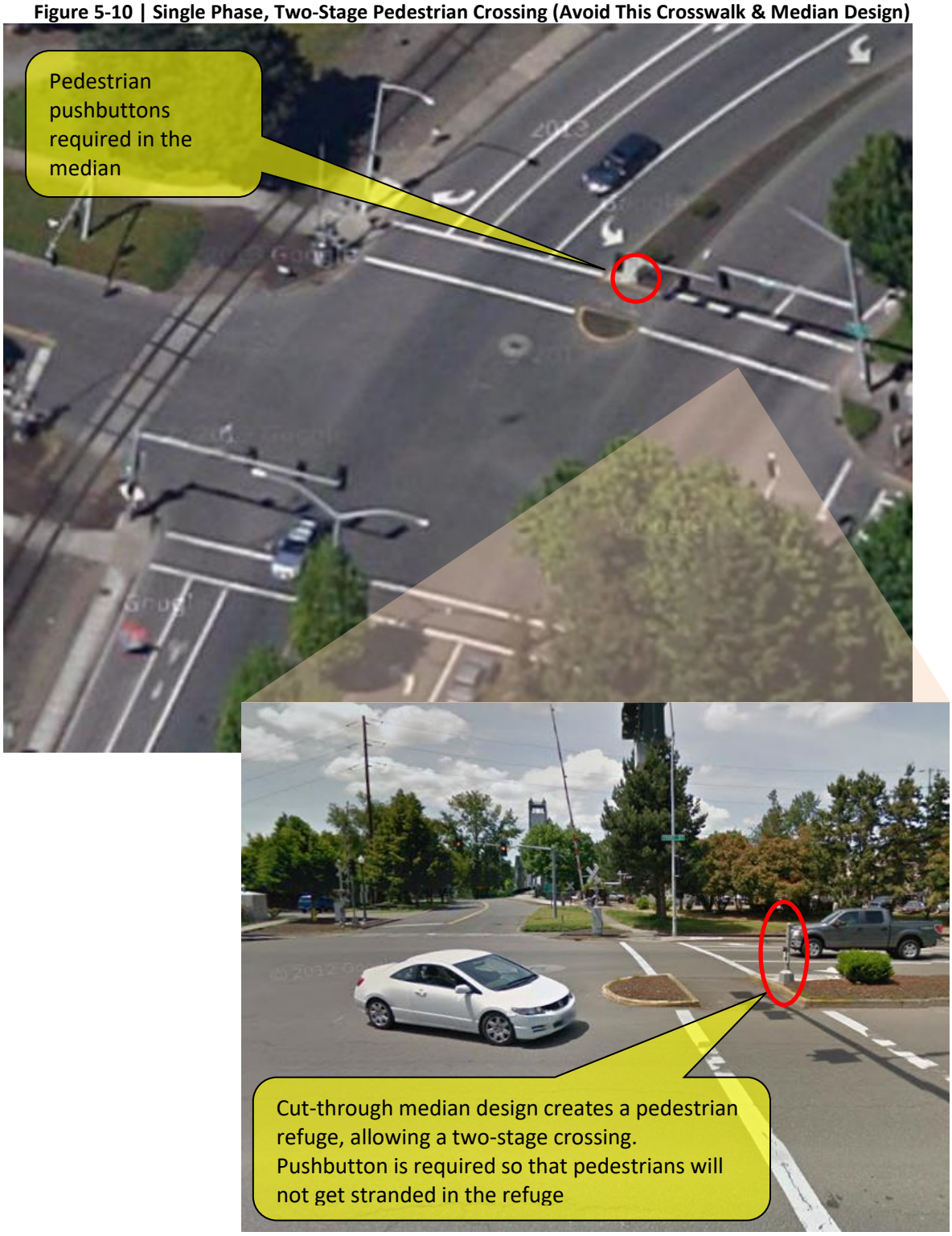


If the median is extended beyond the crosswalk with the cut-through style option, a pushbutton is required. See Figure 5-10. This is because the cut-through design is used to create a pedestrian refuge which allows pedestrians the option of a two-stage crossing, even though the pedestrian crossing is only a single phase (i.e. the pedestrian phase is timed to allow a pedestrian to cross the entire crosswalk, not just to the median). **A straight aligned crosswalk with a median cut-through should not operate as a two-phase pedestrian crosswalk (see Two-Phase Pedestrian Crossing requirements above).** Single phase, two-stage pedestrian crossings are not desirable and should be avoided for two reasons:

- The pushbutton in the median is often pushed by pedestrians even if they have no intention of making a two-stage crossing. This results in inefficient signal operations due to the pedestrian phase being serviced again in the next cycle when there is no demand. This is especially problematic if the signal is operating near, at, or over capacity.

- By placing a pedestrian refuge with a pushbutton in the median, pedestrians may be unsure if they should stop in the median and wait for the next WALK/FLASHING DON'T WALK to finish the crossing. However, the use of countdown pedestrian signal heads has largely eliminated this concern, as pedestrians now have info about how long the pedestrian phase will last and can make a more informed decision if they should wait in pedestrian refuge or not.

Figure 5-10 | Single Phase, Two-Stage Pedestrian Crossing (Avoid This Crosswalk & Median Design)



5.1.6 Driveway Approaches at Signalized Intersections

All approaches of an intersection shall be signalized, even if an approach is only a driveway or alley and serves a very limited amount of traffic. Figure 5-11 shows an example of a driveway forming the fourth approach of an intersection. Half signals or an unsignalized approach at the intersection are not allowed (this excludes right turn slip lanes which may be signalized, STOP or YIELD controlled as specified in the operational approval).

Figure 5-11 | Signalized Driveway Example

Typically a driveway approach is according to the roadway standard drawings RD715 (non-sidewalk driveways) or RD725 thru RD750 (sidewalk driveways). Sidewalk driveway options shown in RD725 thru RD750 should NOT be used when the driveway approach will be signalized. Instead, a small radius with sidewalk ramps (and standard crosswalk striping) as shown in RD756 should be used instead. A small radius with sidewalk ramp will make the approach look and feel like a typical signalized approach; drivers should be more likely to stop at the proper location and watch for pedestrians and pedestrians should be more likely to notice the pedestrian indications and comply. For comparison purposes, see Figure 5-12 showing the before photo of a signalized sidewalk driveway and
Figure 5-13 showing the after photo with a new small radius, sidewalk ramps and crosswalk striping.

Figure 5-12 | Signalized Sidewalk Driveway (Before Photo) – Avoid This Approach Design

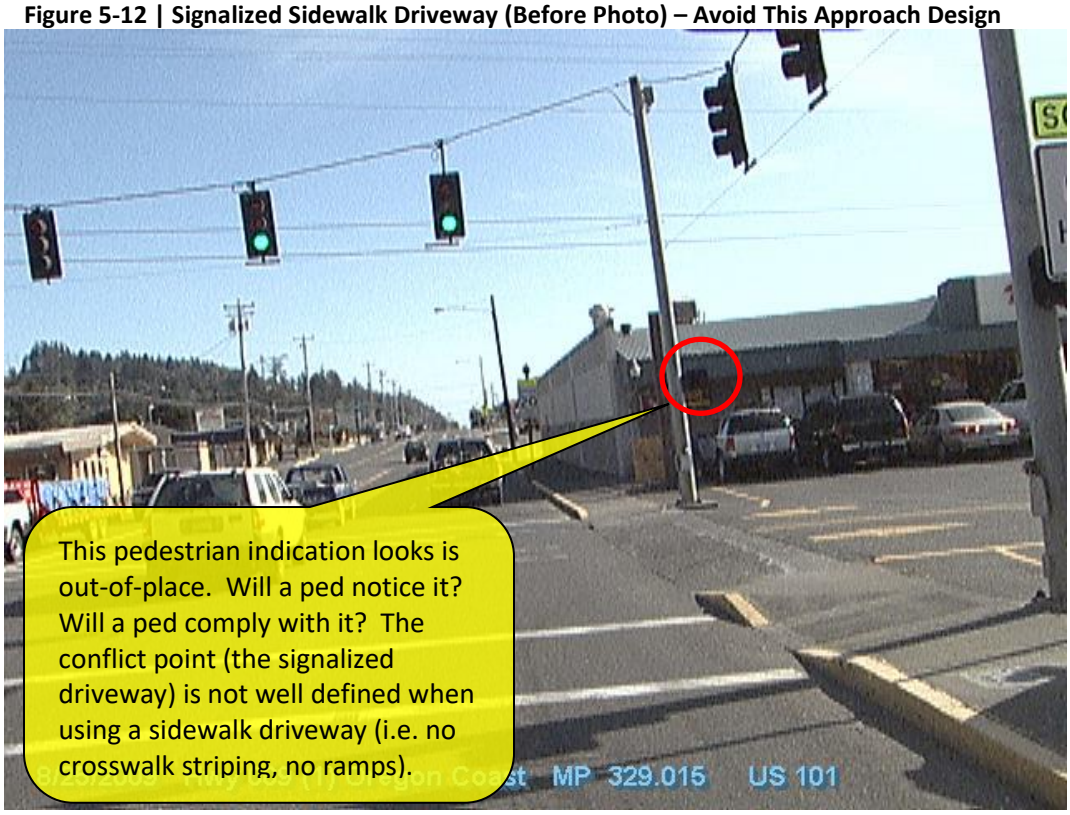
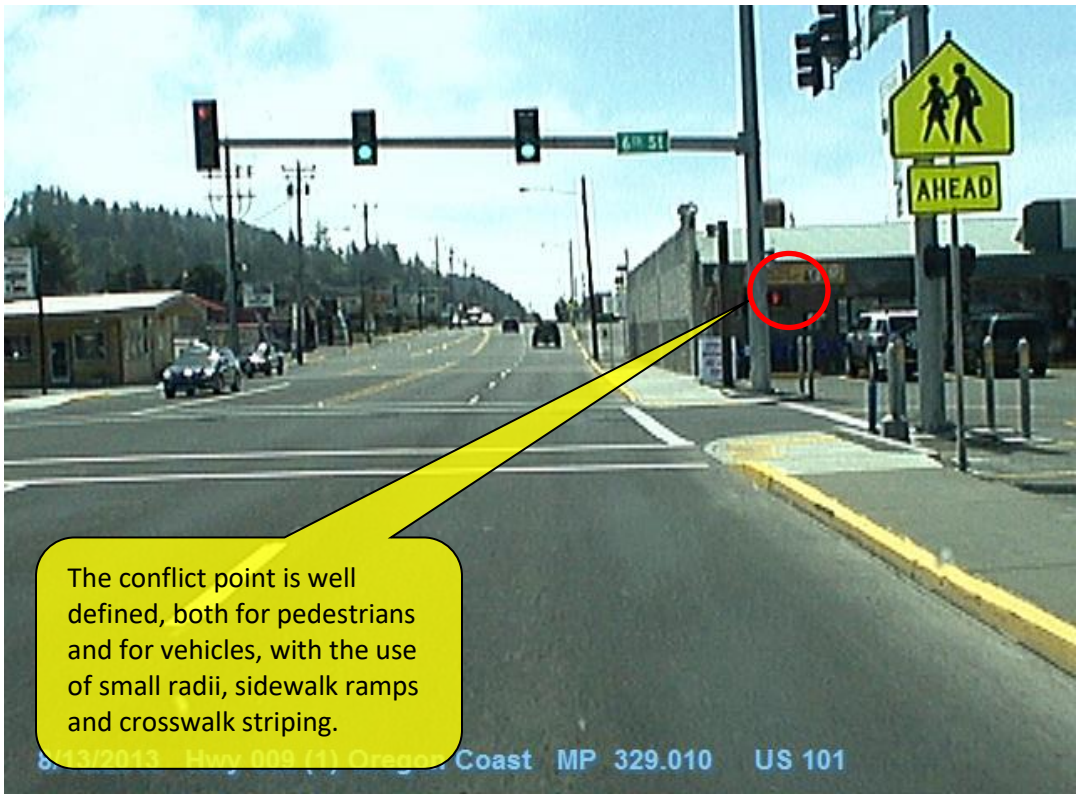


Figure 5-13 | Signalized Driveway with small radius and sidewalk ramps (After Photo) – Use This Approach Design



5.2 Vehicle Signal Head Layout

Signal head location is guided by the Manual on Uniform Traffic Control Devices (MUTCD) and the Oregon Supplements to the MUTCD. Once the number of lanes, lane use, location of crosswalks, signal phasing and roadway geometry are known, the vehicle signal heads can be laid out. This, in conjunction with the pedestrian signal equipment layout (Section 5.3), will be the basis for determining what type of signal support structures (mast arms, span wires, pedestrian pedestals, custom design, and/or pushbutton posts) should be used at the intersection.

The Operational Approval and the Roadway Geometry MUST match!

Some basic guidelines per approach:

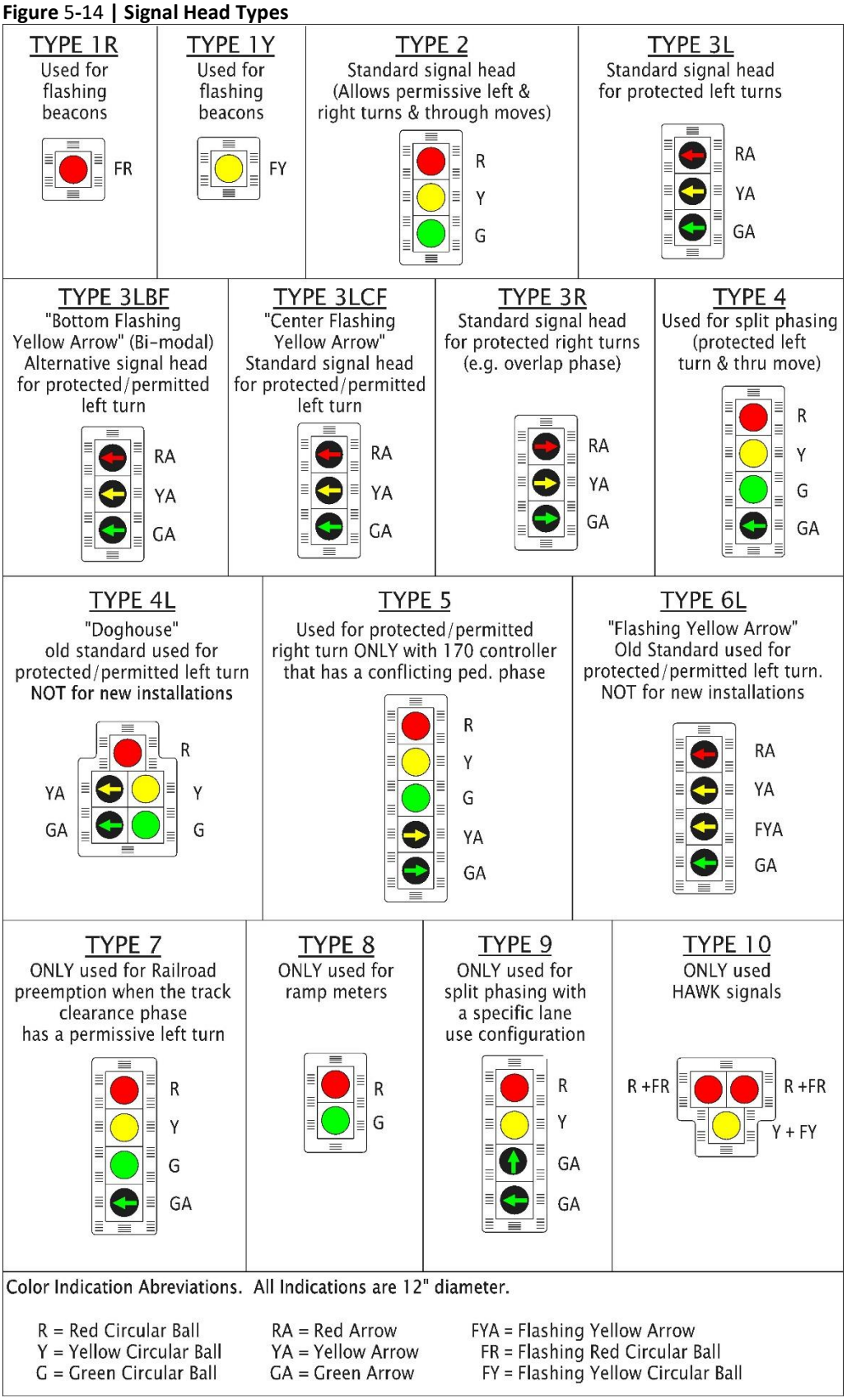
- Signal heads should be mounted over head on mast arms or span-wires for all movements. Supplemental signal heads may be ground mounted on vehicle pedestals.
- Signal heads should be aligned vertically (vs. horizontally)
- A minimum of two signal faces shall be provided for the through movement on the approach. If no through movement exists, a minimum of two signal faces shall be provided for the major movement from the approach.
- A signal face per lane shall be used when there are 3 or more through lanes on the approach.
- Heads for the same phase shall not be located closer than 8 feet apart (horizontally from each other). They should be located at least 10 feet apart when possible.
- Heads shall not be less than 45 feet (based on standard 18-19 foot mounting height) from the “STOP” line (or nearside crosswalk line if there is no stop line). Heads located greater than 180 feet from the “STOP” line require a near-side supplemental head.

5.2.1 Head Types

The type of signal heads that can be used are defined in Standard Drawing TM460 and shown in Figure 5-14. Head types are designated by a number or a combination of number and letter for the head type to be used. Each signal head type has a specific use.

If the need arises to use a signal head type or layout that that is not covered by this manual (such as bike, U-turn, flashing yellow right turn arrow, etc.), contact the Traffic Signal Engineer to discuss and resolve the unique situation. See Section 2.2 for more information on non-standard and experimental design.

Figure 5-14 **| Signal Head Types**



5.2.2 Head Placement

The even phases (ø2, ø4, ø6, and ø8) are typically the through movements. These phases typically require two Type 2 heads. The location of the heads in free space depends on the number of receiving lanes and the roadway geometry. See Table 5-1. The alignment of the through signal heads is based on the receiving lanes (Figure 5-15), NOT the projected approach lanes (Figure 5-16).

Table 5-1 | Standard Signal Heads for Through Movement Phases

Standard Signal Heads for Through Movement Phases	
Number of receiving lanes	**Number and placement of signal heads**
Single receiving lane	Two Type 2 signal heads, placed one foot inside the projected receiving lane lines
Two receiving lanes	Two Type 2 signal heads, one placed in the center of each receiving lane
More than two receiving lanes	One Type 2 signal head for each receiving lane, placed in the center of each receiving lane

Signal head alignment for THROUGH movements are based on the RECEIVING lane lines (See Figure 5-15).

Signal head alignment for TURN movements are based on the PROJECTED lane lines (See Figure 5-19 and Figure 5-20).

Figure 5-15 | Signal Head Placement For Through Movement Using Receiving Lane Lines (CORRECT METHOD)

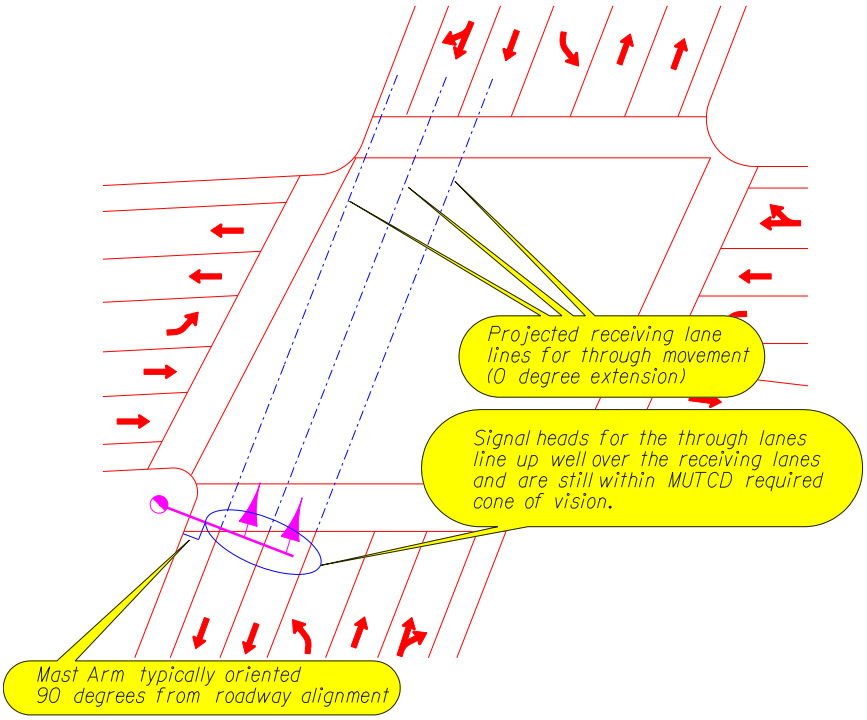
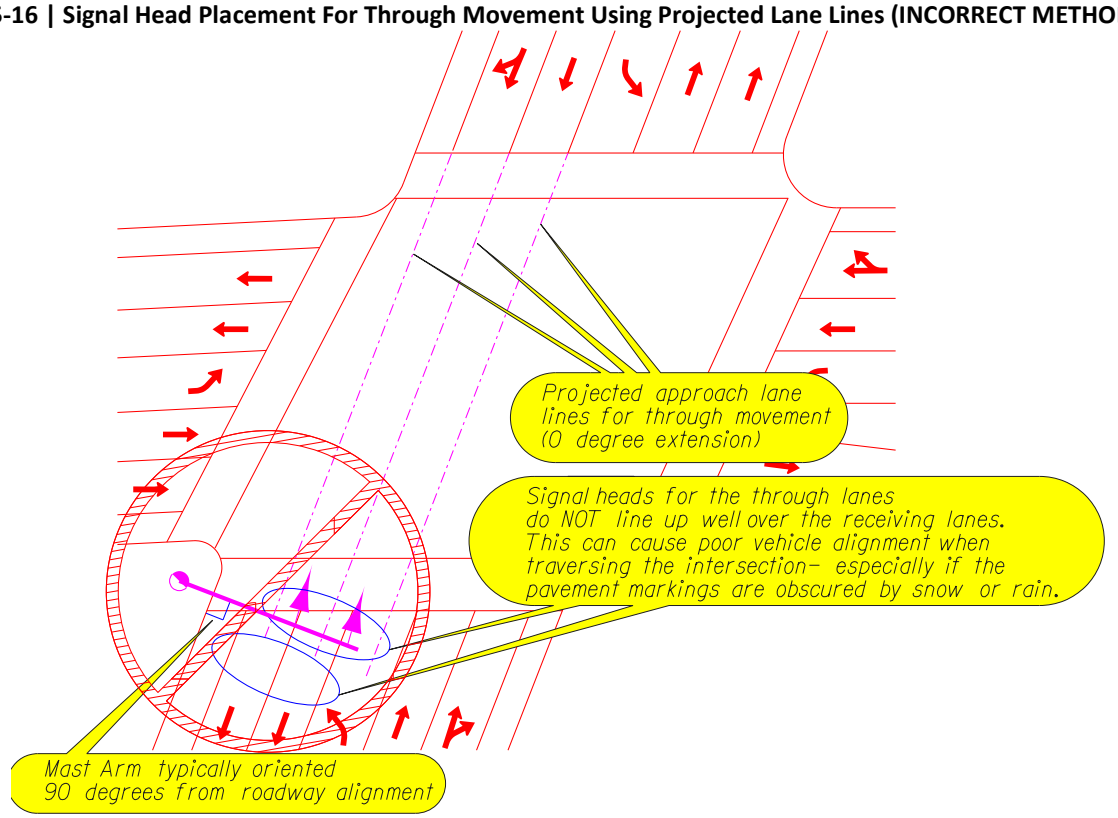
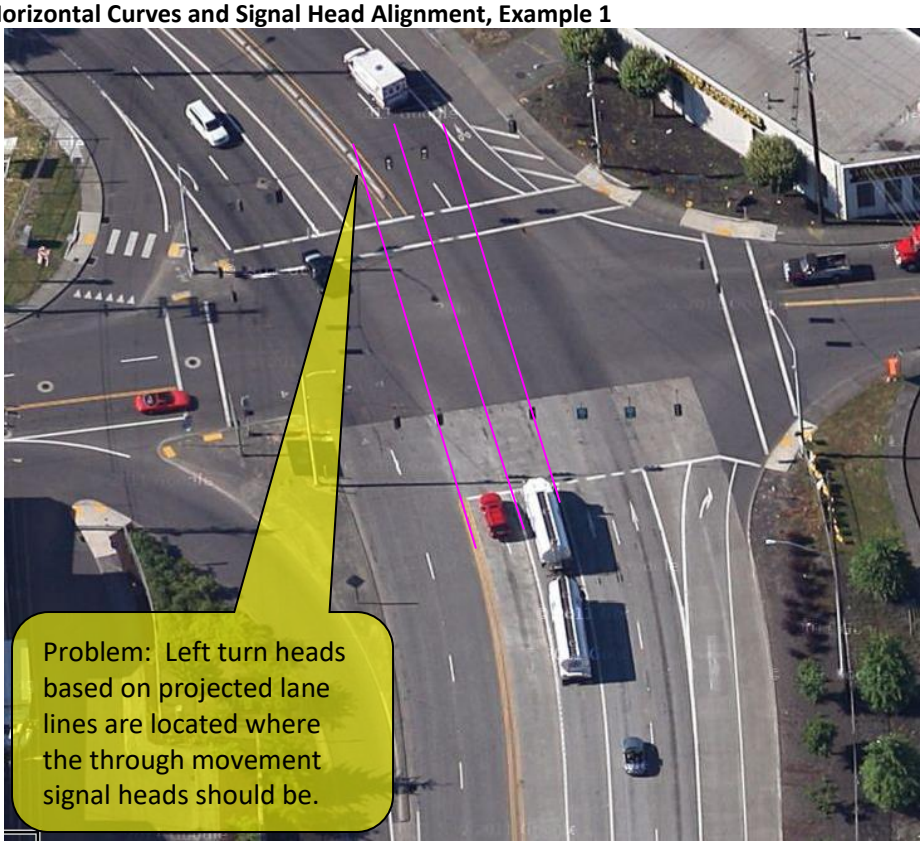


Figure 5-16 | Signal Head Placement For Through Movement Using Projected Lane Lines (INCORRECT METHOD)



When the intersection is located within a horizontal curve, strict adherence to signal alignment based on the receiving lane lines (through movements) and projected lane lines (turn movements) may not be possible; it could result in the left turn heads being located to the right of the through movement heads in one direction and the left turn heads being located to the left of the through movement heads by a ridiculous distance in the other direction. In these cases, the signal head alignment for the through phases takes precedence and should be determined first, according the receiving lane lines. This is because the through movements are more likely to be approaching and proceeding through the intersection at speed, while the turn movements are more likely to be coming to a stop and will proceed through the intersection at a slower speed. The turn signal head alignment is determined next, with the left turn head always located to the left of the through movement heads and the right turn heads always located to the right of the through movement heads, regardless of the projected lane lines. The turn signal heads should be kept within a reasonable distance of the through movement heads if possible, approximately 6 to 12 feet. See Figure 5-17 and Figure 5-18.

Figure 5-17 | Horizontal Curves and Signal Head Alignment, Example 1



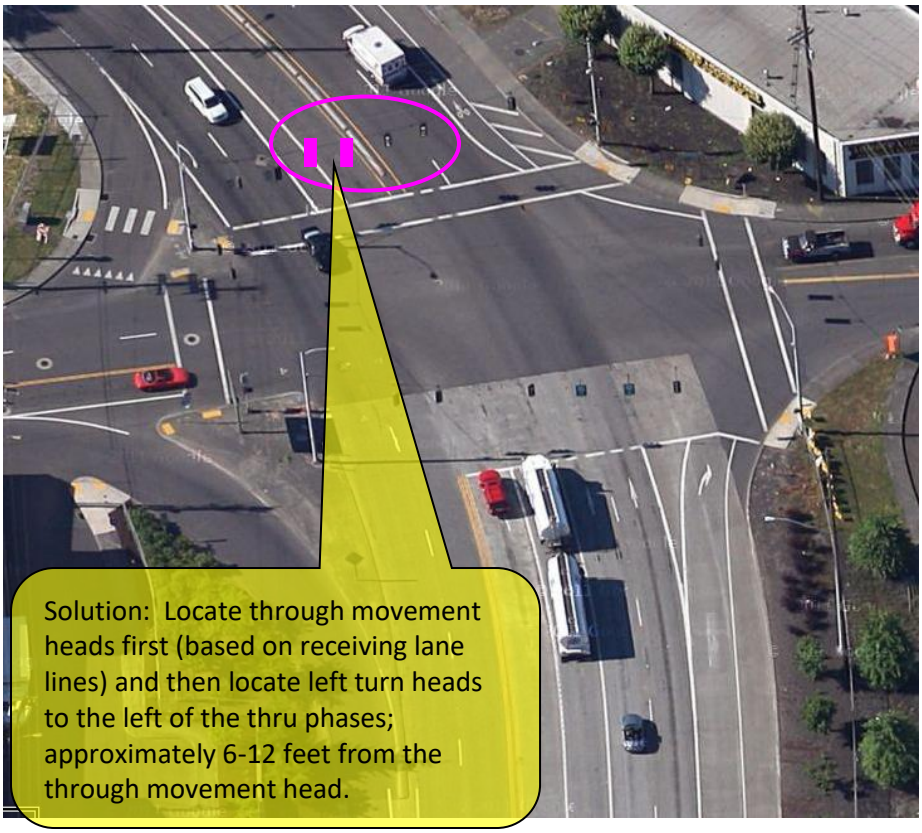
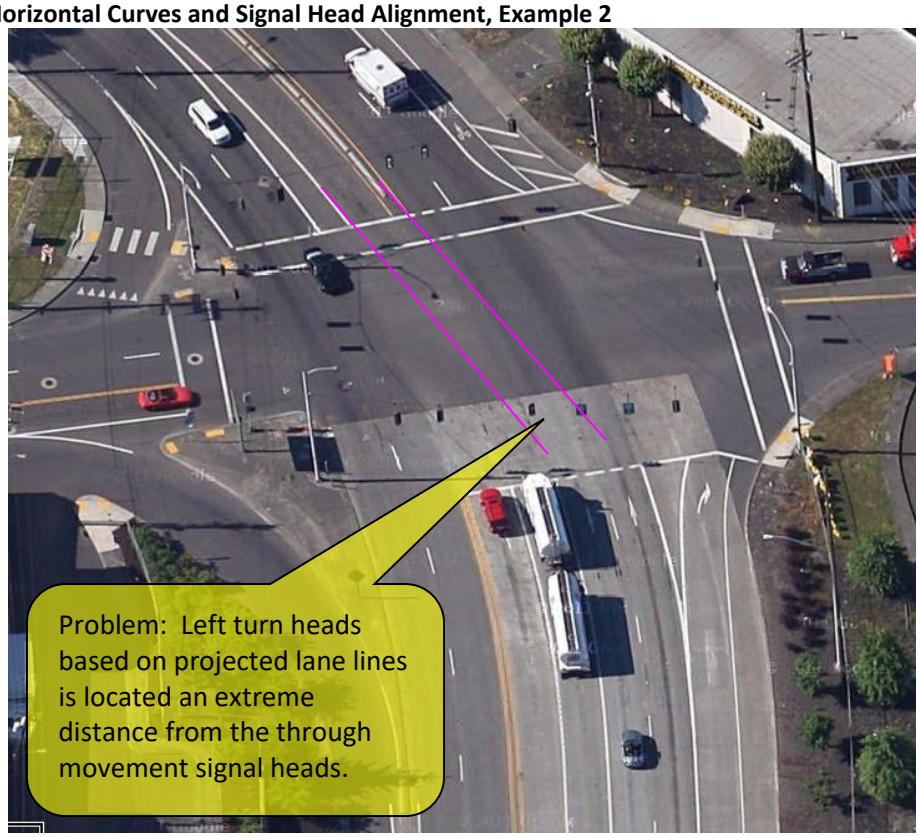
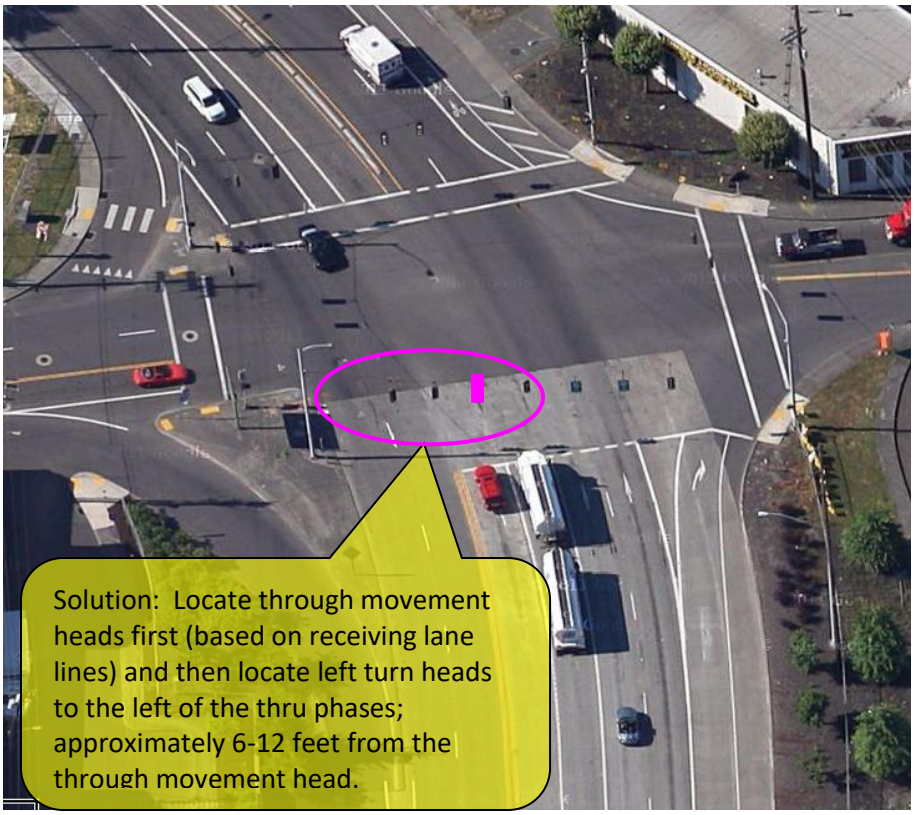


Figure 5-18 | Horizontal Curves and Signal Head Alignment, Example 2





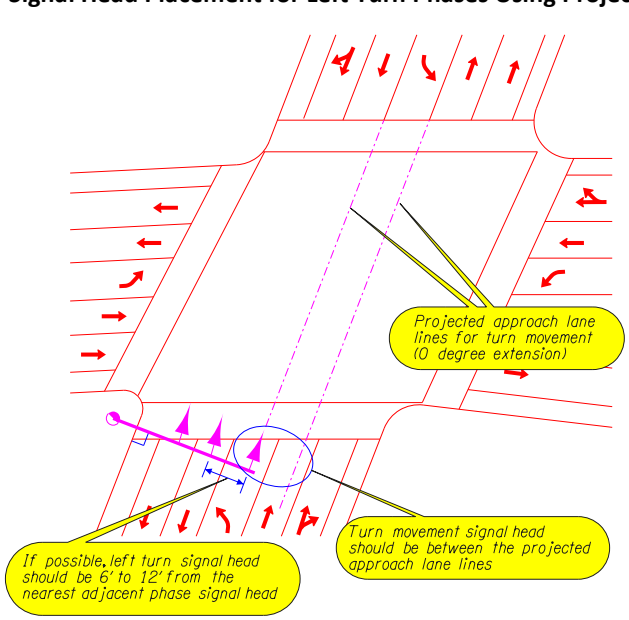
The odd phases (ø1, ø3, ø5, and ø7) are typically the left turn movements and would require one signal head. Dual turn movements, require two signal heads. The signal head type will depend on the desired operation of the left turn phase (as stated in the operational approval). The alignment of the left turn signal heads is based on the projected approach lanes. See Table 5-2 and Figure 5-19.

Table 5-2 | Standard Signal Heads for Left Turn Phases

Standard Signal Heads for Left Turn Phases	
Type of Operation	**Number and placement of signal heads**
Protected Only Phasing	One Type 3L signal head, placed in the center of the projected lane lines*
Protected/Permitted Phasing	One Type 3LCF signal head, placed in the center of the projected lane lines.* The Type 4L and 6L head is no longer used. The location of the Type 3LCF needs to be inventoried by the State Traffic Operations Engineer. Use of Type 3LBF (bi-modal) heads is discouraged and should only be considered as a last resort (Section 4D.20 of the Oregon Supplement to the MUTCD).
Permissive Only Phasing	Signal head PROHIBITED from being located within the projected lane lines. Use signal head placement as described for through movement phases.
Dual Left Turns (typically protected only phasing)	Two Type 3L signal heads, one placed in the center of each projected lane lines*

* If possible, left turn phase signal heads should be located within 6 to 12 feet of the nearest adjacent phase signal head.

Figure 5-19 | Signal Head Placement for Left Turn Phases Using Projected Lane Lines



Right turn movements are typically permissive only, and as such require no additional signal heads. However, if an exclusive right turn lane is to be operated other than permissive only, the signal head type will depend on the desired operation (as stated in the operational approval). The alignment of the signal heads is based on the projected approach lanes, with the exception of right turn slip-lanes. See Table 5-3 and Figure 5-20.

Table 5-3 | Standard Signal Heads for Right Turn Phases

Standard Signal Heads for Right Turn Phases	
Type of Operation	**Number and placement of signal heads**
Overlap phasing (operating as protected only)	One Type 3R signal head, placed in the center of the projected lane lines*. This is the standard when using a 2070 controller (conflicting crosswalk phase must either be closed or use the "not ped" software feature)
2-phase operation (operating as Protected/Permitted)	One Type 5 signal head, placed in the center of the projected lane lines*. This operation should ONLY be used 1.) when using a 170 controller AND the conflicting crosswalk phase cannot be closed or 2.) when the opposing left turn is PPLT or permissive only and there is a single receiving lane (MUTCD 4D.05, F, 1).
Permissive Only Phasing	No signal head required
Dual Right Turns (typically protected only phasing)	Two Type 3R signal heads, one placed in the center of each projected lane lines*.
Signalized right turn slip lanes, single lane (e.g. overlap phase)	Two Type 3R signal heads, placed one foot inside the approach lane line. The opposing left turn CAN NOT be a permissive left turn if there is a single receiving lane.
Signalized right turn slip lanes, dual lanes (e.g. overlap phase)	Two Type 3R signal heads, one placed in the center of each approach lane. The opposing left turn CAN NOT be a permissive left turn.

* If possible, right turn phase signal heads should be located within 6 to 12 feet of the nearest adjacent phase signal head.

Figure 5-20 | Signal Head Placement for Right Turn Phases Using Projected Lane Lines

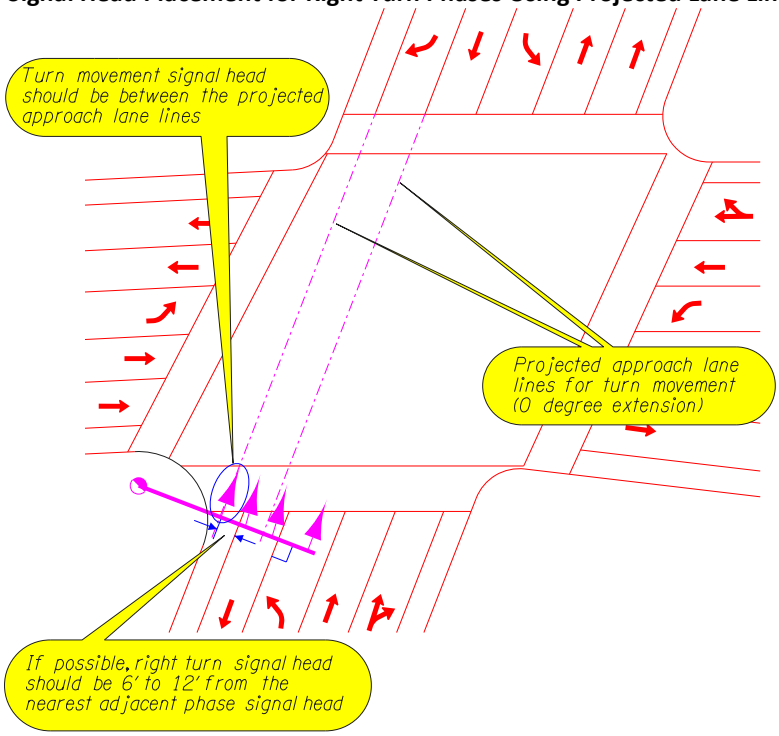
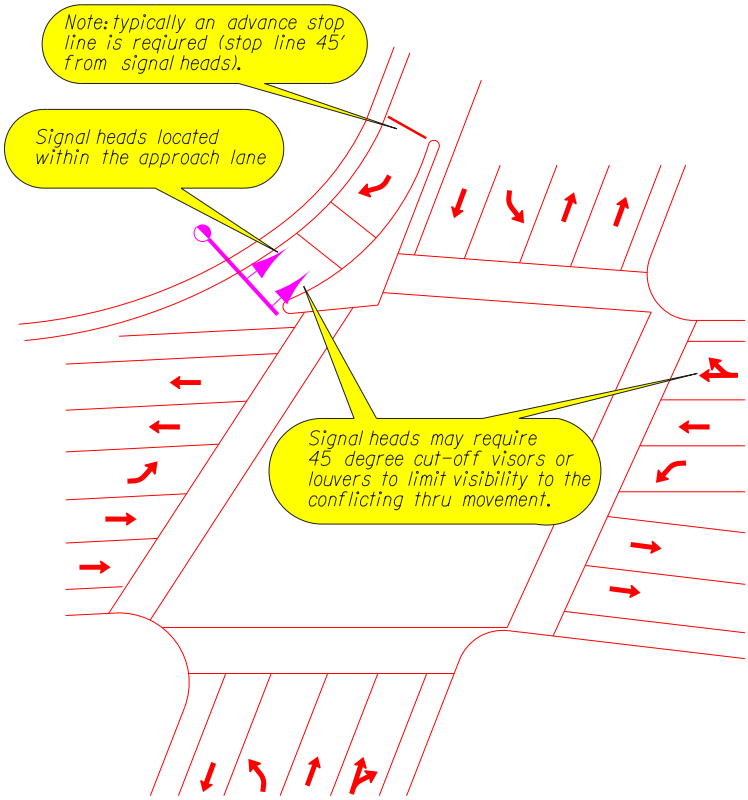


Figure 5-21 | Signal Head Placement for Right Turn Phases –Right Turn Slip Lanes



There are a few special signal phasing/lane configurations that noted below. While they are not used frequently, they are not uncommon and therefore have standards associated with them. See Table 5-4.

Table 5-4 | Standard Signal Heads for Special Phasing/Lane Configurations

Signal Heads for Special Phasing/Lane Configurations	
Type of Operation	**Number and placement of signal heads**
Split phasing	A type 4, 3L or 9 is required if the approach has a left turn movement. The signal type is dependent on the lane use. See Figure 5-26
Approach with a vehicle clear-out interval (railroad preemption) AND a permissive left turn phase.	A Type 7 signal is required, placed as shown in Figure 5-28
Through-left turn lane with protected/permitted left turn phasing	A type 4L signal head is used for this unique phasing when an exclusive left turn lane is not available as shown in Figure 5-24

Figure 5-22 through Figure 5-28 show examples of typical signal head placements.

Figure 5-22 | Signal Head Placement for Lanes Sharing the Same Phase

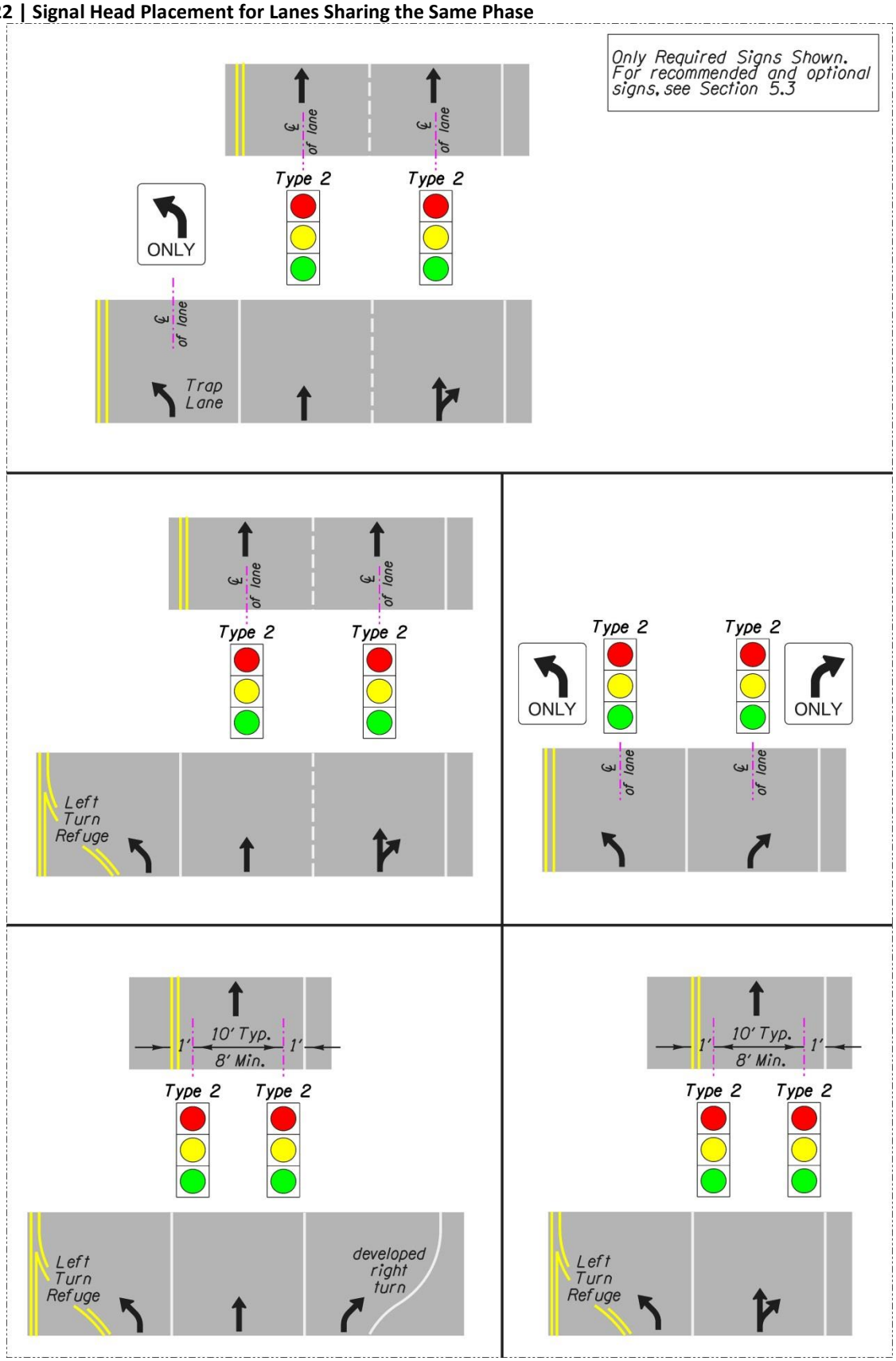


Figure 5-23 | Signal Head Placement for Lanes Sharing the Same Phase (cont.)

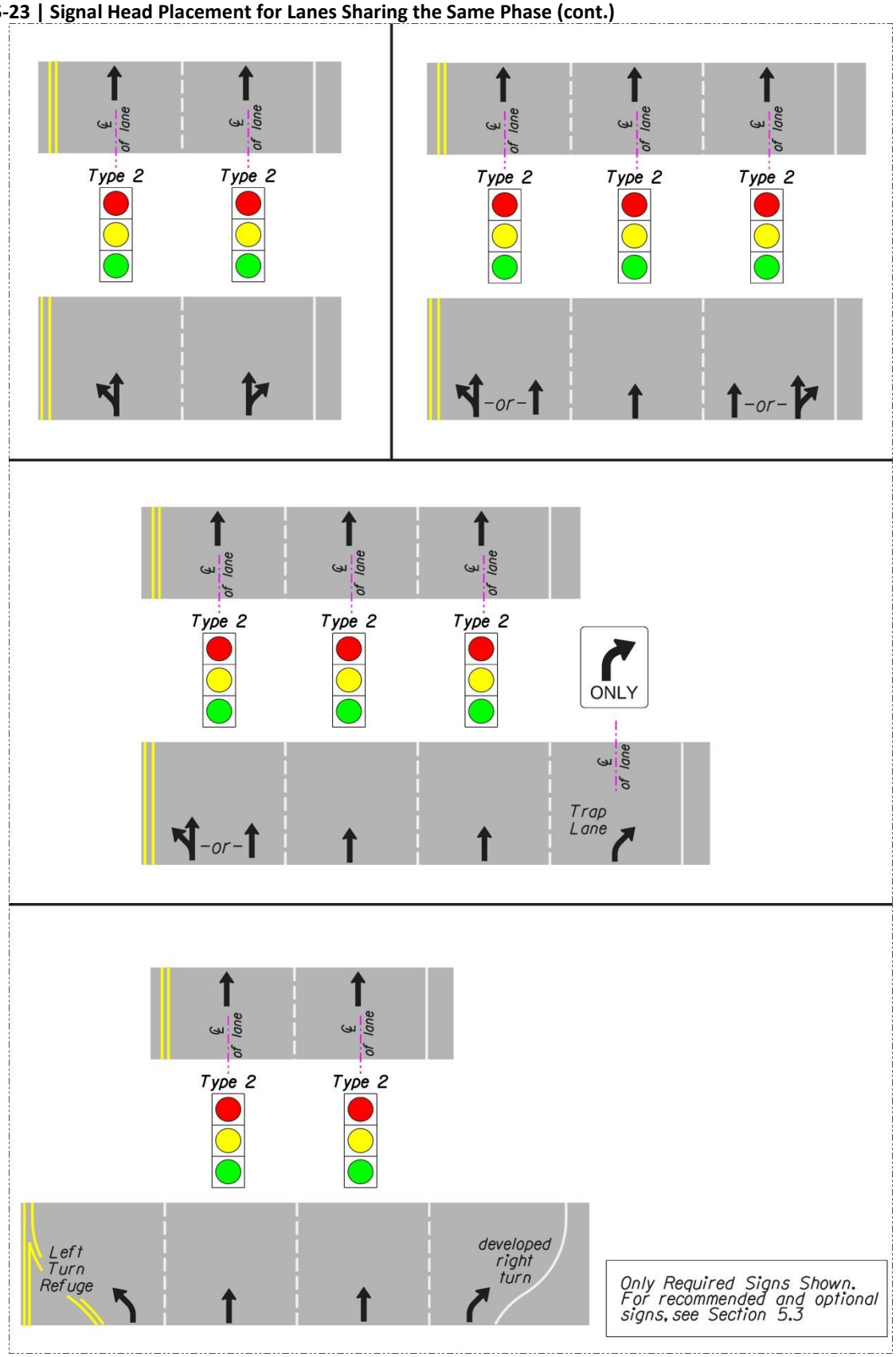


Figure 5-24 | Signal Head Placement for Left Turn Phasing

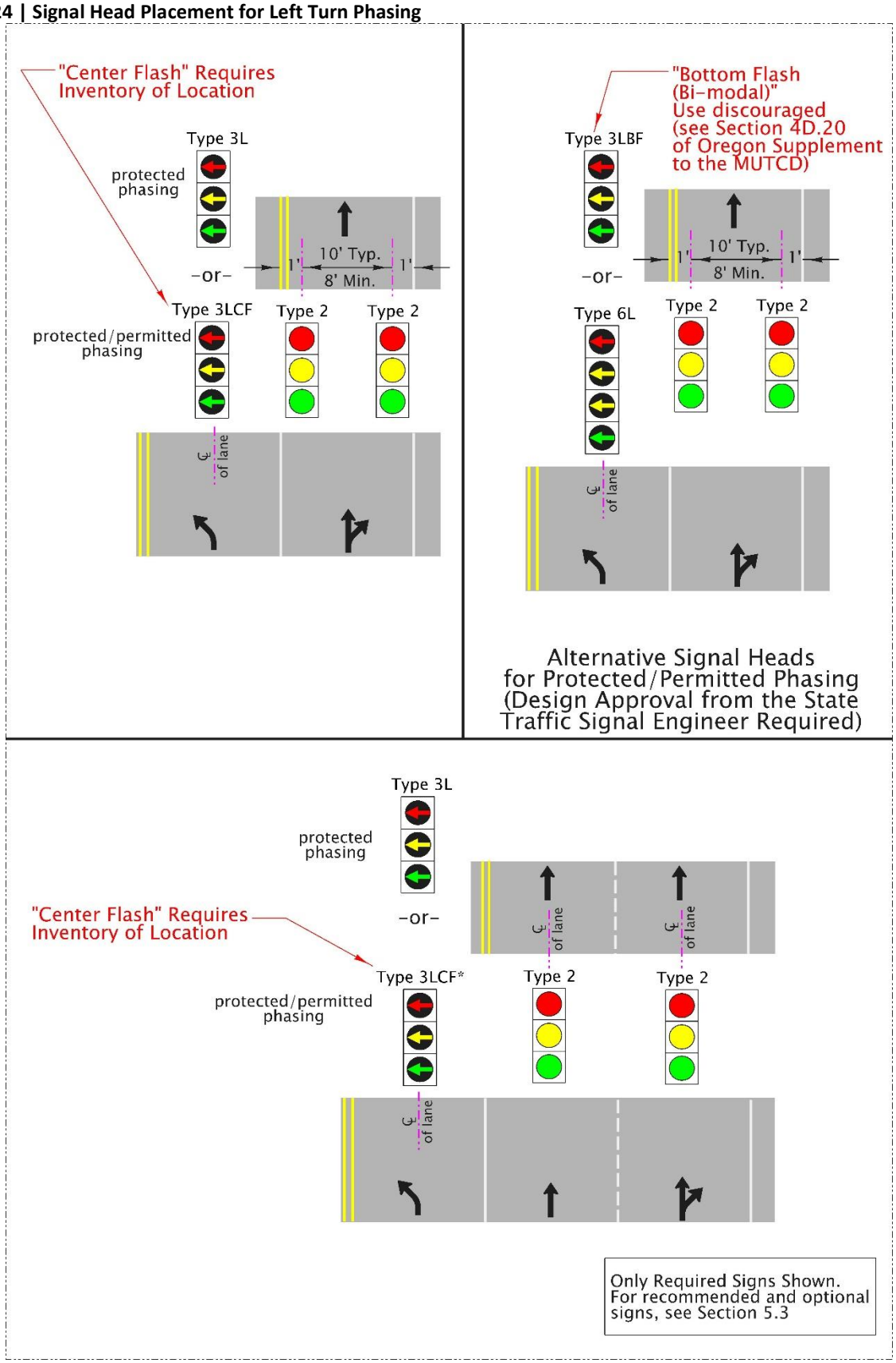


Figure 5-25 | Signal Head Placement for Right Turn Phasing

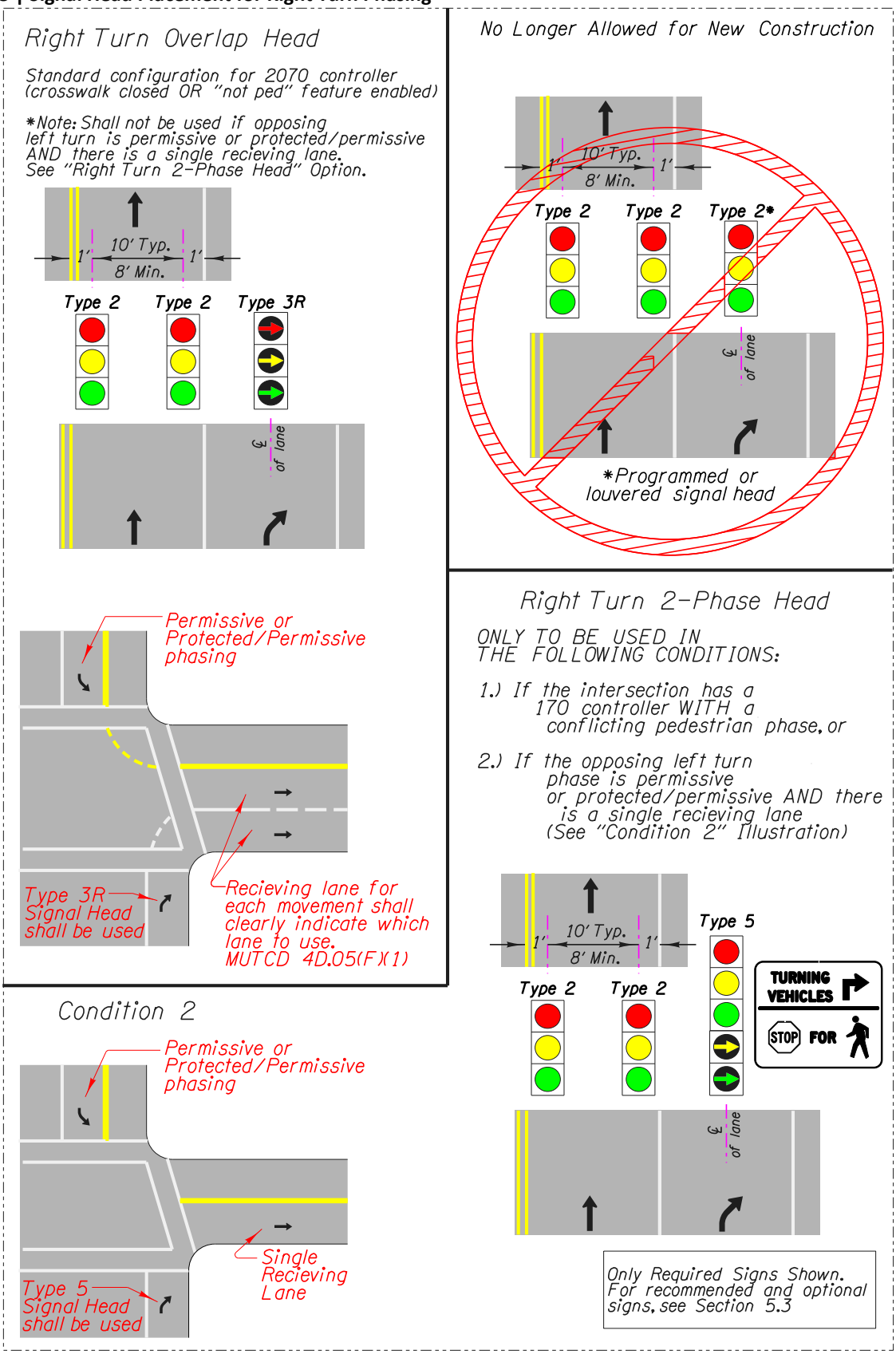


Figure 5-26 | Signal Head Placement for Split Phasing

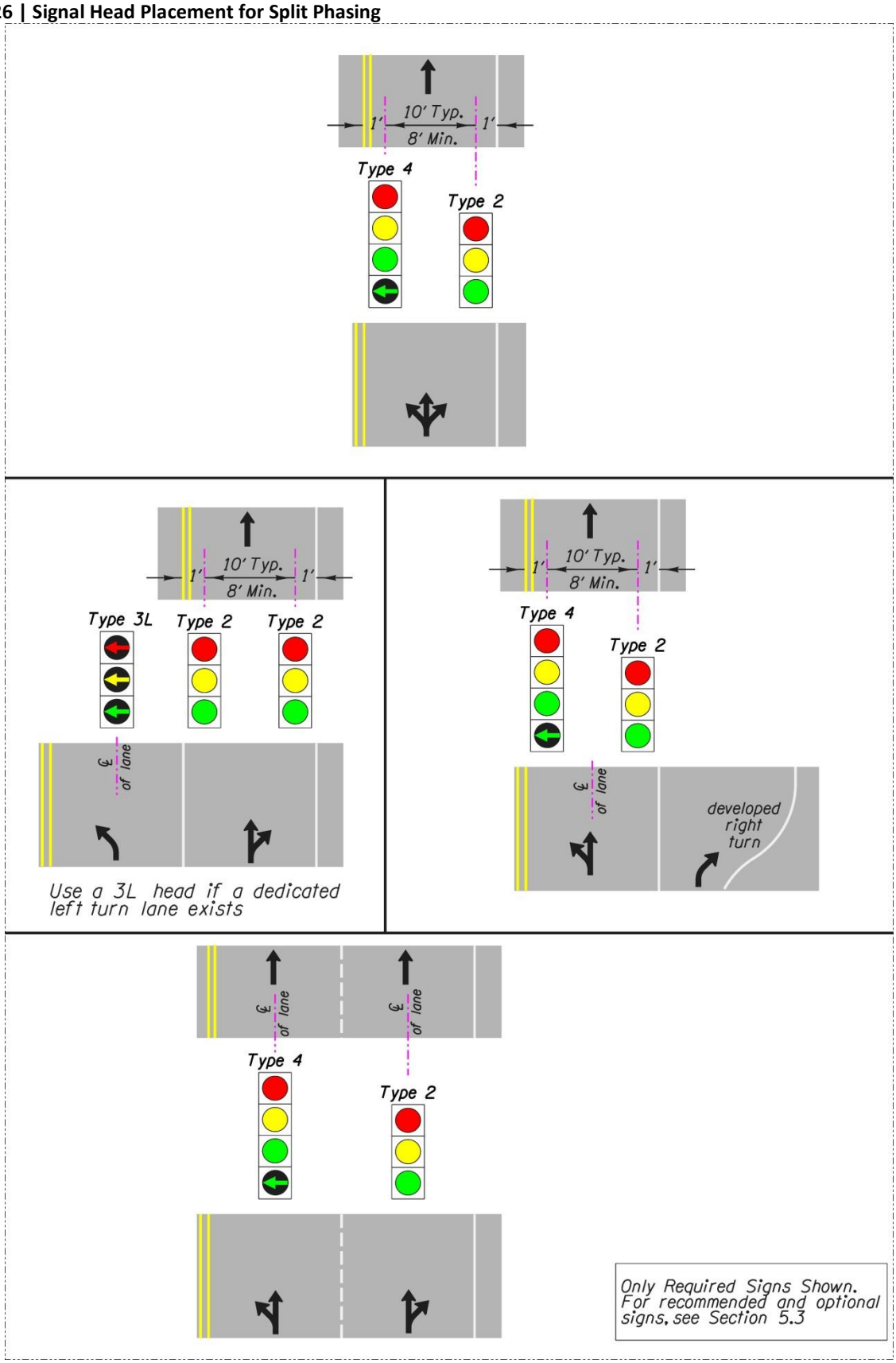


Figure 5-27 | Signal Head Placement for Split Phasing (cont.)

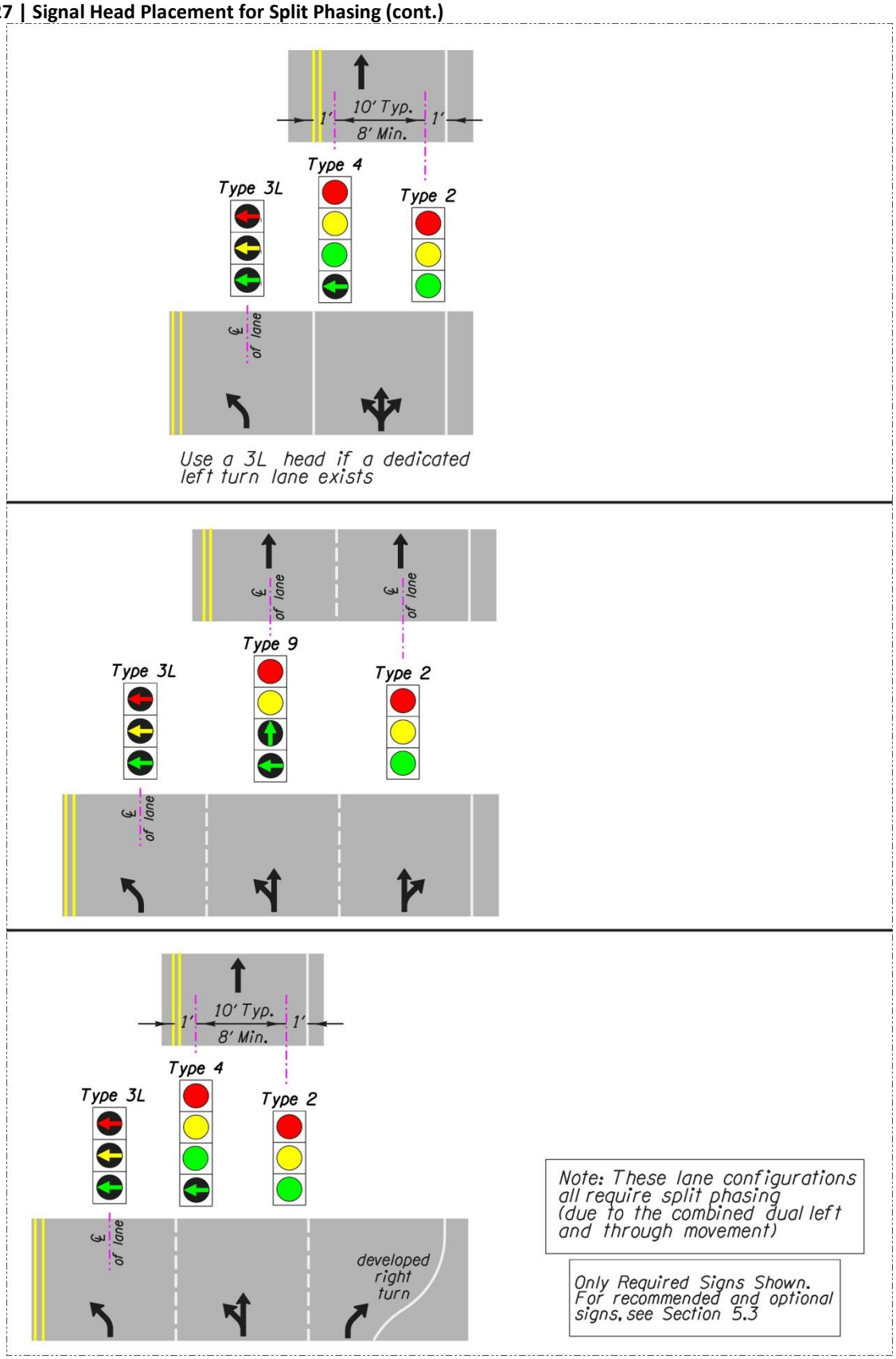
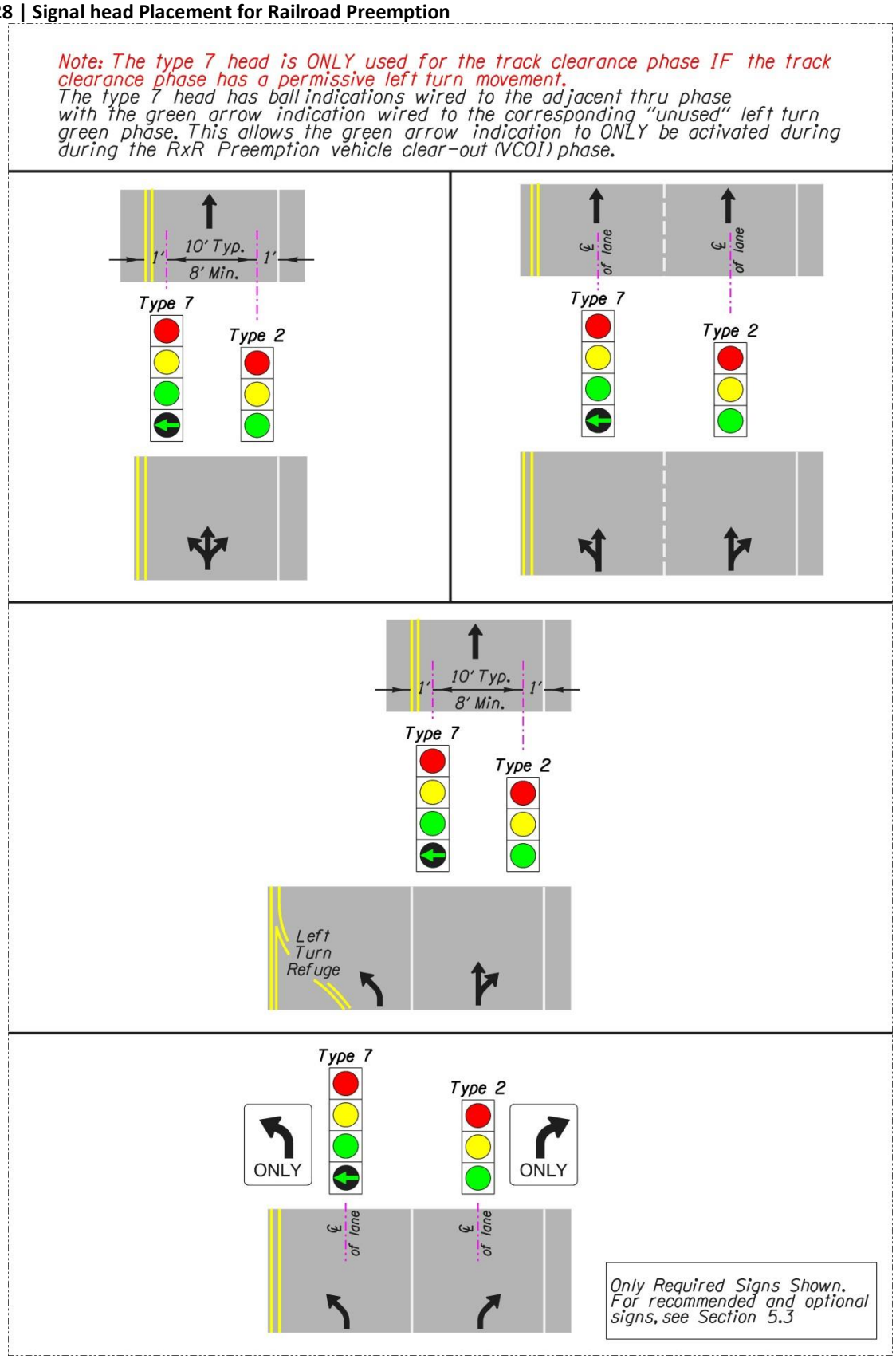


Figure 5-28 | Signal head Placement for Railroad Preemption



5.2.3 Supplemental signal heads

As per the MUTCD, supplemental near side signal heads are required when signal heads are located greater than 180 feet from the "STOP" line. They may also be used to improve conspicuity and visibility to the signalized intersection. There are two main locations where supplemental signal heads can be placed:

- Near-side supplemental heads: signal heads are located before the intersection. This is the most common location, and typically will be for the thru phase. See Figure 5-29. It may also be used for left turn phases. See Figure 5-30. The head will be on the vertical signal pole (left or right side of the road, depending on the roadway curvature) or overhead if the supporting structure allows proper alignment (i.e. the mast arm is long enough or a span wire is used).

- Far-side supplemental heads: signal heads are located across the intersection. This location is not as common as the near-side location. The typical application is for left turn phases. See Figure 5-32. It may also be for thru phases. See Figure 5-31. The head will be on the vertical signal pole (on the left side for a left turn phases, or on the right side for a thru phase).

Figure 5-29 | Supplemental Near-side signal heads – Typical Placement for Thru Phase

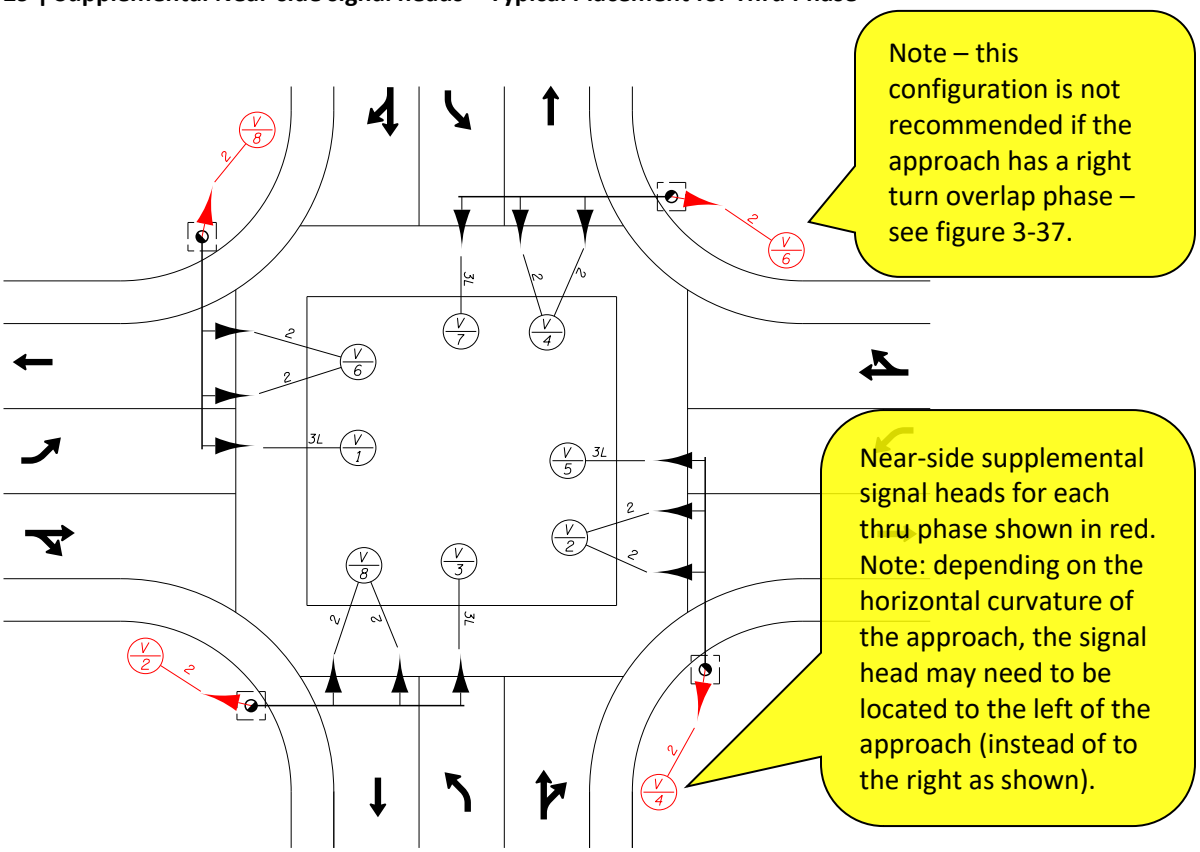


Figure 5-30 | Supplemental Near-side signal heads – Typical Placement for Left Turn Phase

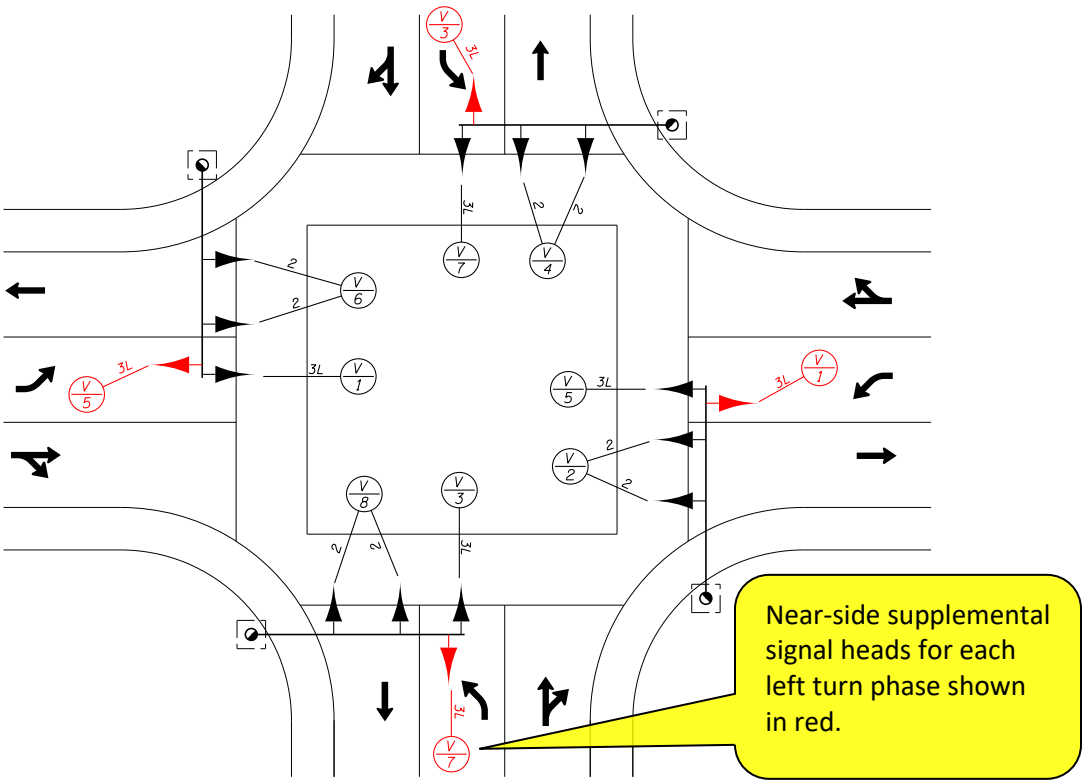


Figure 5-31 | Supplemental Far-side signal heads – Typical Placement for Thru Phase

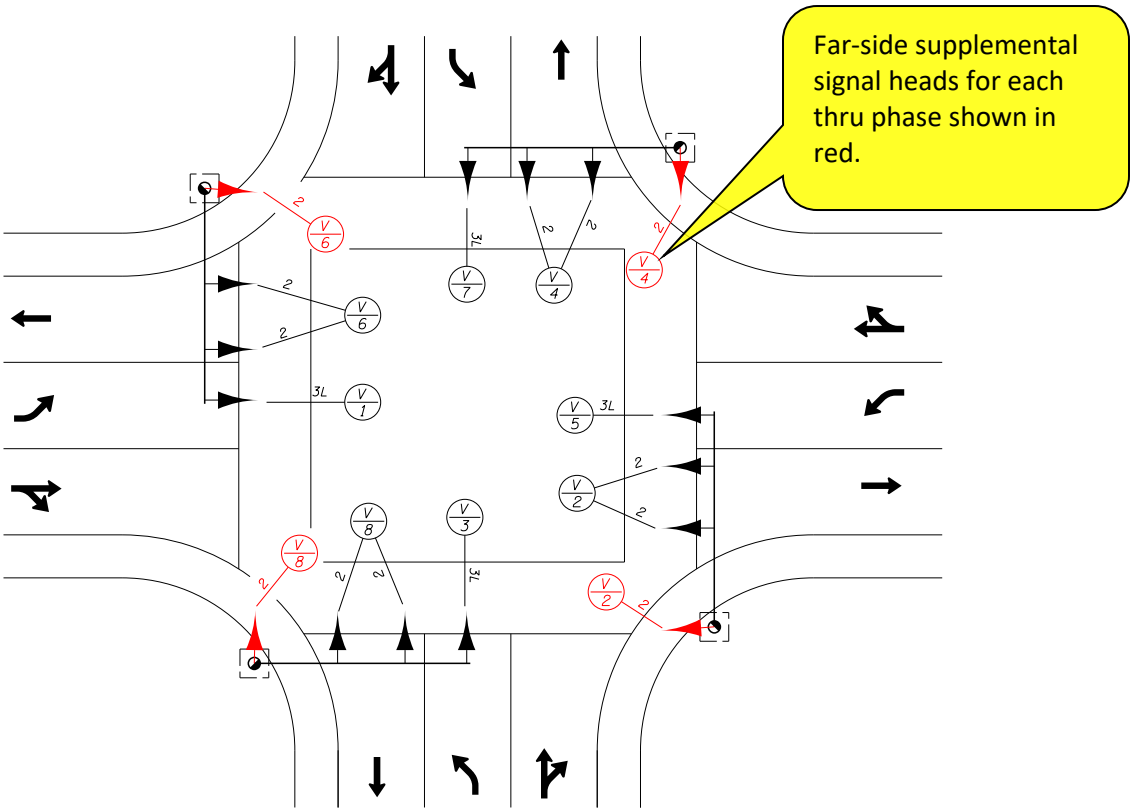
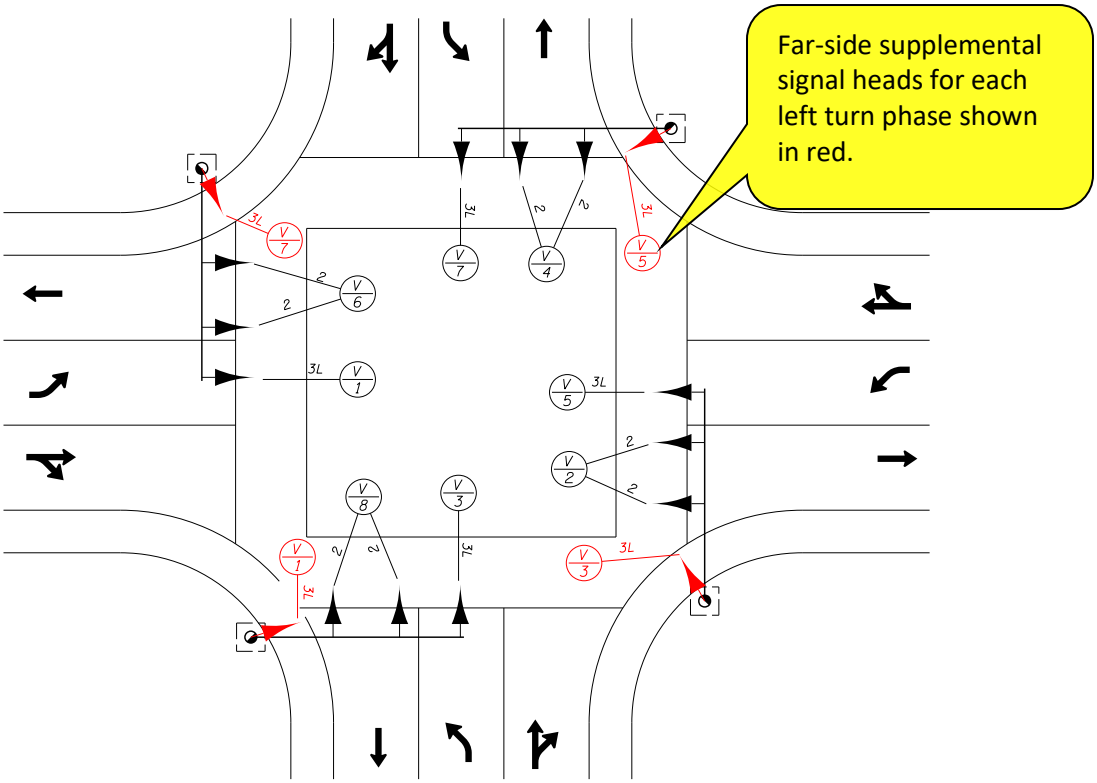


Figure 5-32 | Supplemental Far-side signal heads – Typical Placement for Left Turn Phase



The use and placement of supplemental heads needs to be careful considered to avoid motorist confusion. Supplemental signal heads can be very beneficial if the signal phasing and geometry allow proper placement. See Figure 5-33. However, there are situations where they should not be installed. For example, near-side supplemental heads should not be used for the right-hand side of the road for the thru movement on an approach that has a right turn only lane with overlap phasing (i.e. the right turn lane is phased differently than the thru phase). See Figure 5-34 which illustrates the potential confusion. Louvers and cut-off visors can help in some situations (see Section 5.2.5).

Figure 5-33 | Supplemental near-side signal head placement: Example 1

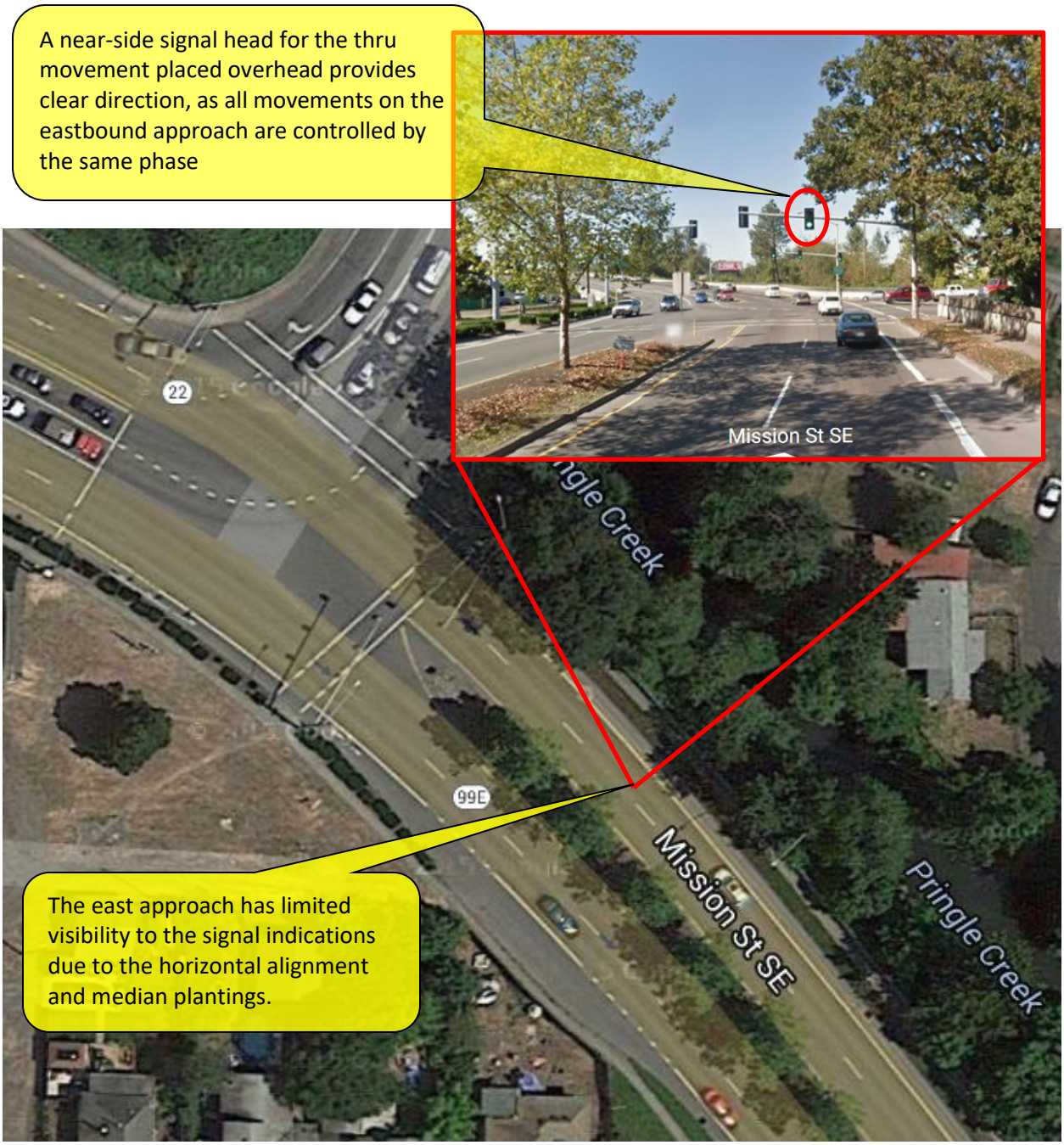
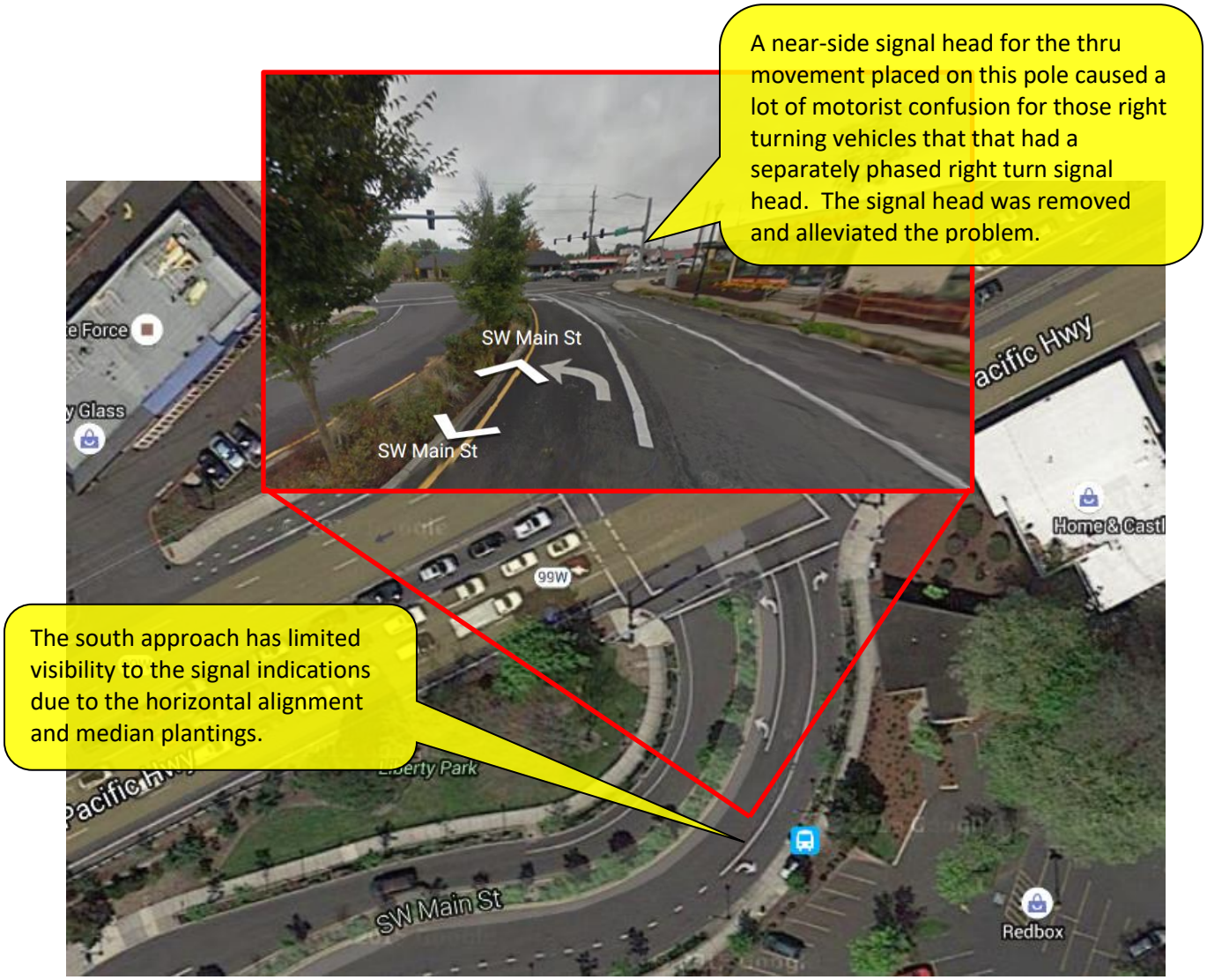
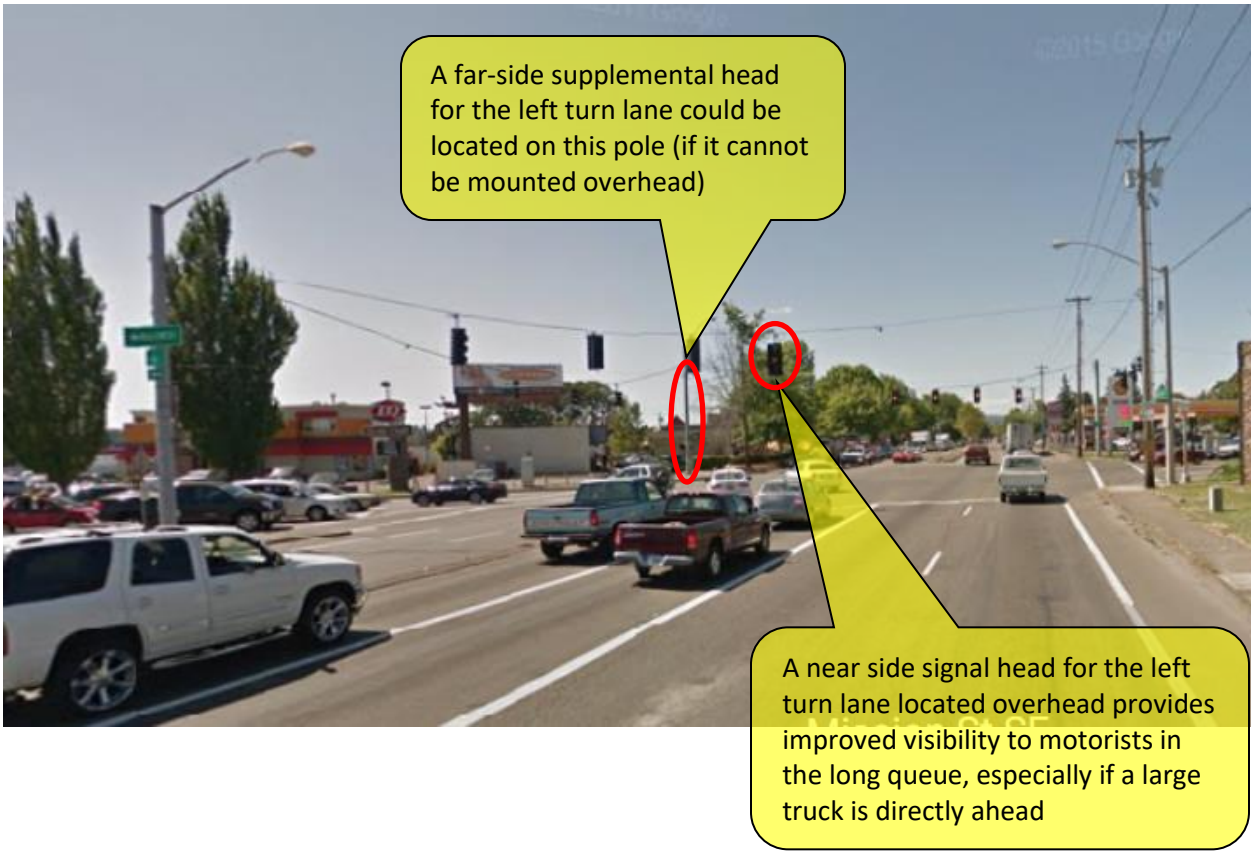


Figure 5-34 | Supplemental near-side signal head placement: Example2



Supplemental signal heads can help improve the operation and reduce the likelihood of red light running for minor phases under certain conditions. For example, a left turn phase that has a high volume (the phase typically maxes out rather than gaps out and has long queues) with a high volume of large trucks (cars behind the large truck have an obstructed view of the signal indications the closer you get to the intersection) can benefit from a supplemental left turn signal head located overhead (preferred) or on the far-side pole to the left of the left turn phase. See Figure 5-35.

Figure 5-35 | Supplemental near-side signal head placement: Example 3



Supplemental signal heads can be beneficial for locations with known sun glare issues where the east/west facing signal heads are in direct alignment with the sunrise or sunset during certain times of the year. Sun glare can make it difficult to maintain continuous visual contact with the signal indication while approaching the intersection (temporary blindness) or difficult to determine what signal indications are on or off. While current signal indication standards have helped solve the issue of sun reflection falsely "lighting up" indications that are not actually on (clear lens with only the LEDs providing the color vs. older versions indications where red/yellow/green colored lens were used with white incandescent bulbs), maintaining continuous visual contact still remains an issue. A supplemental signal head may be able to provide a better position or angle that helps direct the driver's eye away from the sun. See Figure 5-36.

Figure 5-36 | Supplemental Signal Head Placement – Sun Glare Example

5.2.4 Head Mounting

There are two approved ways to mount signal heads:

- Adjustable Bracket for attachment to a mast arm
- Spanwire Hanger for attachment to a span wire

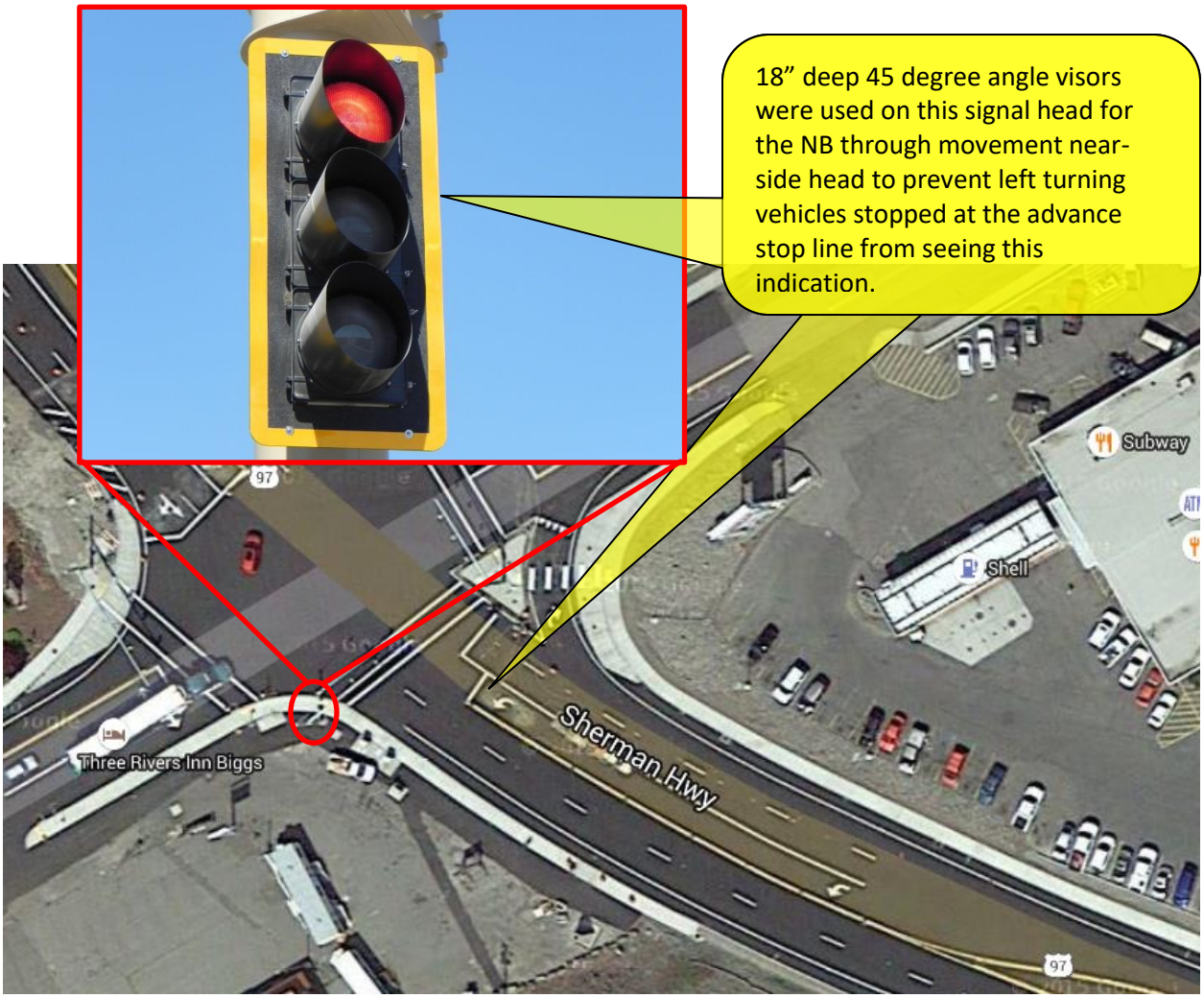
In the past, the use of plumbizers (and elevated plumbizers) to attach signal heads to mast arms was the standard, common practice. This practice required very precise control of vertical constraints, as plumbizers didn't allow much flexibility for installation. Adjustable Brackets, on the other hand, offer much more flexibility of the control of the vertical elevation.

5.2.5 Signal Head Louvers and Angle Visors

In situations where it is possible to view multiple conflicting phases of traffic signal indications, which may lead to motorist confusion, signal louvers and/or 18” deep 45 degree angle visors should be used. See Figure 5-37.

Programmed signal heads were used in the past, but are no longer an option.

Figure 5-37 | Cut-off visor Example



5.3 Sign Requirements and Layout

Depending on the operation of the intersection and type of signal heads used, certain signs may be required. Other signs may be recommended or optional. The following figures show common signs associated with traffic signal control. Note that positive symbol signs (i.e. "THROUGH ONLY" sign, which tells the motorist what to do) are preferred over negative word signs (i.e. "NO RIGHT TURN" sign, which tells the motorist what NOT to do).

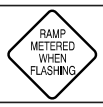
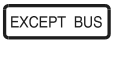
All the signs listed in Figure 5-38 and Figure 5-39 are typically shown and detailed on the signal plan sheet, NOT on the signing plan sheet.

Note for signs mounted on signal structures: When showing and detailing design items on signal plan sheets that have the potential to also be shown and detailed in other discipline's plan sheets (e.g. Signs, Bollards, Illumination, ITS), always coordinate with the other discipline to ensure that the design item is only detailed in one plan sheet, not both. If the item is detailed in both plan sheets, it causes confusion during construction as to how the design item is paid for. This can result in paying twice for the same item or extra paperwork and time to define how the item will be paid for.

Figure 5-38 | Common Signs Used for Traffic Control

SIGN NUMBERS & SIZE (signs beginning with an "O" are Oregon specific)	SIGN TYPES: Aluminum	SIGN TYPES: Part Time Restriction	RECOMMENDED OR REQUIRED
R6-2L 30"x36"	AL 1L		Required for one-way streets. One way signs can be installed on the mast arm (R6-2L) OR ground mounted (R6-1L). See MUTCD 2B.40(P10)
R6-2R 30"x36"	AL 1R		Required for one-way streets. One way signs can be installed on the mast arm (R6-2R) OR ground mounted (R6-1R). See MUTCD 2B.40(P10)
R10-11A 30"x36"	AL 3		Region Traffic Engineer Operational Approval Required
OR3-12 30"x36"	AL 3U		StateTraffic-Roadway Engineer Operational Approval Required
R5-2 30"x30"	AL 3T		StateTraffic-Roadway Engineer Operational Approval Required (typically used in conjuction with U-turn permitted sign)
OR3-5TD 30"x36"	AL 4		
R3-6L 30"x36"	AL 4L		
R3-6R 30"x36"	AL 4R		
OR3-5TT 30"x36"	AL 4T		
R3-5L 30"x36"	AL 5L		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5R 30"x36"	AL 5R		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5A 30"x36"	AL 5T		
R3-3 36"x36"	AL 6		Use of appropriate lane use signs is preferred over R3-3

Figure 5-39 | Common Signs Used for Traffic Control (Cont.)

SIGN NUMBERS & SIZE (signs begining with an "O" are oregon specific)	SIGN TYPES: Aluminum	SIGN TYPES: Part Time Restriction	RECOMMENDED OR REQUIRED
R3-2 36"x36"	AL 6L	PR 6L	Use of appropriate lane use signs is preferred over R3-2. PTR version used for RxR applications
R3-1 36"x36"	AL 6R	PR 6R	Use of appropriate lane use signs is preferred over R3-1. PTR version used for RxR applications
R5-1 36"x36"	AL 7		
R10-28 24"x30"	AL 8		For overhead mounting
OR20-1 24"x12"	AL 8s		
R10-6 24"x36"	AL 9		
R10-12 30"x36"	AL 11		Required with a Type 4L signal head. Recommended when a permissive left turn phase has an exclusive left turn lane. Optional otherwise.
OR10-15 30"x36"	AL 12		Required with a Type 5 signal head
W3-8 36"x36" 	AL 16		
OR20-5 24"x30"	AL 17		
W3-4 36"x36"	AL 18		
W16-13p 24"x18"	AL 19		
OR3-7a 30"x9" 	AL 20		

5.3.1 Layout of Regulatory Signs

Regulatory signs installed on mast arms or span wires should either be located near the signal head that they apply to or centered within the lane that they apply to. For example, the "TURNING VEHICLES YIELD TO PEDS" sign should be placed near the right turn signal head and the "LEFT TURN YIELD ON green ball" sign should be centered within the left turn lane. When placing signs next to signal heads, they will need to be a minimum of 3 feet apart (measured for the center of the signal head to the center of the sign). This accommodates placement of a standard regulatory sign next to all signal indications except for a type 4L (doghouse) head. If placing a sign next to a type 4L head, the sign needs to be a minimum of 4 feet apart.

In the situation where the signal head and the sign should both be centered over the lane (i.e. three through lanes each with a "THROUGH ONLY" sign), the location of the signal head takes precedence (center over lane) and the sign should be located just to the left or right of the signal head. The message on sign will help determine which side of the signal head to place it on. For example, in the left-most through only lane, the "THROUGH ONLY" sign would be more beneficial if placed to the left of the signal head where it is more in the motorist's line of sight if they attempt to make an incorrect left turn. In the right-most through only lane, the "THROUGH ONLY" sign would be more beneficial if placed to the right of signal head for the same reason. In the center through only lane, the placement of the sign to the left or right of signal head would both be equally beneficial.

Occasionally, there are times when two regulatory signs may be desired for one lane. For example, an exclusive right turn lane with a type 5 signal head; The "RIGHT TURN YIELD TO PEDS ON green ball" sign is required and the "RIGHT TURN ONLY" sign may also be appropriate to install. In this case, it is recommended to install one sign to the left of the signal head and one sign to the right of the signal head.

Some signs are applicable to all lanes of traffic, such as the "ONE WAY" signs. In this case, the sign should be placed in the location where the information would be the most critical. For example, on a three lane approach where a "ONE WAY left arrow" sign is required, the location where this information is most critical is the right-most travel lane (of the three approach lanes, a motorist in the right-most lane is most likely to make wrong-way movement).

For large and/or complex intersections, locating the appropriate signing can sometimes be challenging and ideal spacing and location of signs and signal heads may not always be achievable. In these cases, aligning all of the necessary equipment becomes a bit of an art, but the final product should broadcast clear, unmistakable information to the approaching motorist.

5.3.2 Street Name Signs and Guide Signs (Custom Designed Signs)

Street name signs and guide signs are custom designed signs (vs. standard MUTCD regulatory signs). Custom designed signs that are mounted to signal poles, mast arms or span wires are detailed on a separate sign plan sheet and only referenced on the signal plan sheet (see the ODOT Traffic Signal Drafting Guide for how to reference custom signs). Custom signs are NOT part of the lump sum traffic signal bid item; they are paid for under the signing bid items (type of sign by the square foot and sign mount type).

Street name signs are required at each intersection, for each approach leg. The standard location for the street name sign is on the mast arm or span wire. If possible, the street name sign should be the sign located closest to the signal pole. All other appurtenances on the mast arm should be located to the left of the street name sign.

Standard signal pole design, as per Standard Drawings TM650 and TM660, allows a maximum street name sign area of 21 square feet (mounted on the mast arm or span wire) and a maximum guide sign of 60 square feet (mounted on the signal pole). Always verify the size of custom signs to ensure they do not exceed the maximum dimensions. If a sign does exceed the maximum dimensions, there are a couple of solutions that can work (listed in order of preference):

1. Contact the sign designer and request a re-design of the sign to fall within maximum dimensions.
2. Ground mount the sign near the signal pole
3. Contact the Traffic Structures Engineer and request an analysis/recommendation for the oversized sign. A non-standard signal pole (SMX) will likely be required.

5.3.3 Part Time Restriction Signs (PTR)

Part Time Restriction (PTR) signs are sometimes used depending on the desired operation (see the operational approval). PTR signs are electronic signs that appear black (blank-out) when not in use and display text/symbols when in use. The most common applications for use of a PTR sign includes signals with railroad/light rail preemption. Other unique applications include restricting turning movements by time-of-day/day-of-week or during certain portions of the signal phasing.

5.3.4 Materials and Mounting

The standard material for small signs mounted on signal structures (poles, mast arms, span wires, pedestals) is sheet aluminum. Extruded aluminum is used for larger signs. In the past, interior illuminated signs were used on signal installations due to the poor performance of sign sheeting when signs were mounted overhead. However, with the vast improvement of modern sign sheetings, coupled with the effort to be more energy efficient, interior illumination is no longer necessary or desirable. Modern sign sheetings are extremely effective and visible when mounted overhead and do not have

the extra maintenance and power costs that are associated with interior illuminated signs.

There are two approved ways to mount signs:

- Adjustable Bracket for attachment to a mast arm
- Spanwire Hanger for attachment to a span wire

5.4 Pedestrian Signal Equipment Layout

Pedestrian signal equipment location is guided by the Manual on Uniform Traffic Control Devices (MUTCD), the Oregon Supplements to the MUTCD, Americans with Disabilities Act Accessibility Guidelines (ADAAG), and Public Rights of Way Accessibility Guidelines (PROWAG). It should be determined in conjunction with the curb ramp and crosswalk layout. This is an iterative process, typically requiring adjustments of each feature (i.e. curb ramp, crosswalk, and pedestrian equipment) to achieve the best possible design. This process should coordinated with the Roadway Designer and be done early in the design process (i.e. DAP plans) so that right-of-way needs can be addressed in a timely manner.

If raised medians are present, additional pushbuttons and/or pedestrian signal equipment may be required depending on the configuration of the median and the crosswalk. See Section 5.1.5 for requirements.

5.4.1 Use of Pedestrian Detection

Pedestrian detection is required for all crosswalks except when the pedestrian phase will be recalled at all times. Pedestrian recalled phases are common in central business districts.

5.4.2 Pushbutton Requirements

Pushbuttons shall meet the following criteria. Note: A Roadway Design Exception is required if unable to meet any of these requirements. Contact Roadway Designer for assistance.

- Horizontal reach to the pushbutton shall be 10 inches maximum. See Figure 5-40.
    - Pedestal cannot be located behind a curb. See Figure 5-42.
- Clear Space to access the pushbutton shall be within the 10 inch horizontal reach and unobstructed. The Clear Space is 30”x48” for a parallel approach or 36”x48” for a head-in/back-in maneuver with a maximum design slope of 1.5% (Max. 2.0% finished slope surface). See Figure 5-40 and Figure 5-45 thru Figure 5-51.
    - Pedestal foundation shall be installed on a level surface (1.5% max. design slope, max. 2.0% finished slope surface). See Figure 5-43 and Figure 5-44.
- Turning Space is 4.5’ x 5.5’ (Signal Equipment is an obstruction). See Figure 5-54.
- Vertical reach to the pushbutton is 36” to 48” from the adjacent finish grade. See Figure 5-55 and Figure 5-56.

Pushbuttons should meet the following criteria:

- Mounted on a pedestrian pedestal or pushbutton post
- 15 feet maximum from the pushbutton to the edge of the ramp. See Figure 5-57.
- 8 foot minimum separation between buttons (i.e. one pushbutton per pedestal). Note this criterion doesn’t apply to (See Section 5.4.6):
    - Diagonal ramps allowed by Design Exception
    - Two ramps that share a single turning space

5.4.3 Deviations from Pushbutton Location Requirements

Meeting all of the criteria listed in Section 5.4.2 may be impossible at certain locations and compromises in the design will need to be made. The "shall" criteria are the highest priorities and should be met before attempting to meet any other criteria, as not meeting these criteria requires a roadway design exception. The "should" criteria, while important, are a lower priority and can usually be acceptably mitigated by the deviations discussed in Sections 5.4.5, 5.4.6, and 5.4.7.

If unable to meet any of the above listed criteria in Section 5.4.2, deviations may be considered. Common deviations are listed below. Any deviations require approval of the State Traffic Signal Engineer during the Design Approval process.

- Pushbutton mounted on a large pole. See Section 5.4.5.
- Two pushbuttons per pedestal/pole (note: this is the preferred solution for diagonal ramps and two ramps that share a single turning space). See Section 5.4.6.
- Use of an extension bracket mount. See Section 5.4.7.

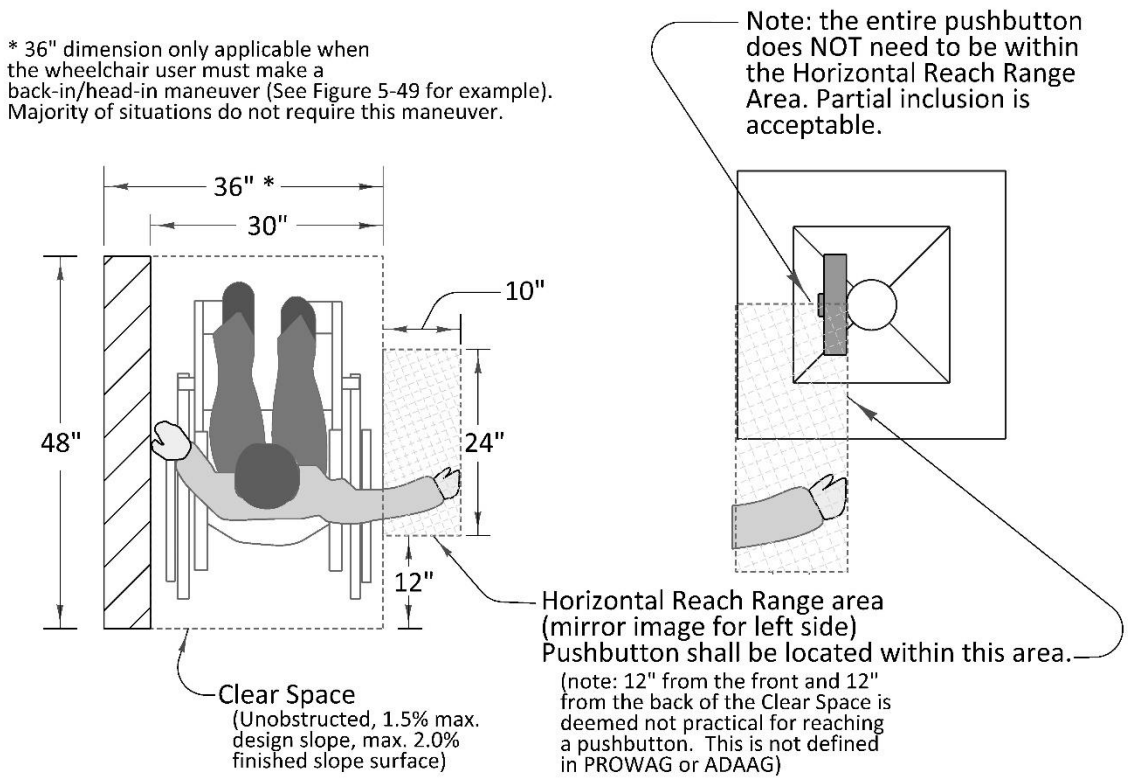
5.4.4 Verifying Pushbutton Requirements

Pushbuttons are mounted with the face of the pushbutton parallel to crosswalk it serves (it should be in-line with the crosswalk striping). It can be mounted on either side of the post as long as all the requirements in Section 5.4.2 are met.

During design, the horizontal reach and Clear Space requirements for the pushbutton should be verified using the "Design Vehicle" (i.e. a wheelchair user) in CADD. See Figure 5-40. The design vehicle should be simulated for each pushbutton in both approach directions. The results of each simulation shall accompany the plan sheets when submitted to the State Traffic Signal Engineer for Design Approval.

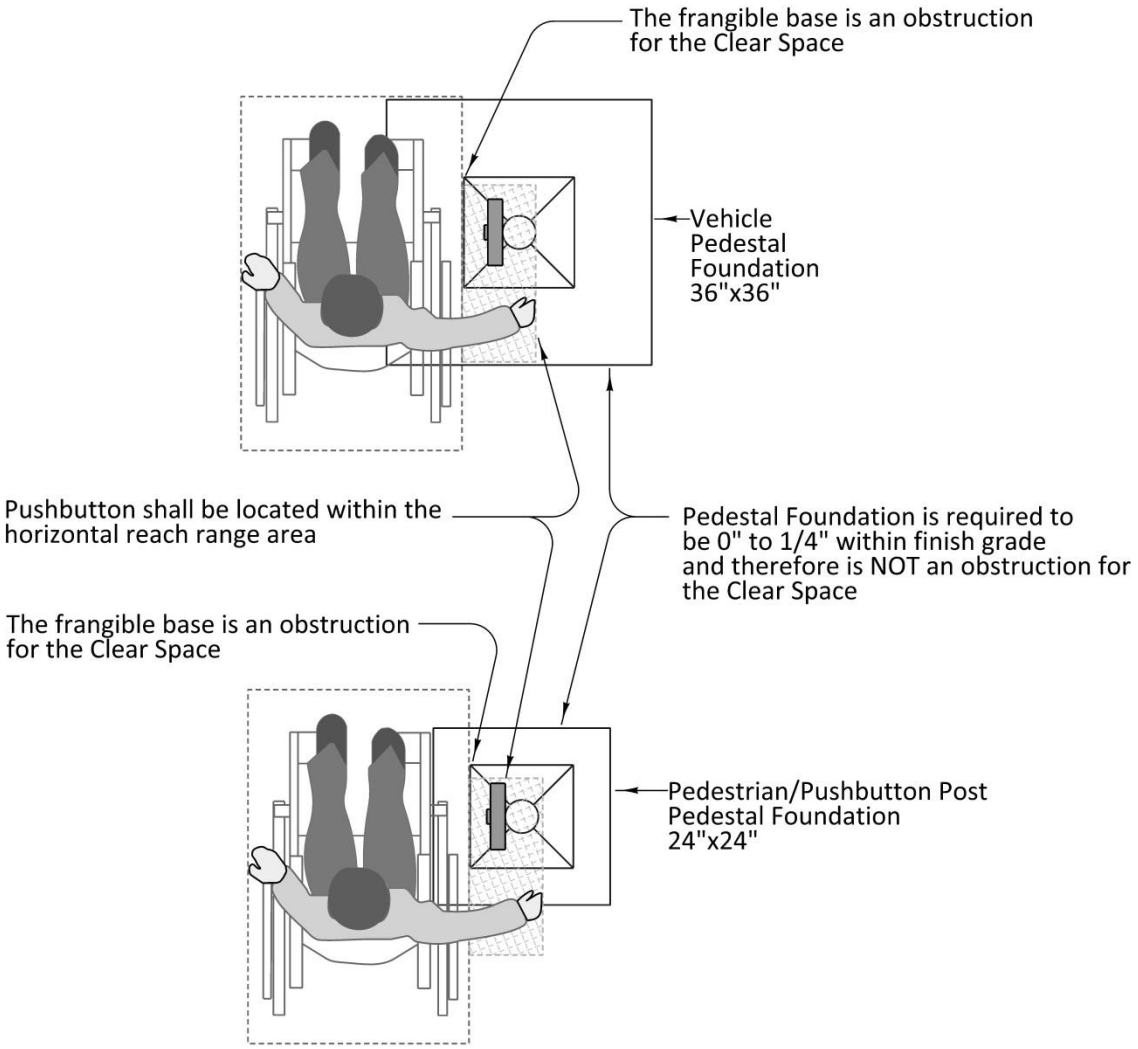
An obstruction to the Clear Space is defined as any vertical difference that is greater than ¼" or any slope that is designed at greater than 1.5% (Maximum 2.0% finished slope surface). When running simulations at each pushbutton, the Clear Space shall be unobstructed.

Figure 5-40 | Design Vehicle (Clear Space with 10" Max Horizontal Reach)



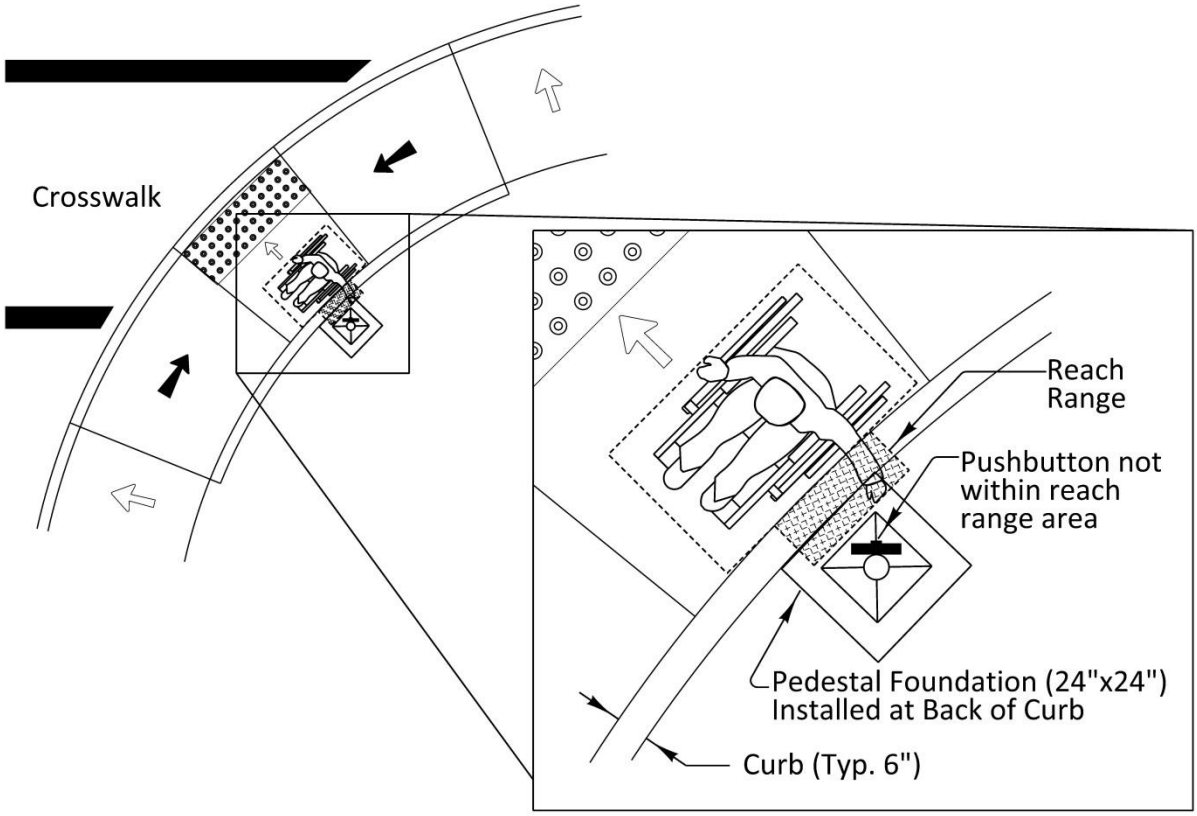
The horizontal reach is measured from the obstruction to the pushbutton. For a pedestrian pedestal or pushbutton post, the obstruction is the edge of the frangible base. The foundation edge is not considered an obstruction as standard drawing TM457 requires the top of foundation to be flush with finish grade (0” to ¼” vertical tolerance). See Figure 5-41.

Figure 5-41 | Measuring Horizontal Reach to Pushbutton Mounted on Pedestal



The 10 inch horizontal reach eliminates the placement of the pedestal behind curbs. Curbs are typically 6 inches wide and with a standard construction of the foundation against the back-of-curb, the horizontal reach becomes approximately 13 inches. See Figure 5-42. While it may be possible to integrate the pedestal foundation with the curb installation to achieve the 10 inch horizontal reach, is not recommended due to the increased the complexity of construction (requires custom design details and excellent coordination and cooperation between subcontractors).

Figure 5-42 | Pedestals Located Behind Curbs Do NOT Meet 10 Inch Horizontal Reach Requirement



Pedestal foundations must be placed on a level surface (1.5% max. design slope) in order to meet the requirements for the 10 inch horizontal reach and Clear Space. See Figure 5-43. Do not place a pedestal foundation across more than one plane. See Figure 5-44.

Figure 5-43 | Pedestal Foundation Placement – Example 1

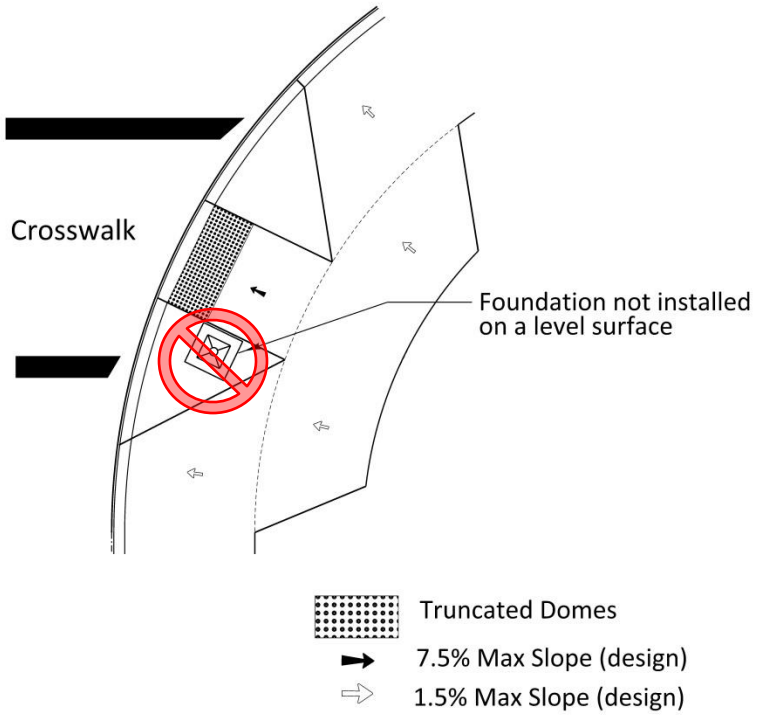
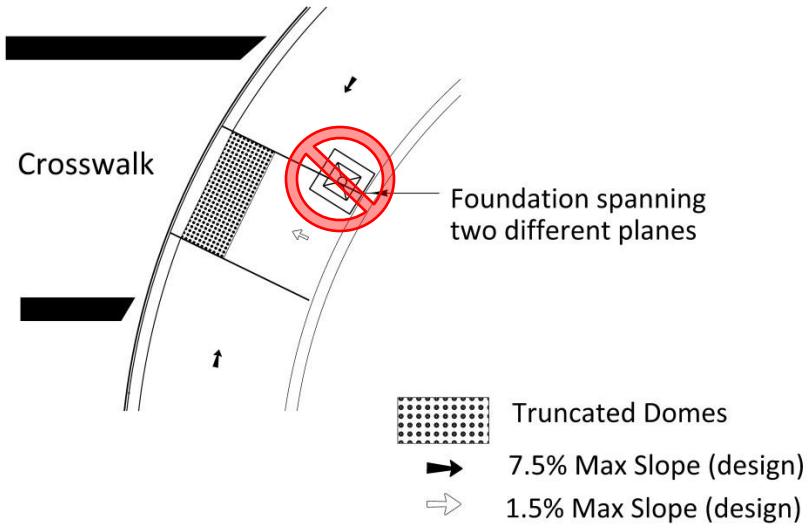


Figure 5-44 | Pedestal Foundation Placement – Example 2

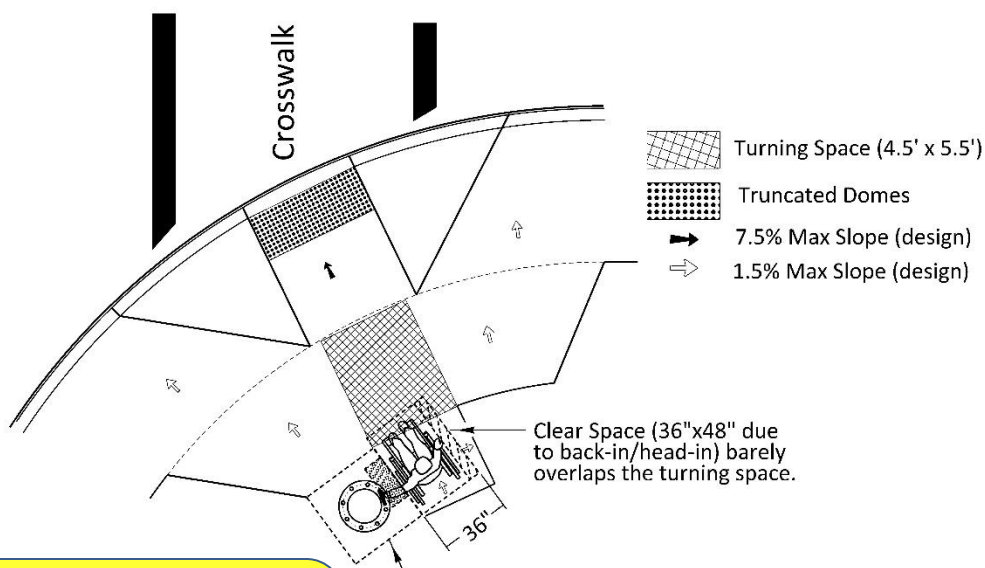


The Clear Space is the area defined as being level (having a maximum design slope of 1.5% or less) and is 30”x48” for a typical parallel approach. If the wheelchair user has to back-in/head-in to access the pushbutton, the clear space requirement becomes a little larger: 36”x48”. Typically the only time a wheelchair user will have to back-in/head-in is when the pushbutton is located on a large pole at perpendicular style ramp. See Figure 5-45. Due to the additional effort required for a back-in/head-in maneuver, ramp design and pushbutton locations that require this maneuver should be avoided.

The ramp Turning Space (with an obstruction at back-of-walk, such as pedestal or signal pole) is defined as the 4.5’x 5.5’ unobstructed area located in front of the ramp, with the longer dimension towards the ramp. The Clear Space and Turning Space are independent of each other; they may coincide, overlap, or not touch depending on the ramp type and geometrics. **The ideal pushbutton location occurs when the Turning Space and Clear Space coincide or have a large overlap for the following reasons:**

- The path the Wheelchair user takes to push the button and use the curb ramp is the most direct path
- The pushbutton location is more likely to meet the other ODOT and MUTCD Section 4E.08 criteria (i.e. distance from crosswalk: See Figure 5-70, distance from edge of curb ramp: see Figure 5-57, etc.)
- Typically easier to meet the sidewalk and curb ramp slope requirements

Figure 5-45 | Turning and Clear Space – Back-in/Head-in Maneuver Required



Note: Back-in/Head-in maneuvers should be avoided. See Section 5.4.5 for more info on mounting pushbuttons on large poles.

Figure 5-46 through Figure 5-48 show pushbutton placement examples for a parallel approach that meets the "Shall" requirements for horizontal reach and Clear Space for the three standard types of ramps (Perpendicular, Parallel, and Combo), while also showing how the Clear Space and turning space relate to each other.

Figure 5-46 | Turning and Clear Space – Perpendicular Ramp (Parallel Approach)

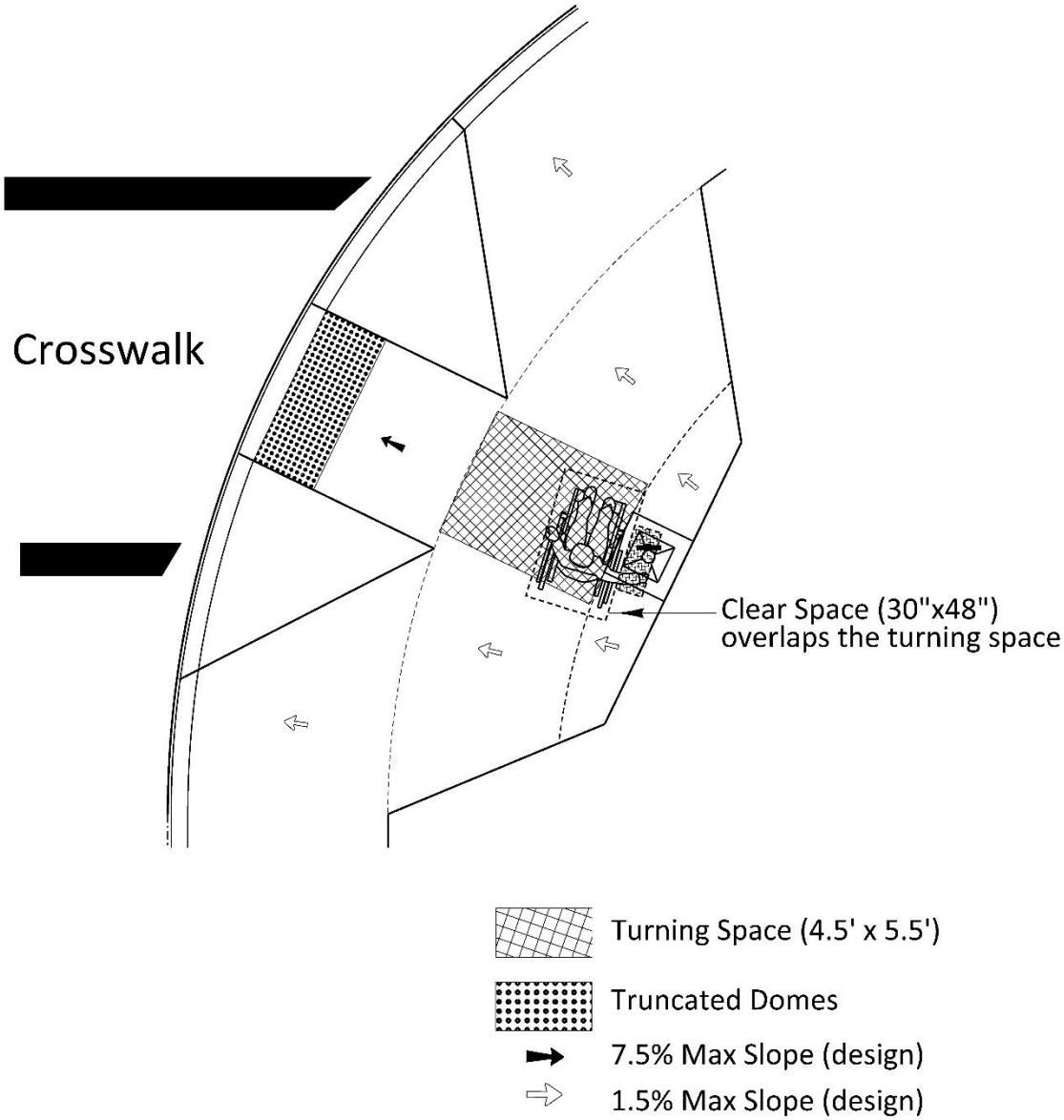


Figure 5-47 | Turning and Clear Space – Parallel Ramp (Parallel Approach)

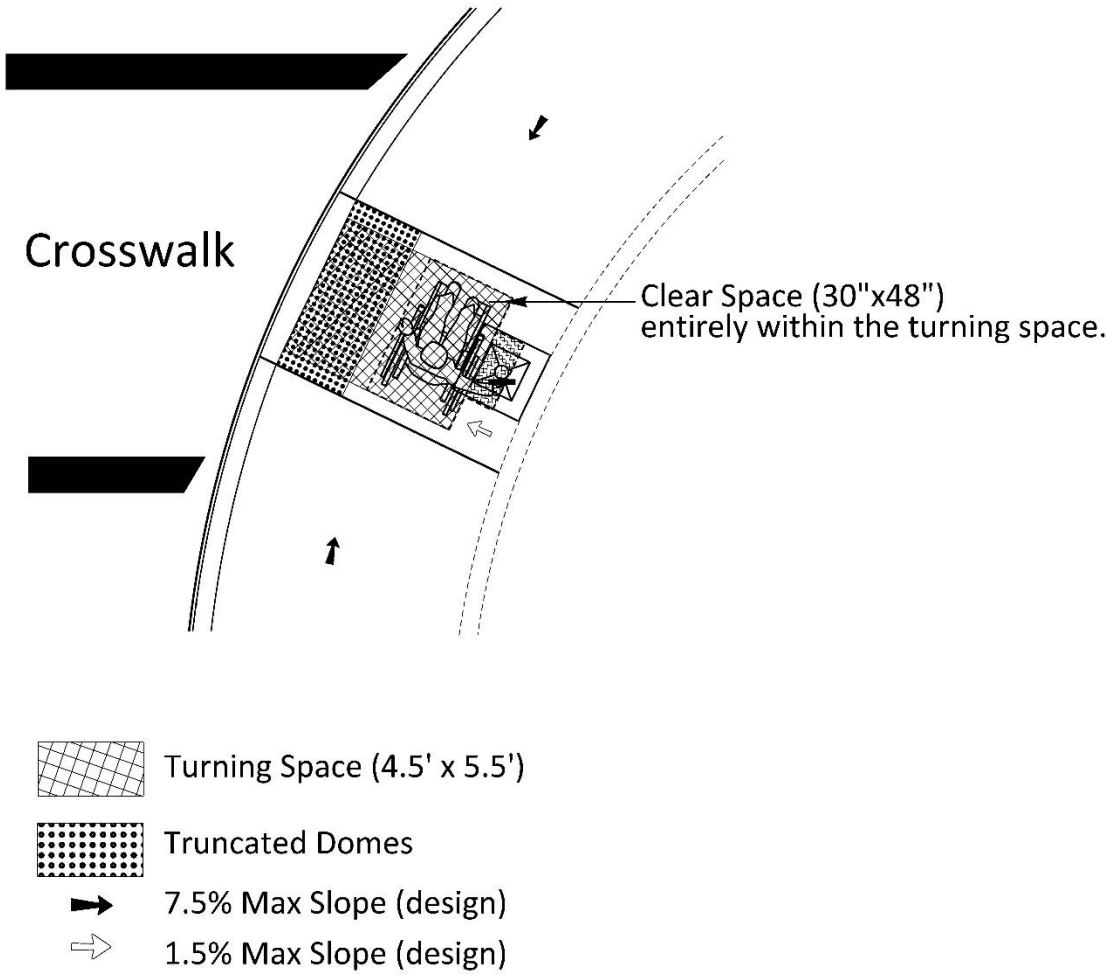
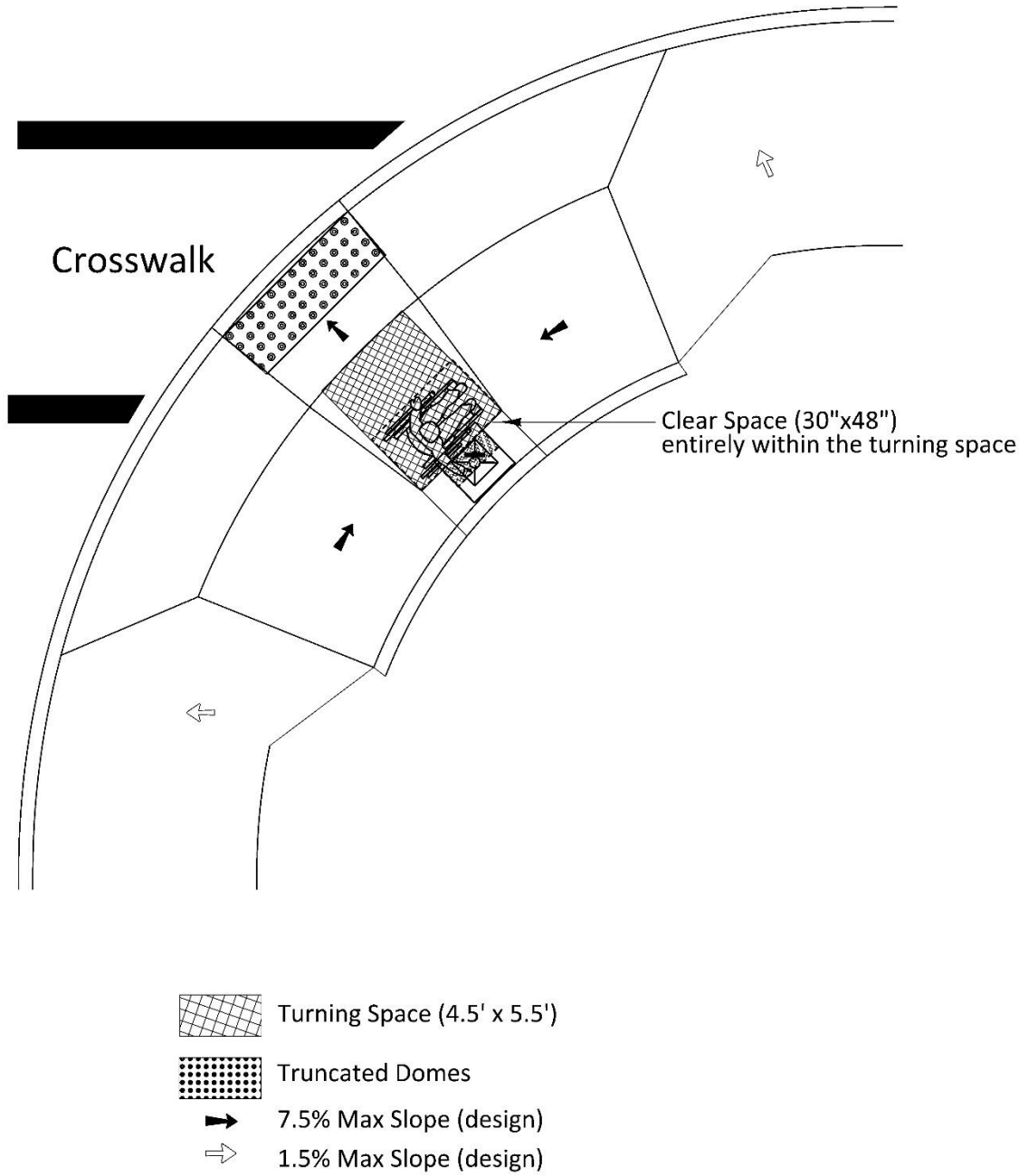


Figure 5-48 | Turning and Clear Space – Combo Ramp (Parallel Approach)



When a wheelchair user is accessing the pushbutton, the Clear Space (30”x48” or 36”x48” as required) cannot be located within any surface that has a designed slope greater than 1.5% (max. 2.0% finished slope surface). See Figure 5-49 through Figure 5-51.

Figure 5-49 | Accessing the Pushbutton – Clear Space within 1.5% Slope (design), Example 1

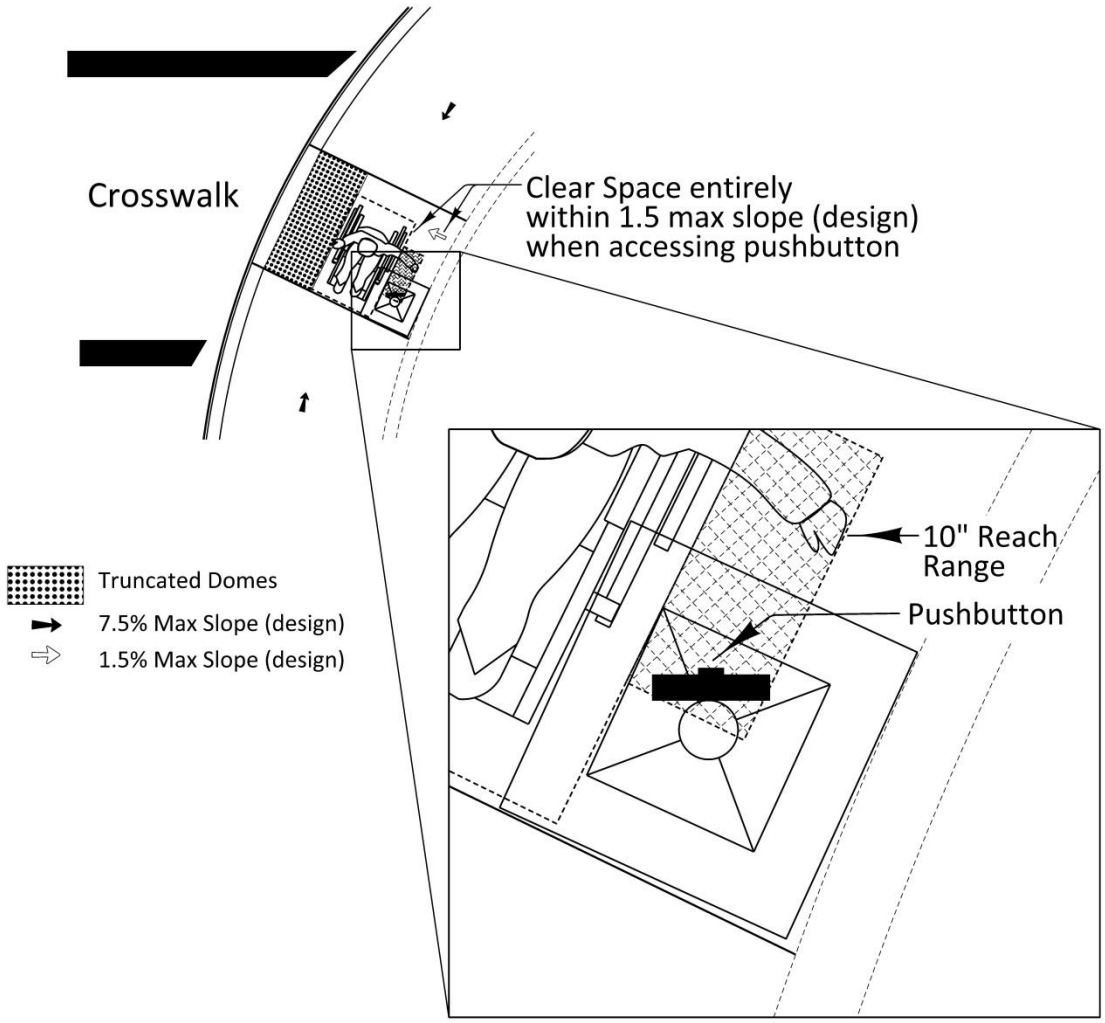


Figure 5-50 | Accessing the Pushbutton – Clear Space within 1.5% Slope (design), Example 2

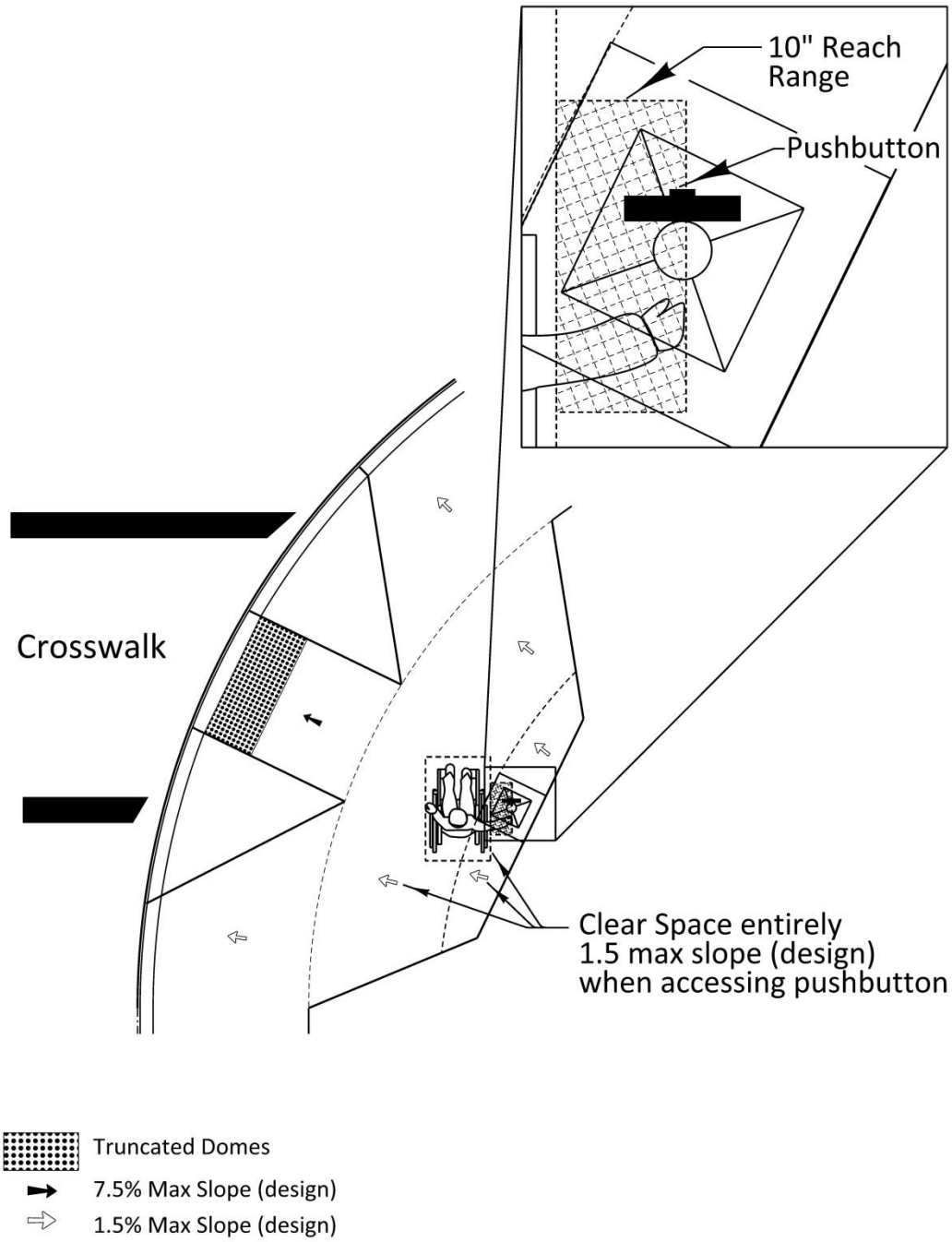
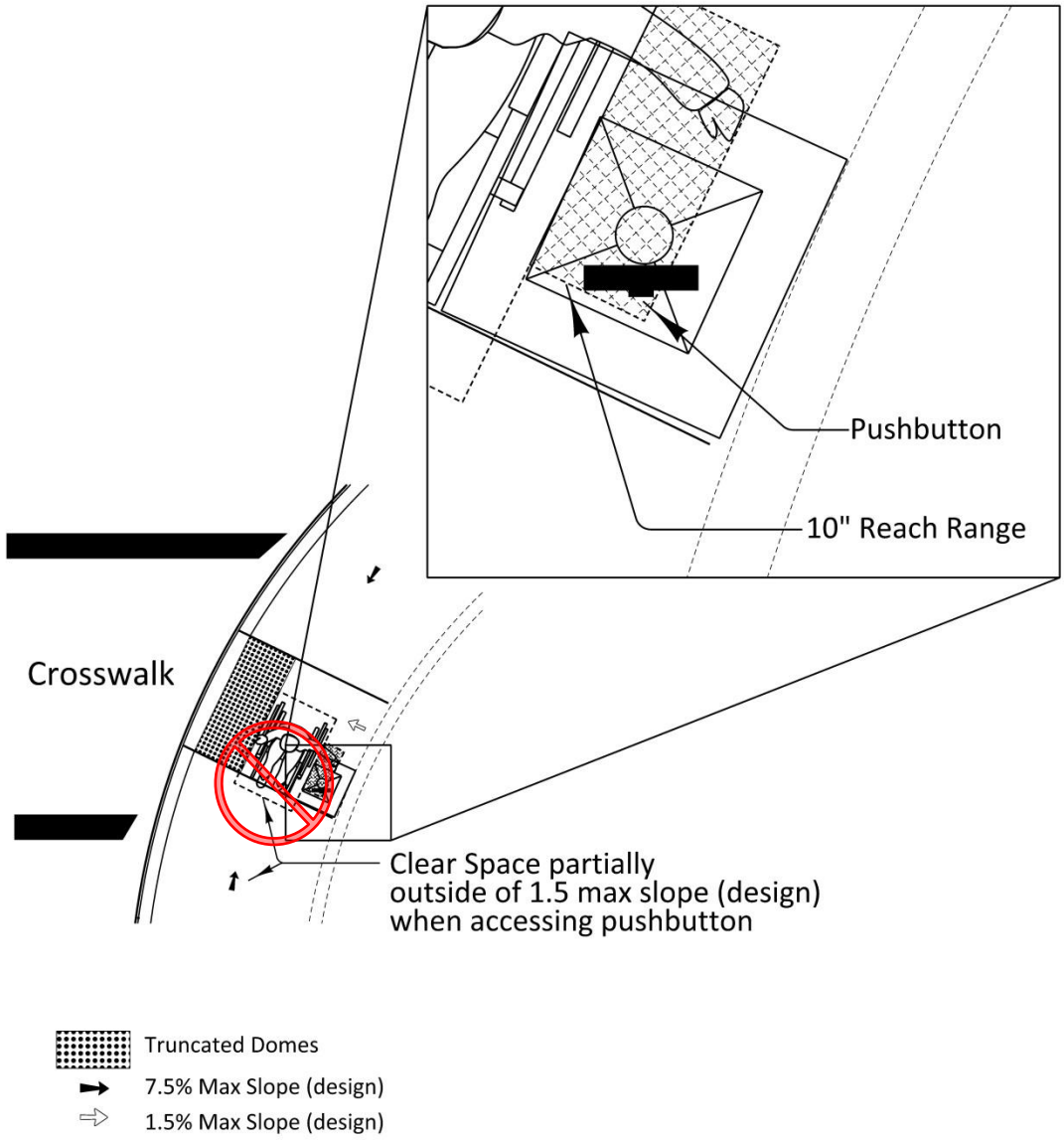


Figure 5-51 | Accessing the Pushbutton – Clear Space NOT within 1.5% Slope (design)

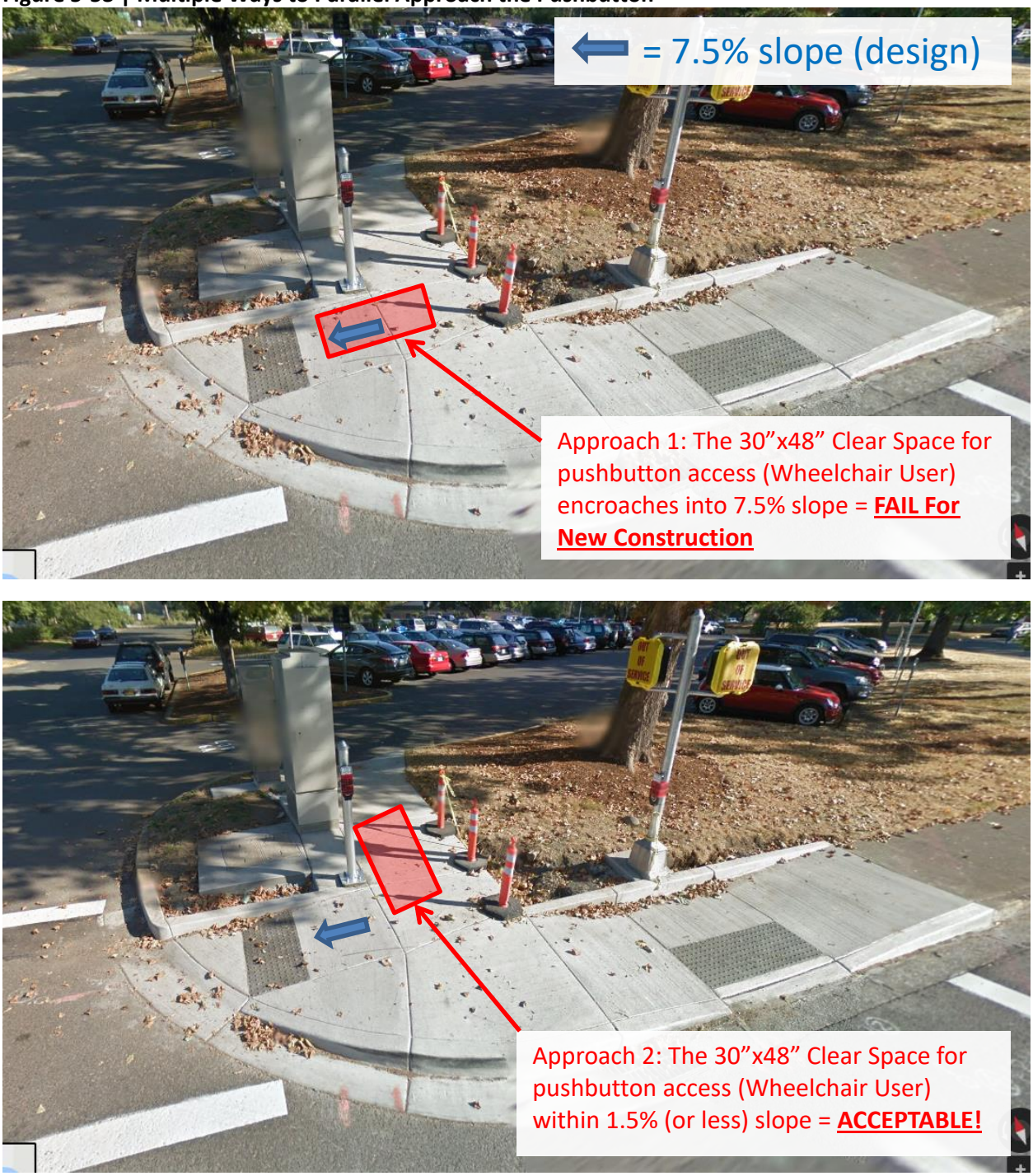


The Clear Space surface shall be comprised of a material that is solid (i.e. concrete, asphalt). Use of a poorly compacted material (pea gravel, uncompacted aggregate or soil) will make it difficult or impossible for a wheelchair user to access the pushbutton. This is especially important to consider for temporary signals. See Figure 5-52.

Figure 5-52 | Poorly Compacted Material Example

Depending on the ramp geometry, there may be multiple ways to parallel approach the pushbutton, which can mean the difference between meeting or failing the Clear Space slope requirement (1.5% design slope). See Figure 5-53. Be sure to verify the Clear Space from all possible approaches with the Wheelchair Design Vehicle in CADD. While only one approach is required to meet the requirements, accessing each approach to the pushbutton can lead to a better overall design that minimizes the amount of maneuvering for the wheelchair user.

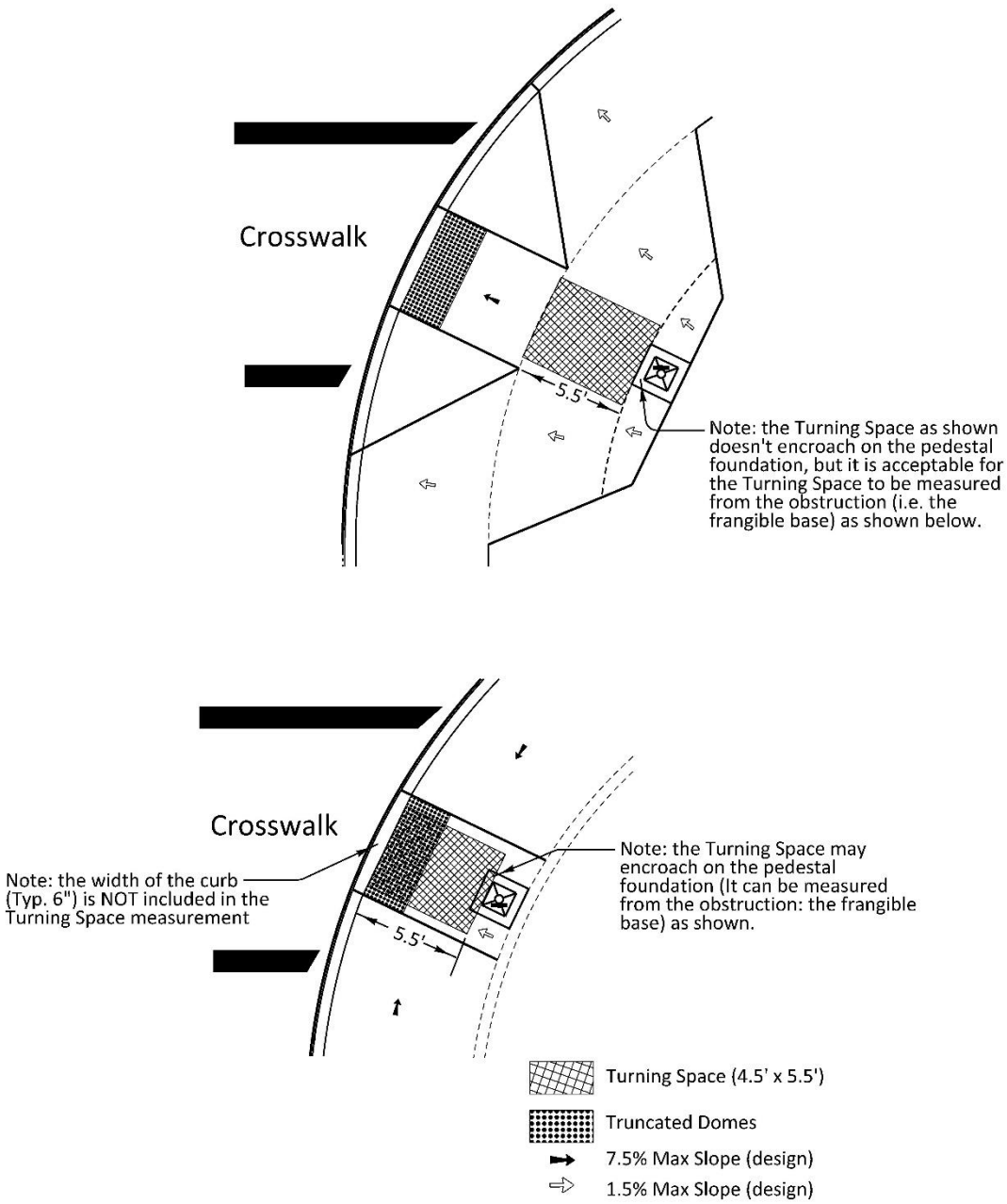
Figure 5-53 | Multiple Ways to Parallel Approach the Pushbutton



The Turning Space for a ramp with pedestrian pedestals or signal poles (i.e. an obstruction) is required to be 4.5’ x 5.5’ with the 5.5’ dimension measured from the obstruction towards the ramp. The width of the curb shall NOT be included in the measurement. An obstruction to the Turning Space is defined as any vertical difference that is greater than ¼” or any slope that is designed at greater than 1.5% (Maximum 2.0% finished slope surface). See

Figure 5-54.

Figure 5-54 | Turning Space Measurement for Ramp with Signal Equipment



The vertical reach requirements for the pushbutton will typically always be met when using standard traffic signal pedestals, poles, and pushbuttons. Pushbuttons mounted to non-standard equipment, structures, or in unusual locations require verification of the vertical requirements. This includes poles with ornamental bases and poles located behind or above barriers. See examples shown in Figure 5-55 and Figure 5-56.

Figure 5-55 | Verification of Pushbutton Vertical Height Required (Non Std. Equipment) – Example 1

Figure 5-56 | Verification of Pushbutton Vertical Height Required (Non Std. Equipment) – Example 2

Pushbuttons should be located no more than 15 feet from the access to the crosswalk (edge of ramp). See Figure 5-57. This distance should be measured going through the middle of the turning space to the edge of the ramp, which may not always be a straight line. See Figure 5-58. In order to achieve the most direct measurement (straight line) the Clear Space and the Turning Space should coincide or have a large overlap.

Note that the MUTCD section 4E.08 states that the pushbutton should be 1.5 feet to 6 feet from the edge of ramp and allows up to 10 feet when physical constraints make closer placement impractical. While it is desirable to follow the MUTCD guidance and stay within 6 feet, we know that many ramps designed using ODOT standards will not even allow the placement of a pushbutton within 10 feet due to the slope requirements and the 7 inch standard curb exposure. Therefore, ODOT allows up to 15 feet to accommodate the majority of ramp designs.

If it is not feasible to place the pushbutton within 15 feet, adjustments to the signal timing WALK phase can be made to mitigate the longer distance. Be sure to coordinate with the Region Signal Timer if this distance will exceed 15 feet.

Figure 5-57 | Distance from Pushbutton to Crosswalk (Edge of Ramp)

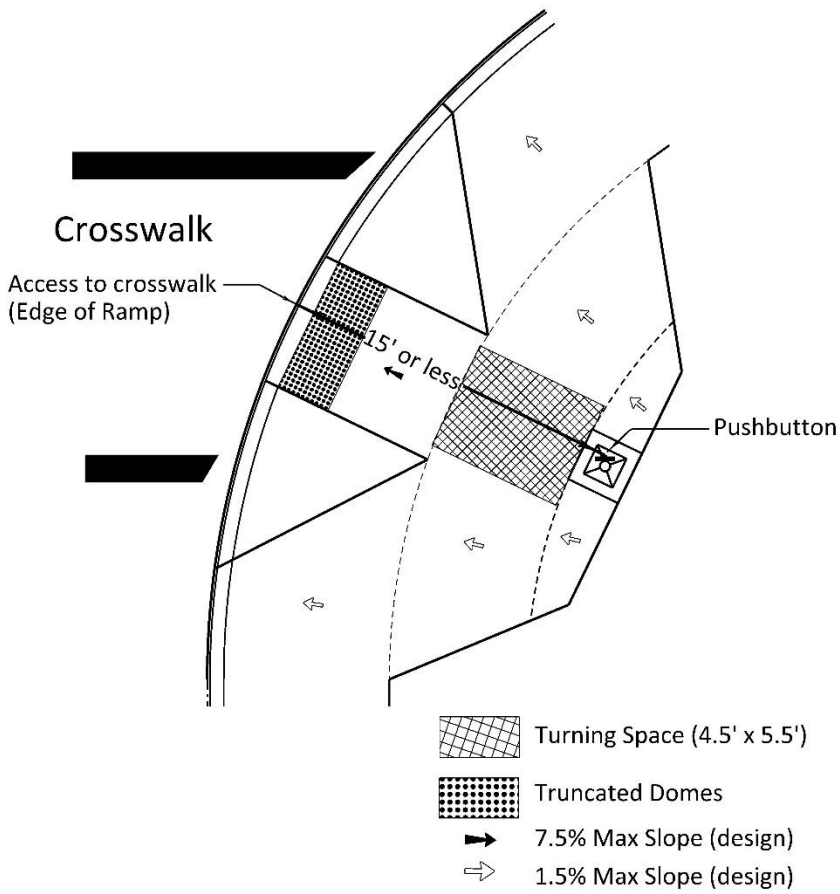
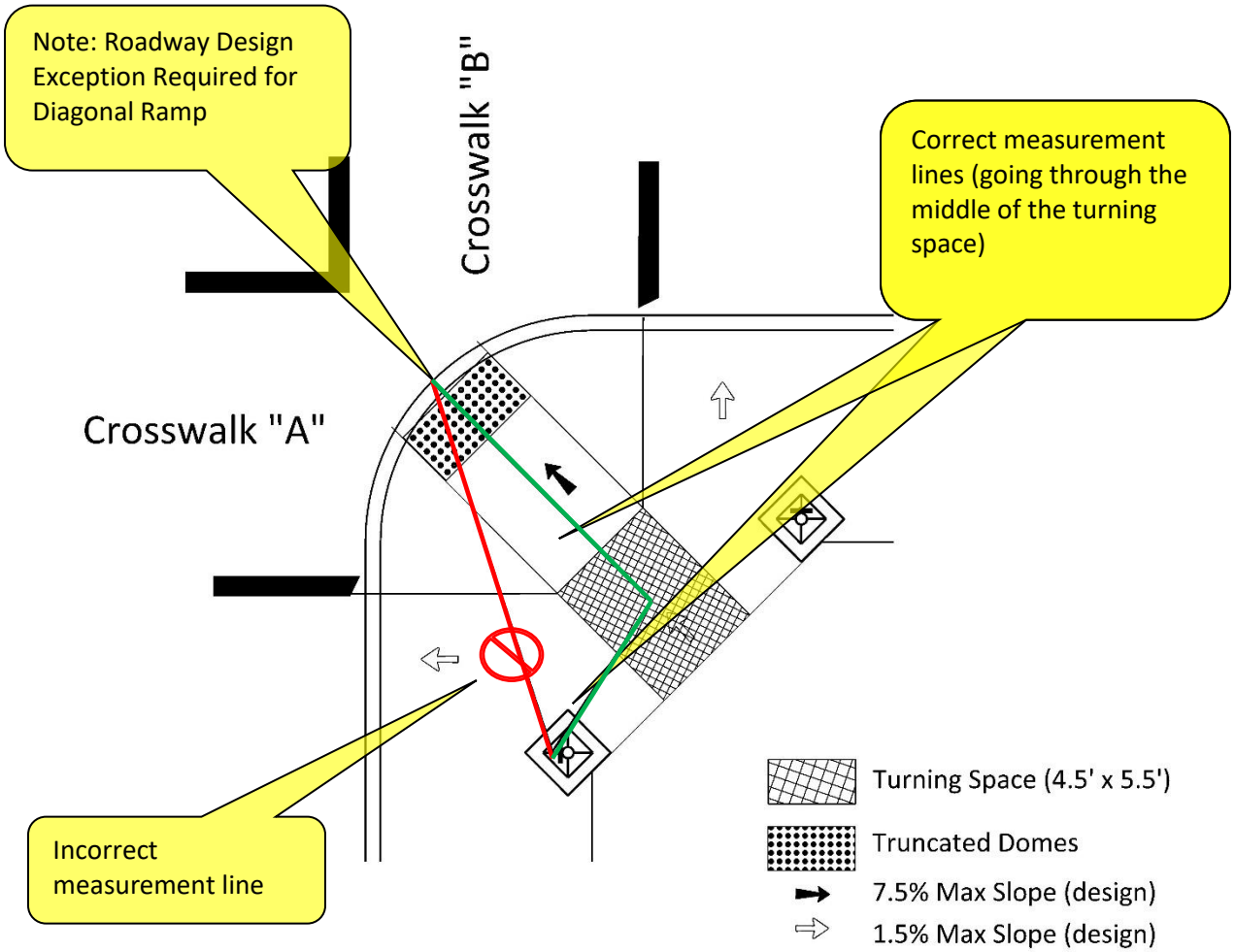


Figure 5-58 | Measuring Distance from Pushbutton to Crosswalk (Edge of Ramp) Example

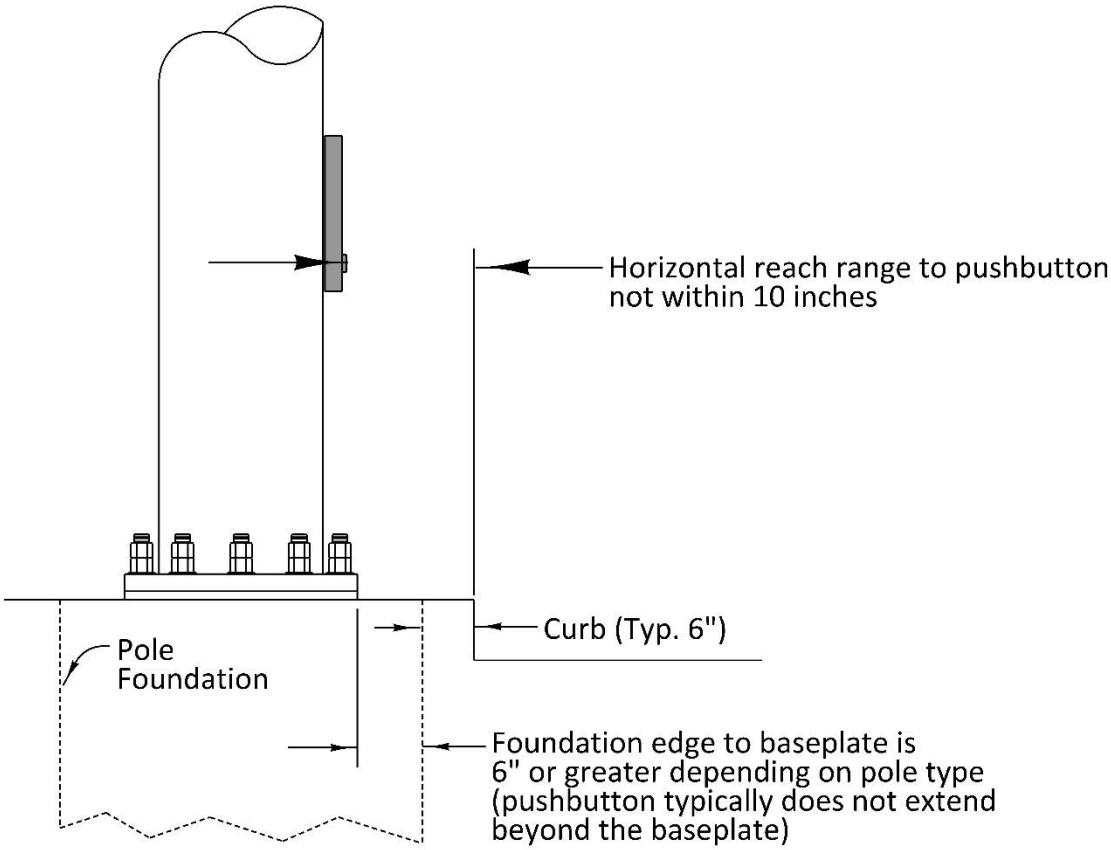


5.4.5 Deviation: Pushbutton Mounted on a Large Pole

Pushbuttons mounted on large poles are discouraged due to the tight tolerances for the 10 inch horizontal reach and high probability of requiring an extension bracket mount. As such, pushbuttons mounted on a large pole should only be considered in rare cases where a pedestal/pushbutton post cannot be installed (i.e. areas with limited right-of-way, utility conflicts, etc.).

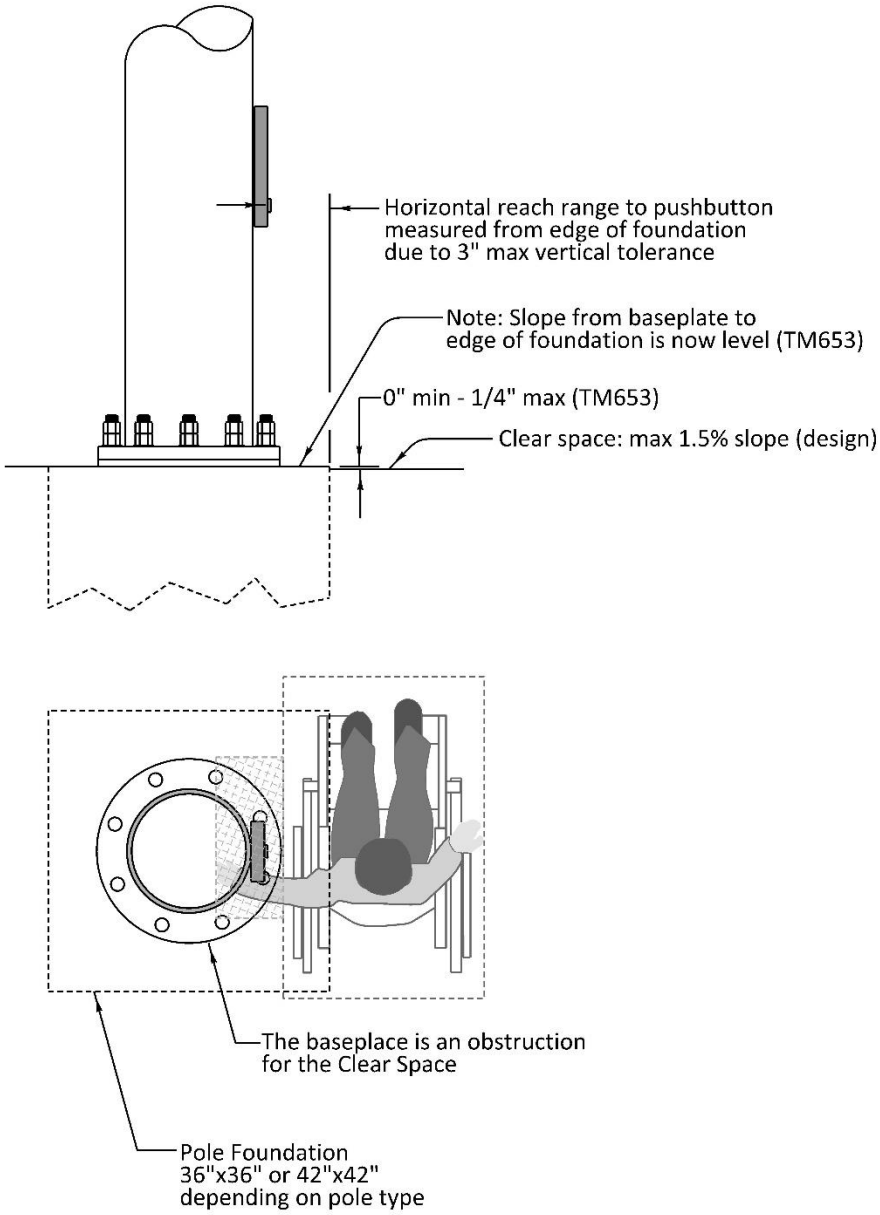
Mounting a pushbutton to a large pole limits the type of ramp that may be used. Typically only a perpendicular ramp style will work, with a larger clear space to accommodate the back-in/head-in maneuver. See Figure 5-45. The two other ramp styles (parallel and combo) both include a curb which will not meet the 10 inch horizontal reach if the pole is placed behind the curb. See Figure 5-59. Unlike a pedestal foundation, it is typically not practical to place the large pole foundation in front of the curb. Integrating the pole foundation with the curb installation, to achieve the 10 inch horizontal reach, is also not recommended due to the increased the complexity of construction (requires custom design details and excellent coordination/cooperation between sub-contractors).

Figure 5-59 | Poles Located Behind Curbs Do NOT Meet 10 Inch Horizontal Reach Requirement



The foundation of the large pole is no longer an obstruction to the clear space due to recent changes to standard drawing TM653 (the slope from baseplate to edge of foundation is now level and the vertical tolerance of the foundation to the adjacent asphalt or concrete finish grade is now 0” to ¼”). For large poles constructed after January 2020, the baseplate is the obstruction to the Clear Space. See Figure 5-60.

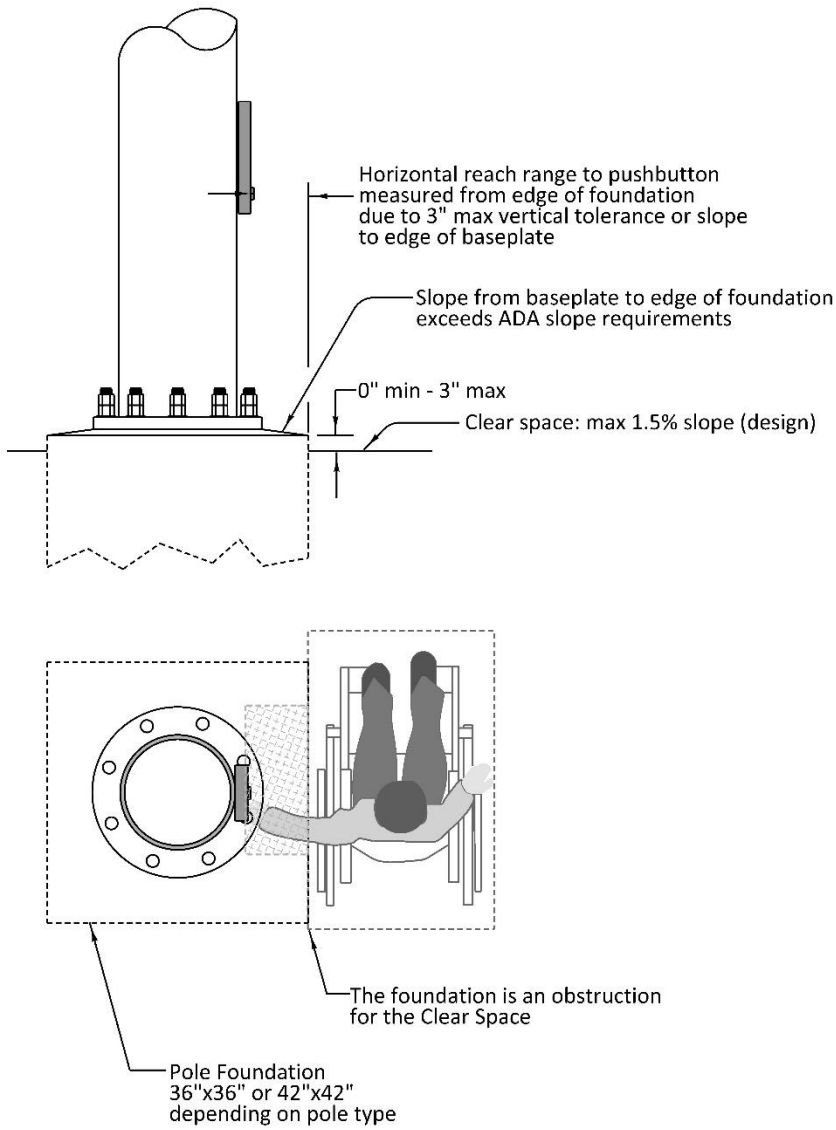
Figure 5-60 | Measuring Horizontal Reach to Pushbutton Mounted on Large Pole (POLES CONSTRUCTED AFTER JANUARY 2020)



For poles constructed before January 2020, the foundation is likely an obstruction to the clear space for two reasons (see Figure 5-61):

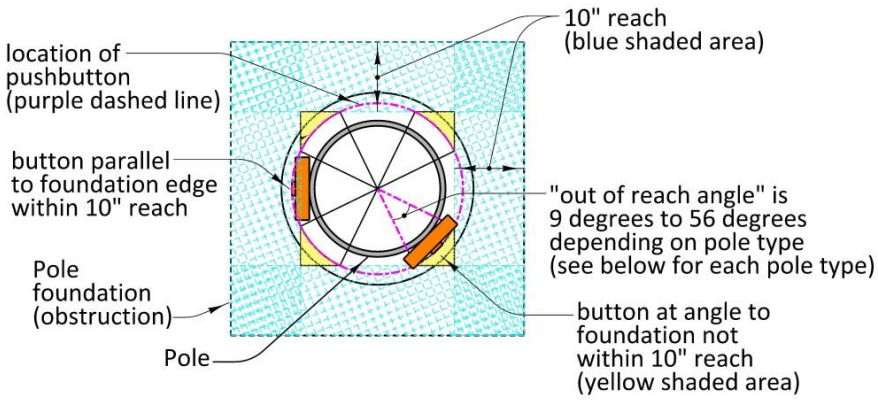
- the 3 inch max vertical tolerance for foundation exposure with respect to the adjacent finish grade, or
- the slope from the foundation control point to the edge of the baseplate exceeds ADA slope requirements.

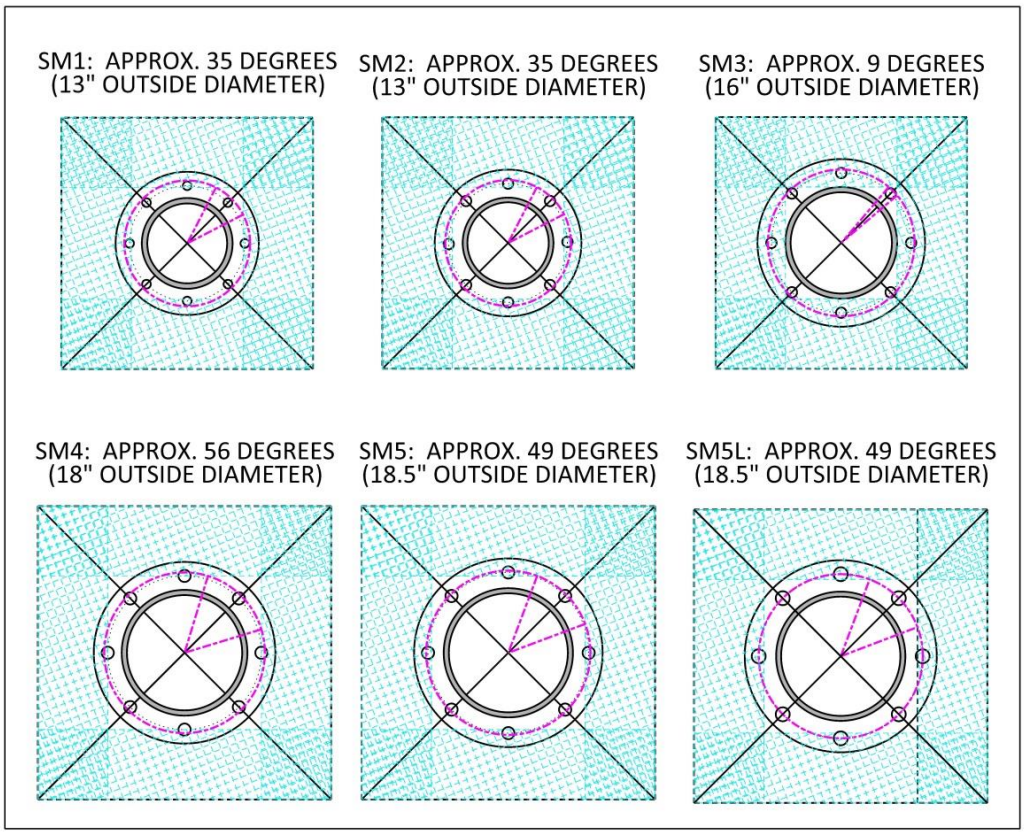
Figure 5-61 | Measuring Horizontal Reach to Pushbutton Mounted on Large Pole (POLES CONSTRUCTED BEFORE JANUARY 2020)



For poles where the foundation is an obstruction for the clear space (typically poles constructed before January 2020), the reach distance measured from the edge of the signal pole foundation to the pushbutton will just barely meet the 10 inch horizontal reach for MOST all pole types and pushbuttons listed on the approved Blue Sheets IF THE PUSHBUTTON IS MOUNTED PARALLEL TO THE EDGE OF THE FOUNDATION. See Figure 5-61. If the pushbutton is installed at an angle to the foundation, there is a point where it will fall outside the 10 inch horizontal reach (i.e. "out-of-reach angle"). See Figure 5-62.

Figure 5-62 | Out-of-Reach Angle for Pushbuttons Located on Large Poles (POLES CONSTRUCTED BEFORE JANUARY 2020)





5.4.6 Deviation: Two Pushbuttons Mounted on a Single Pedestal

Two pushbuttons on the same pedestal is the preferred solution for two scenarios:

- For two ramps that share a single turning space
- When a roadway design exception has been granted for a diagonal ramp (one ramp that will serve two crosswalks)

Trying to accommodate the 8 foot button separation for these two scenarios is not recommended due to the following drawbacks:

- The Turning Space and the Clear Space would separated by a large distance. This creates a longer (and unnecessary) path for the wheelchair user in certain directions. For example, a parallel style diagonal ramp the wheelchair user would have to traverse the 7.5% slope three times if approached from a certain direction. See Figure 5-63

- Unable to meet the MUTCD requirement of 60 inch maximum from the outside edge of the crosswalk striping to the pushbutton in the majority of cases. When Pedestrian signal indications are mounted on the same pedestal as the pushbutton, they would likely be blocked from the pedestrian's view by cars stopped at the intersection. See Figure 5-63

- If the buttons are placed adjacent to the turning space (so that the clear space will coincide with or overlap the turning space), typically only 5 to 6 feet of separation can be achieved. Short separation distances are not desirable as they can create an "obstacle course" on the sidewalk that may be difficult for the sight impaired to navigate. See Figure 5-64

Note that the MUTCD section 4E.08 states that the pushbuttons should be separated by 10 feet and allows the pushbuttons to be placed closer or on the same pole when it is impractical to achieve the 10 foot separation. While it is desirable to follow the MUTCD guidance and separate the pushbuttons by 10 feet, we have encountered enough locations where pushbutton separation between 8 to 10 feet provides the best access to the pushbuttons within the site constraints. Pushbutton separation of 8 to 10 feet still allows a reasonable amount of separation to avoid creating an "obstacle course" and alternative audible pedestrian messages for buttons less than 10 apart are allowed as per the MUTCD. Therefore, ODOT allows a minimum pushbutton separation of 8 feet. If it is not feasible to separate the pushbutton 8 feet, both pushbuttons should be mounted on a single pedestal.

Figure 5-63 | Drawbacks to the 10 foot Separation of Pushbuttons at Diagonal Ramps

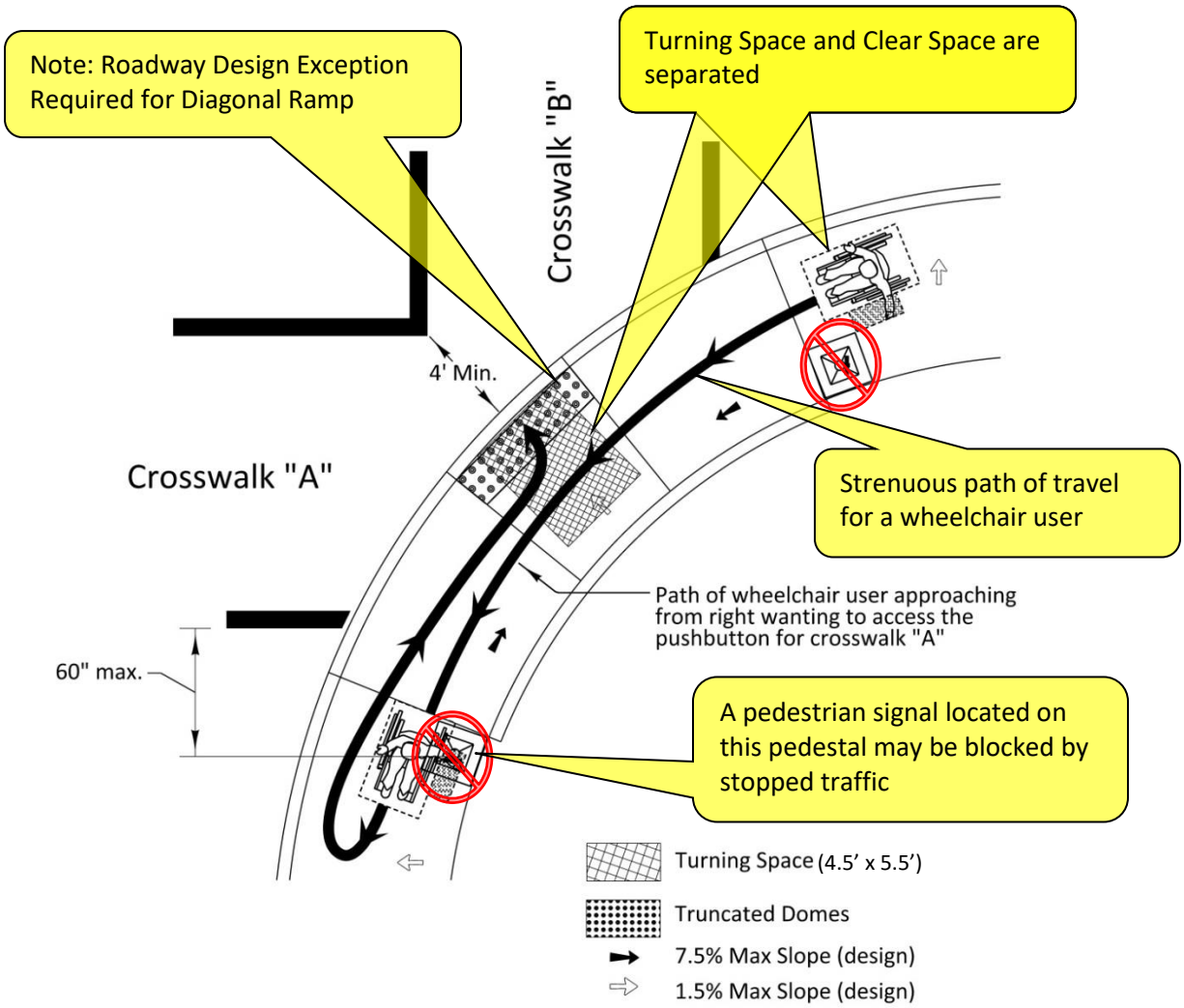
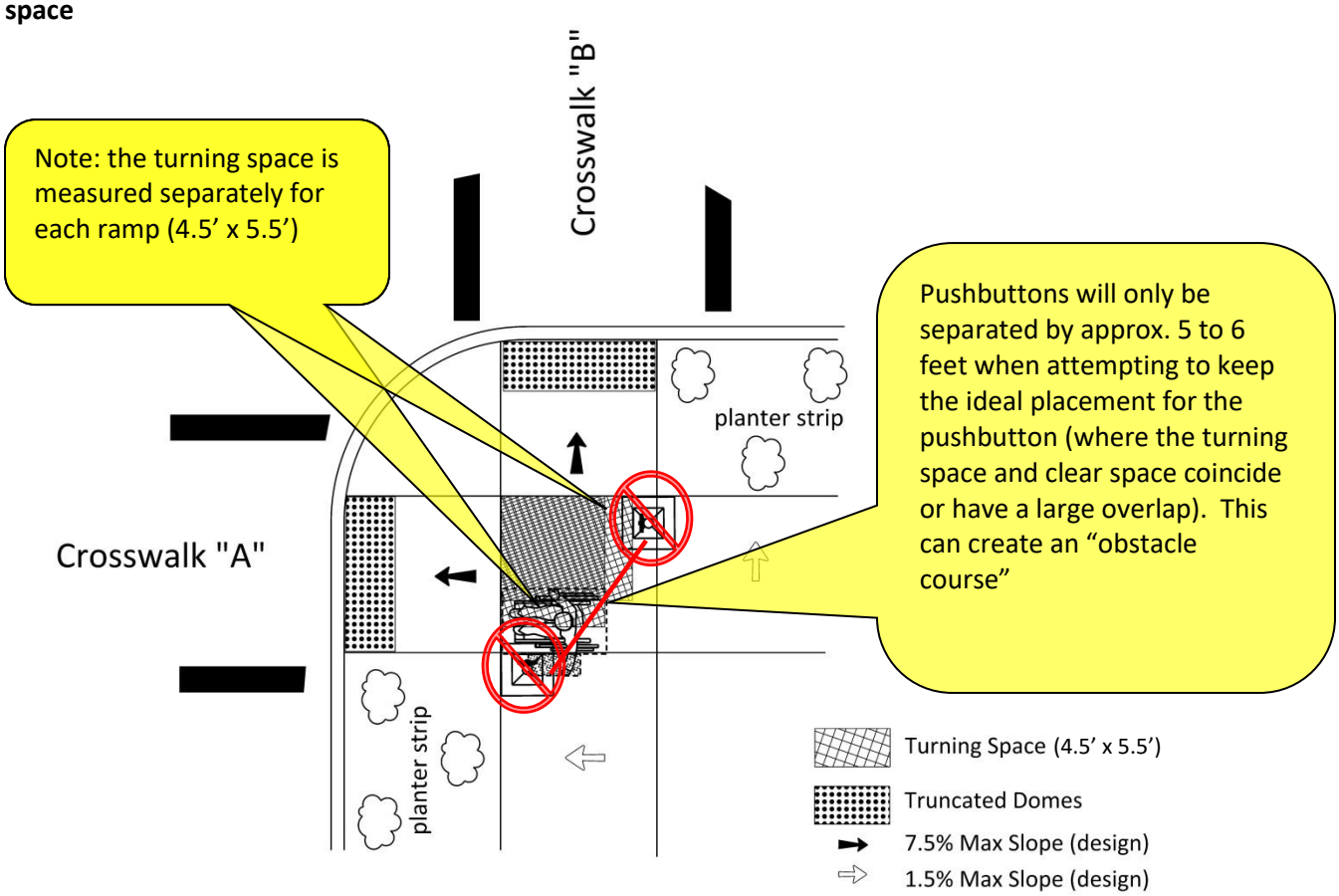


Figure 5-64 | Drawbacks to the 10 foot Separation of Pushbuttons at two ramps that share a turning space



See Figure 5-65 for an example of the preferred placement for two ramps that share single turning space and Figure 5-66 through Figure 5-69 for the preferred placement for common styles of diagonal ramps.

Figure 5-65 | Preferred Pushbutton Placement for two ramps that share a turning space (Two Buttons on Pedestal)

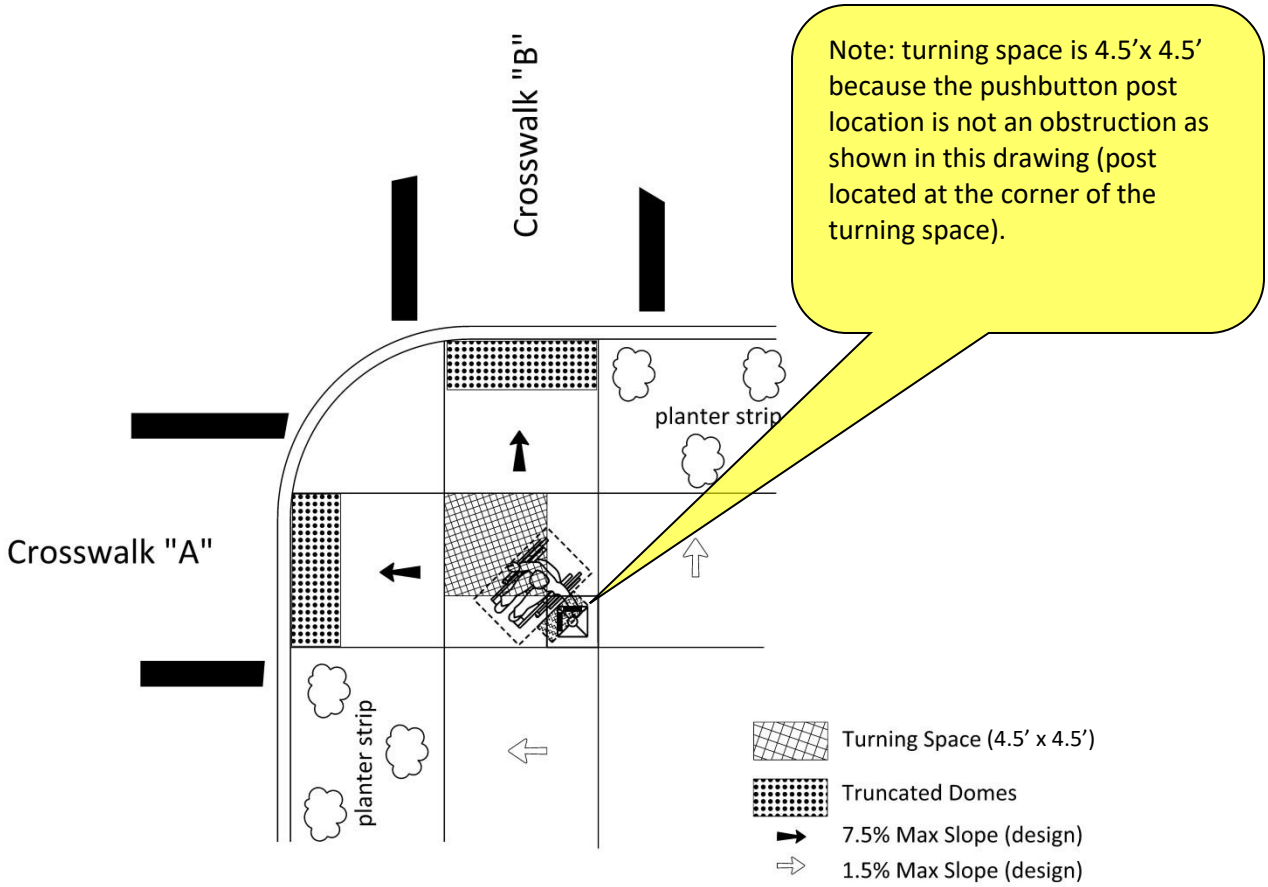


Figure 5-66 | Preferred Pushbutton Placement for Diagonal Perpendicular Style Ramp (Two Buttons on Pedestal)

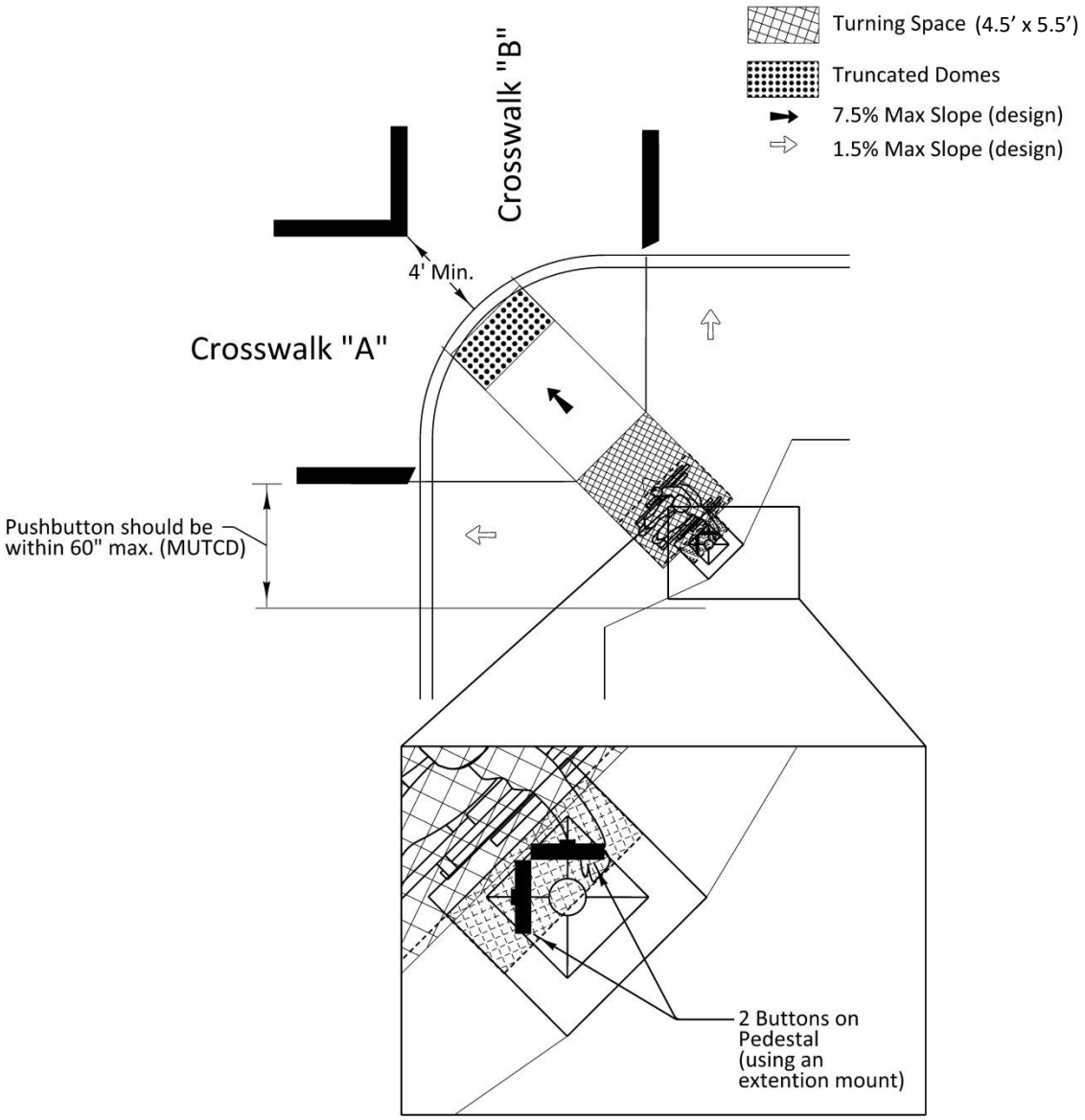


Figure 5-67 | Preferred Pushbutton Placement for Diagonal Parallel Style Ramp (Two Buttons on Pedestal) – Example 1

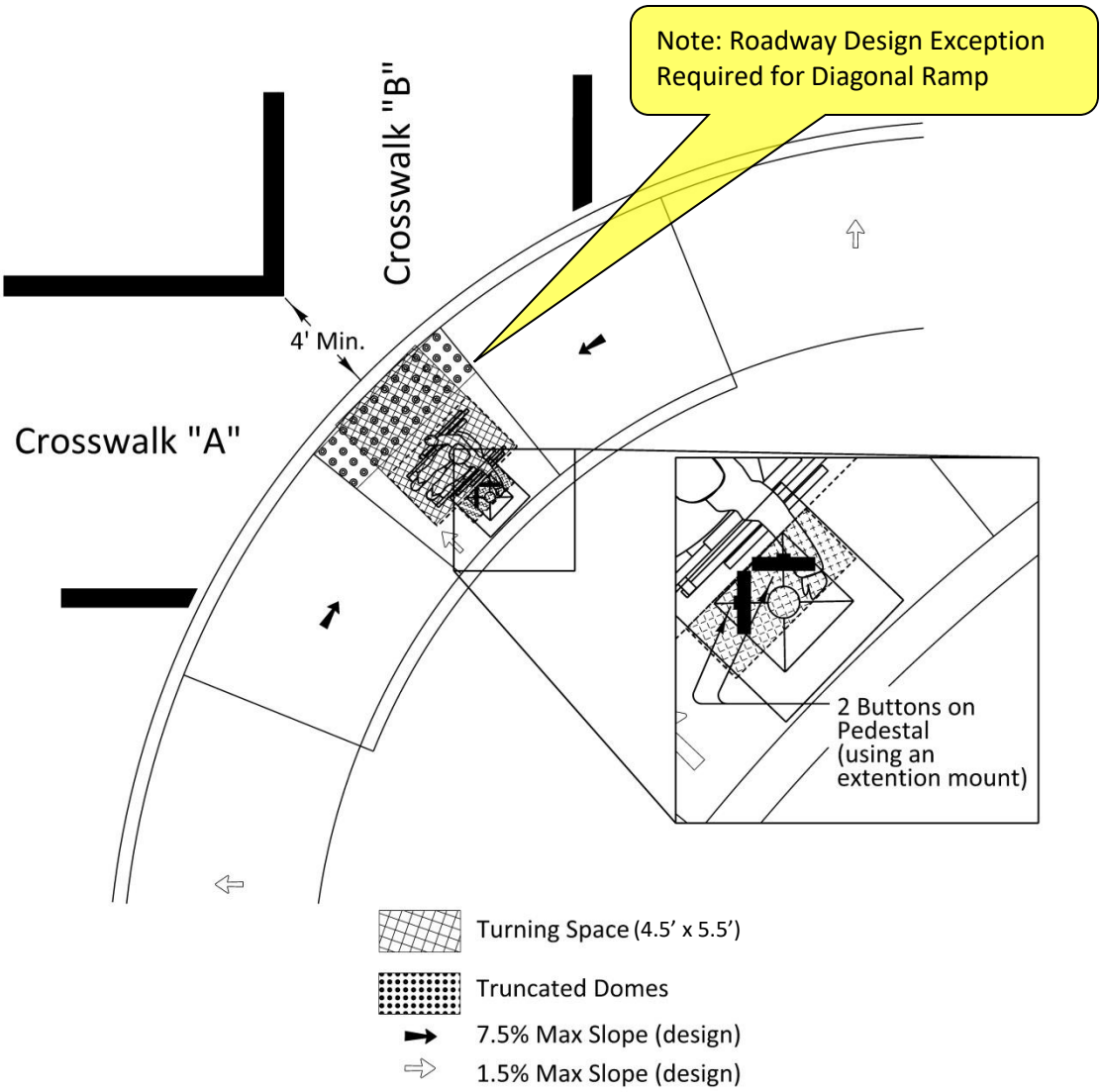


Figure 5-68 | Preferred Pushbutton Placement for Diagonal Parallel Style Ramp (Two Buttons on Pedestal) – Example 2

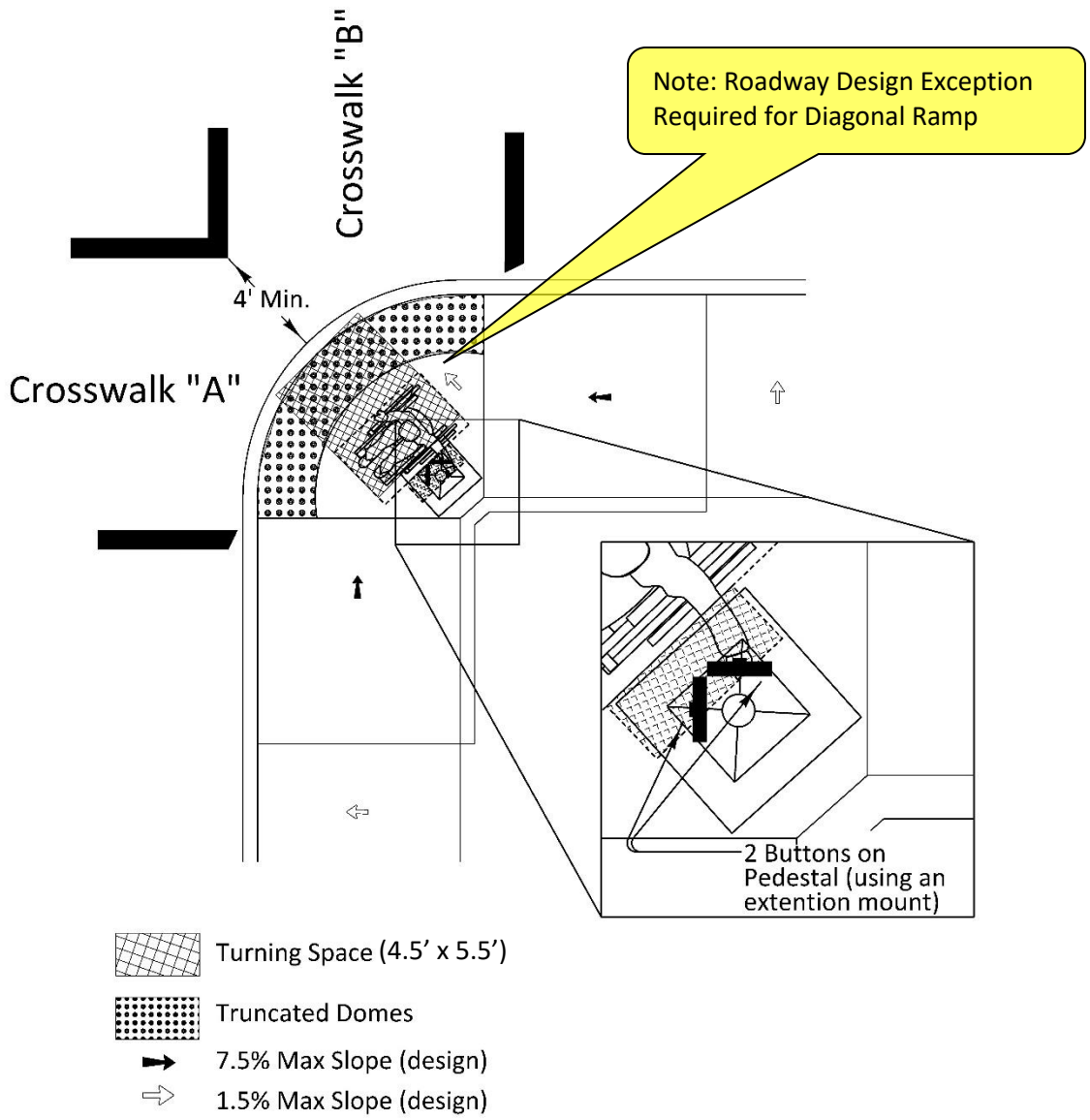
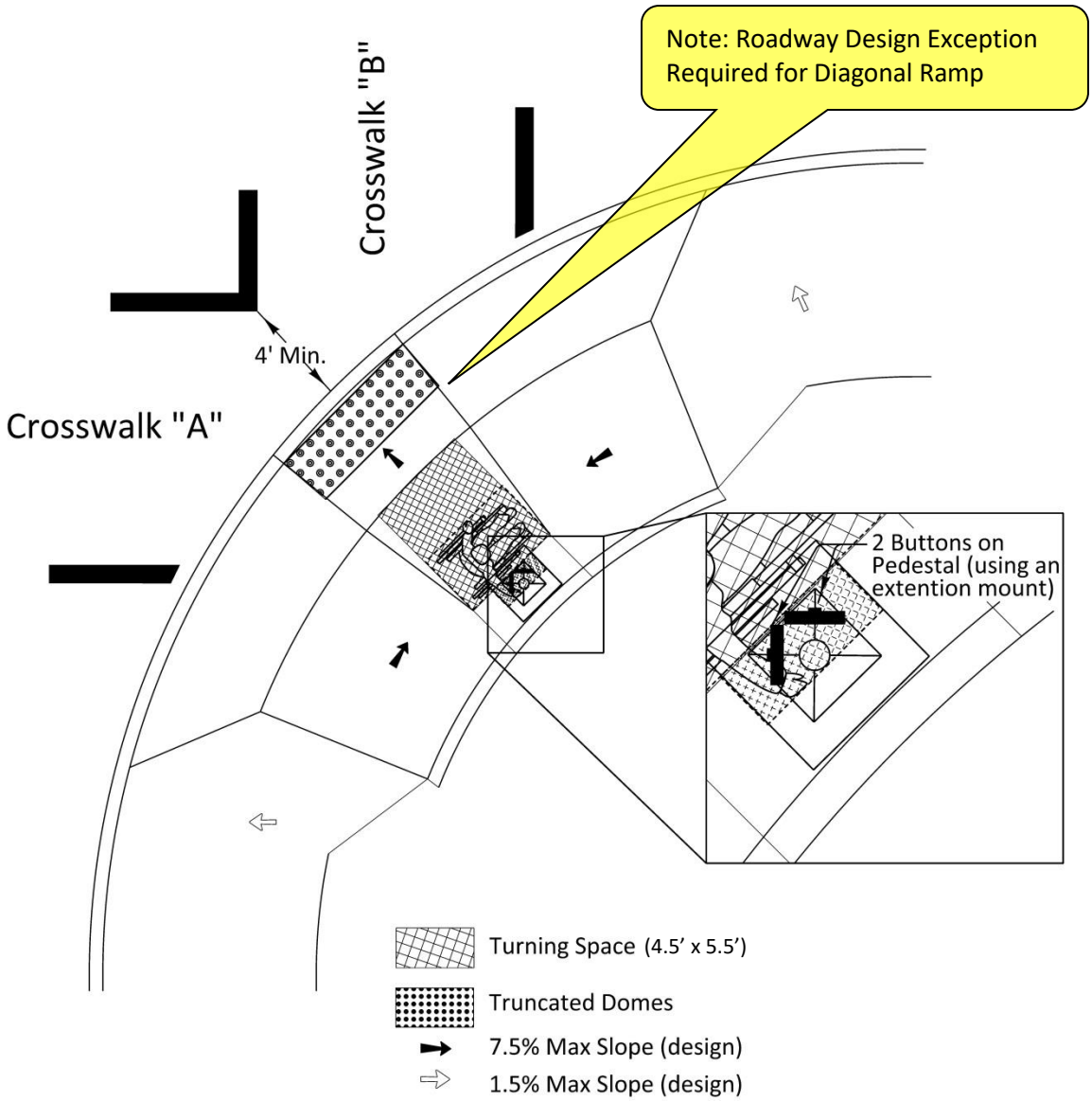


Figure 5-69 | Preferred Pushbutton Placement for Diagonal Combo Style Ramp (Two Buttons on Pedestal)



Several items need extra attention when a diagonal ramp serves two crosswalks. Verify the following:

- The pushbutton is located within 60 inches of the outside edge of the crosswalk striping. See Figure 5-70.
- The location of the pedestrian indications will not be blocked by from view by traffic stopped at the stop line. This can be challenging when the radius is small. Advance stop lines may be an appropriate solution to preserve the pedestrian's line of sight to the pedestrian indications.
- There is 4' minimum between the curb ramp and the inside crosswalk striping. This distance provides the wheelchair user a location to maneuver to the desired crosswalk and should be outside of the travel way (including bike lanes). Note that meeting this 4' minimum dimension may not be possible with a small radius. See Figure 5-71.

Figure 5-70 | Pushbutton 60" From Outside Edge of Crosswalk Striping at Diagonal Ramp

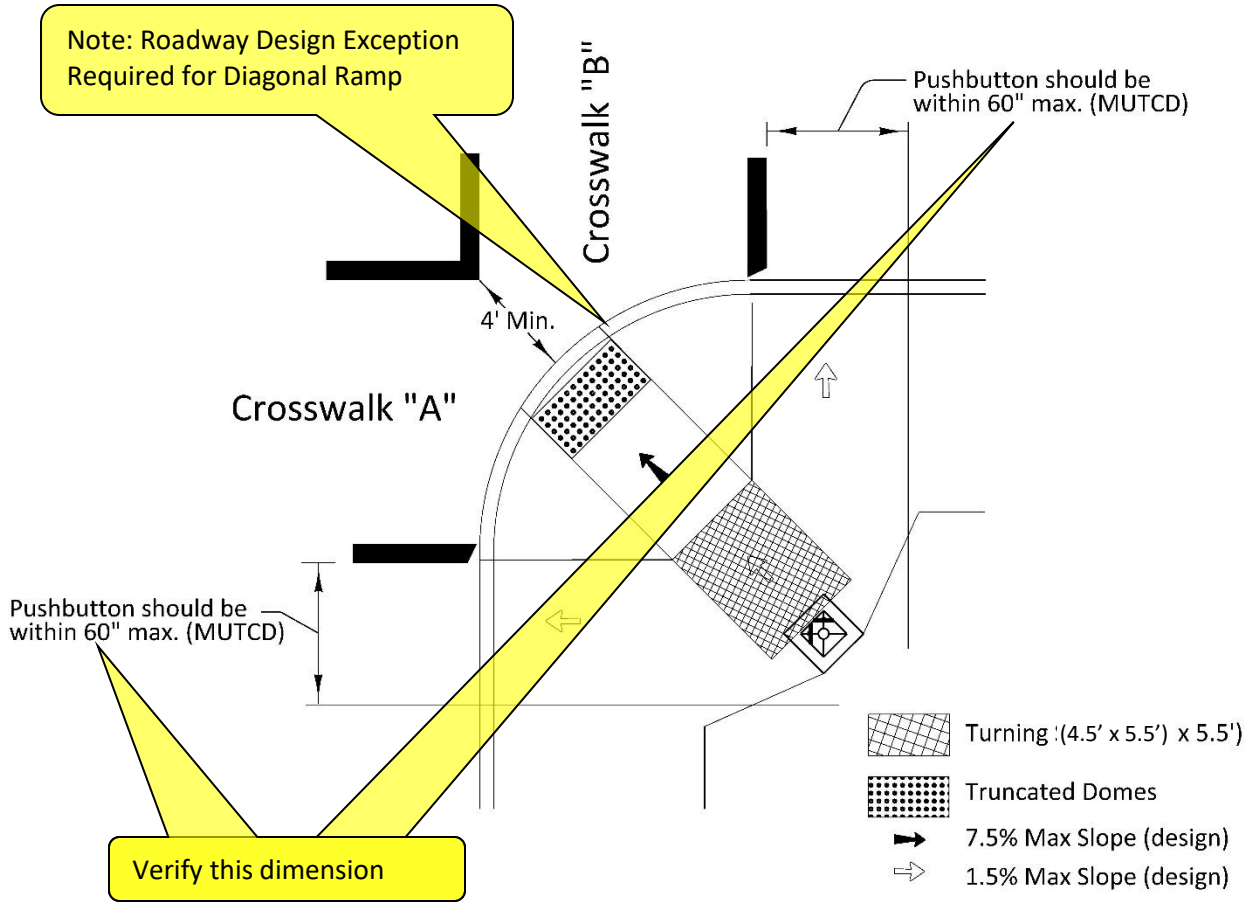
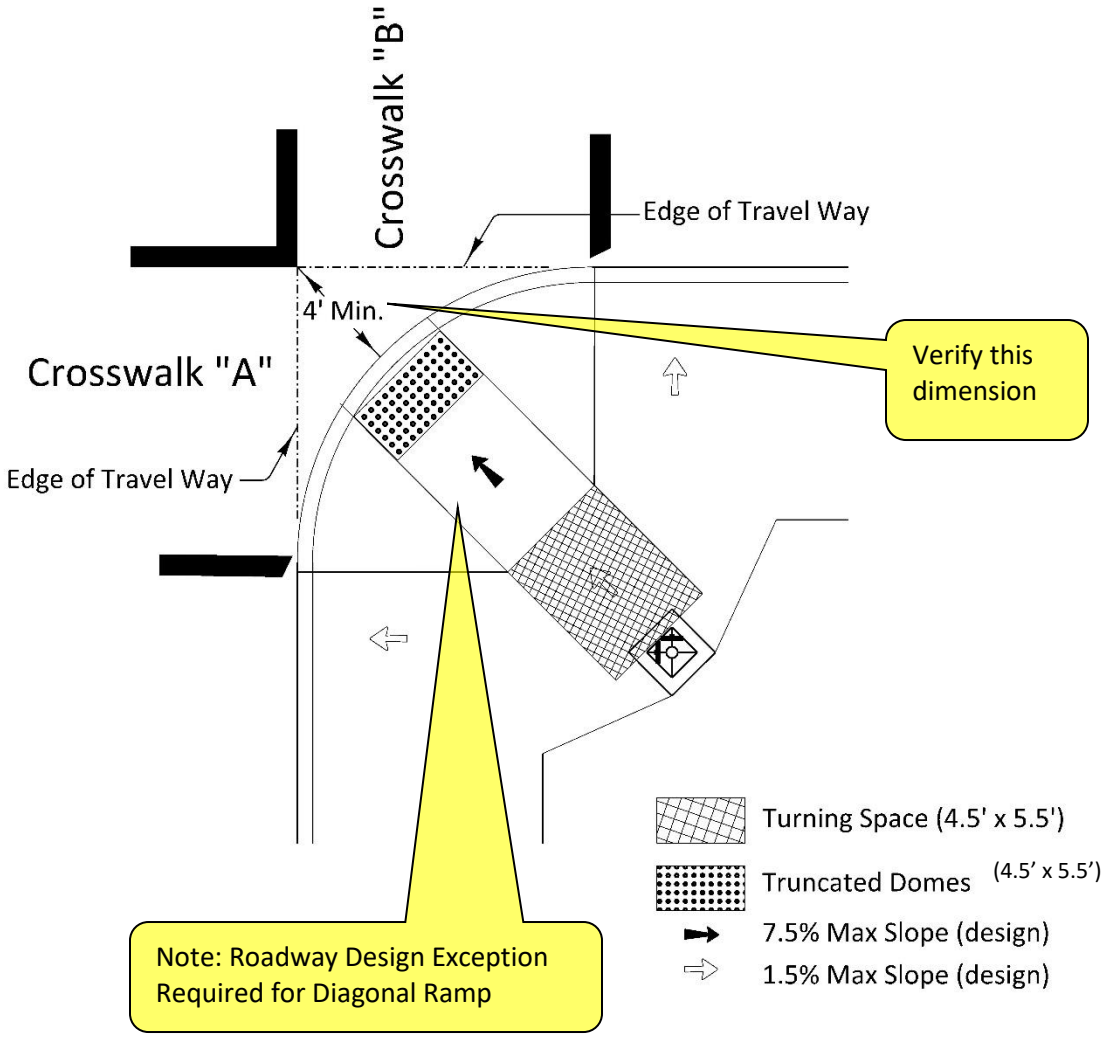


Figure 5-71 | 4' Minimum Distance Between Curb Ramp and Inside of Crosswalk Striping at Diagonal Ramp



5.4.7 Deviation: Use of an Extension Bracket Mount

Pushbuttons mounted on extensions are discouraged due to the potential for increased maintenance problems and they can also be a potential hazard for the blind that use caning for navigation if they protrude into the clear circulation path. Pushbuttons using an extension bracket may not extend more than 4 inches into the clear circulation path (see standard drawing RD720). As such, they should only be used in two specific cases:

- When two pushbuttons must be mounted on 4” diameter pole. See Figure 5-72.
- Retro-fitting existing installations that do not meet the 10 inch horizontal reach. See Figure 5-73 and Figure 5-74.

Figure 5-72 | Extension Bracket Mount for Two Pushbuttons on 4 Inch Diameter Pole

Figure 5-73 | Extension Bracket Mount Example – Standard Button Style

Figure 5-74 | Extension Bracket Mount Example – H-Frame

5.4.8 Pushbuttons Located behind Guardrail

While not ideal, pushbuttons may be located behind guardrail if they meet the criteria specified in Section 5.4.2. This can be accomplished by positioning the pedestrian pedestal or pushbutton post between the guardrail posts. Additional coordination between the guardrail installer and the signal installer during construction will be necessary to ensure compliance.

5.4.9 Extended Pushbutton Press Feature

The extended pushbutton press feature provides slower pedestrians an opportunity to request and receive a longer pedestrian clearance time. The Traffic Signal Operations Engineer will determine if this feature is needed. If this feature is used, an additional sign PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) is required to be mounted adjacent to the pedestrian pushbutton (see Figure 5-75). The Oregon specific sign shown in Figure 5-76 combines the two required federal signs and is preferred over installing the two federal signs.

Figure 5-75 | Extra Crossing Time Sign R10-32P

Figure 5-76 | Extra Crossing Time Sign OR-32

5.4.10 Pedestrian Signal Location

All pedestrian signals shall have clear line of sight from within the crosswalk lines from one end of the crosswalk to the pedestrian signal at the other end of the crosswalk (see Figure 5-77).

Figure 5-77 | Good Pedestrian Signal Visibility

5.4.11 Indication Type

All pedestrian signal indications installed on new projects shall be the countdown type. See Figure 5-78. If the scope of the project impacts an existing non-countdown indication (e.g. adjustment of the head due to curb ramp changes) or necessitates the need to install only one new pedestrian signal indication, all pedestrian signal indications for the entire intersection should be updated at the same time. The reason for doing this is to provide uniformity and consistent information to the pedestrian at that particular location.

Figure 5-78 | Countdown pedestrian signal Indications

White

Portland Orange

5.4.12 Audible Pedestrian Signals

The Operational Approval for the traffic signal will state if audible pedestrian signals are required. Verify with the Region Traffic Engineer. See the Traffic Signal Policy and Guidelines for additional information.

5.5 Pole Selection and Placement

ODOT's standard is the use of mast arm poles in all new signal and retrofit installations. Span wire installations are allowed if standard length mast arms will not allow for proper signal head placement. Local jurisdictions may also request strain poles. Custom supports (other than mast arm or span wire) should only be considered if standard supports are not feasible.

5.5.1 Right-of-Way

All equipment (including foundations) must be located within right-of-way or permanent easements and shall not overhang private property.

5.5.2 Overhead Structures and Vertical Clearance Standards

Contact the Region Mobility Liaison when any proposed project (new construction, reconstruction, preservation, or maintenance) adds a new or modifies an existing overhead structure (Truss Sign Bridge, Monotube Cantilever, Signal Mast arm, and Signal Strain Pole) regardless of meeting the existing minimum vertical clearance standards. In addition, contact the Region Mobility Liaison for any project that reduces the existing vertical clearance regardless of meeting the minimum vertical clearance standards. The Region Mobility Liaison will provide the appropriate coordination with the Region, and MCTD. This coordination should address not only project specific mobility requirements, but also any corridor level vertical clearance and mobility needs. Vertical clearance greater than 19'-0" for sign, VMS, and signal support structures are considered non-standard and require a design exception. The Traffic designer is to follow the procedures outlined in Chapter 14 of the HDM. The design exception request process for increasing the vertical clearance greater than the above mentioned 19'-0" will need to consider safety, operations, and impact to other design features in order to support the approval of the design exception.

5.5.3 Height Restrictions

When working on signals located near airports, there is the possibility of height restrictions which can have an impact on pole selection, especially poles with illumination. Permitted high loads and oversized truck routes should also be considered. Check with the airport in question regarding flight paths and any height restrictions and with the ODOT Trucking Industry Representative regarding permitted route issues.

5.5.4 Utility Conflicts

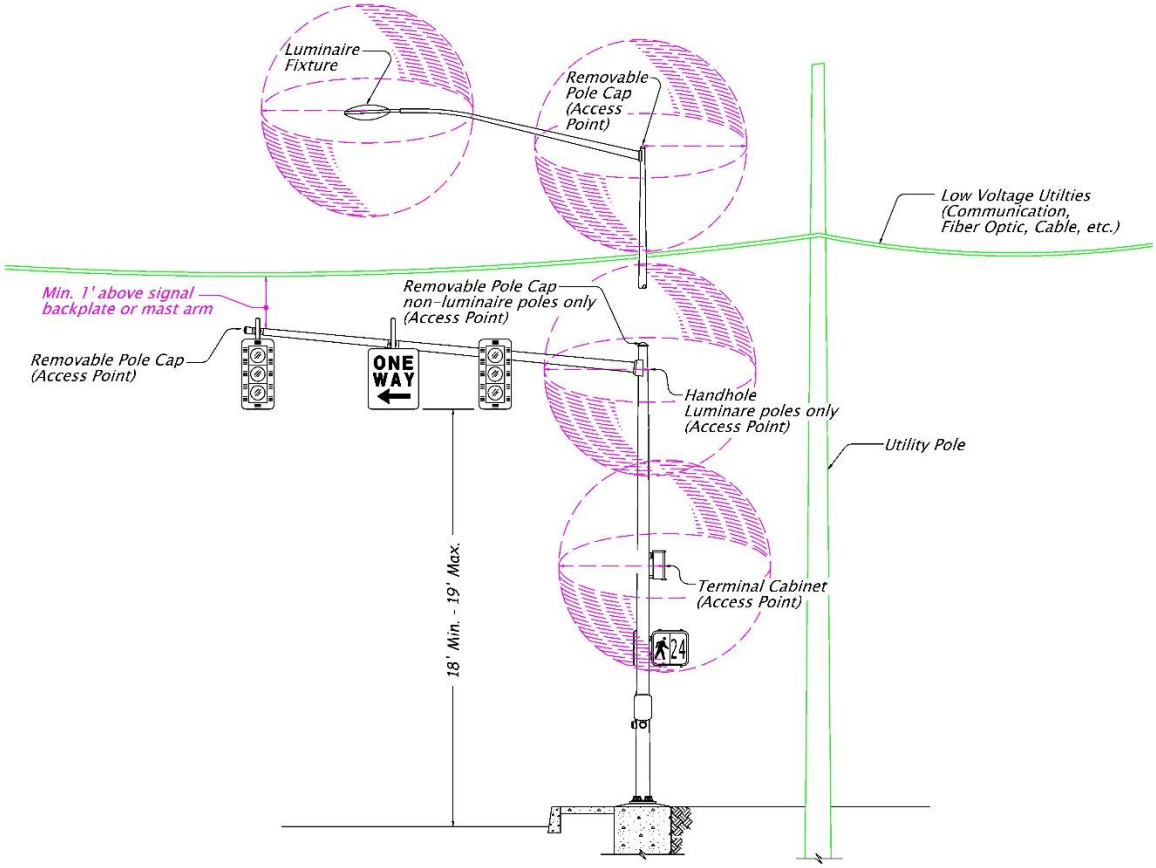
Always check to see if there is the possibility of overhead and underground utility conflicts when locating poles. Conflicts with overhead and underground utilities will

need to be addressed during the design of the signal. A minimum of 10 feet from overhead high voltage lines is required as per OAR 437-002-0047. For low voltage utilities (e.g. communication, fiber optic, cable, etc.), the following minimum clearances should be provided (See Figure 5-79):

- A minimum of 5 feet from access points (e.g. removable pole caps, handholes, and terminal cabinets) and illumination fixtures
- A minimum of 1 foot from above the mast arm and backplates

If there are any known conflicts with utilities, contact the Region Utility Specialist for help. There are three possible solutions depending on the situation; 1.) the signal pole location may need to be adjusted (which may require other auxiliary signal equipment such as pedestrian pedestals), 2.) the utility may need to be relocated, or 3.) a combination of number one and two. Utility conflicts shall be addressed and resolved before the design is complete.

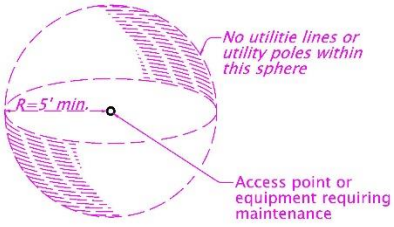
Figure 5-79 | Low Voltage Utility Clearances



LOW VOLTAGE UTILITY CLEARANCES

GENERAL NOTES:

1. *Clearance of access points such as removable pole caps, handholes, terminal cabinets and equipment such as luminaire fixtures should be as shown to allow for maintenance activities.*



2. *Clearance above signal backplate shall be as shown to allow for unobstructed view of signal head indications and maintenance activites.*
3. *Verify utility provider clearances. Use utility provider clearances if greater than these.*
4. *Clearances shown apply only to low voltage utilities. For high voltage utilities, follow clearance requirements set forth in OAR 437-002-0047*

5.5.5 Roadside Placement Requirements

Traffic signal poles shall be located no closer than 5 feet from face of curb to the face of pole or 6 feet from normal edge of pavement when curb is not present. Poles may be located in raised islands if 5 feet clearance can be maintained on all sides of the pole.

5.5.6 Mast Arm Poles

Mast arms come in sizes ranging from 15 feet to 55 feet in 5-foot increments. Mast arm poles are normally positioned with the mast arm perpendicular to the center line alignment.

The furthermost piece of equipment on the mast arm (i.e. signal head, sign, or fire preemption detector) shall be located no closer than 6 inches from the tip end of the mast arm. This is measured from the centerline of the mount location (which is typically the centerline of the equipment).

Illumination is typically included on all the mast arm poles at an intersection. The orientation of the illumination (location of the illumination relative to the mast arm) is usually located in-line with the mast arm, but it can be located at any degree on a standard mast arm pole as necessary.

When designing a mast arm for current permissive left turn phasing operation (especially if the lane use for the approach contains a left turn lane), the mast arm should be long enough to allow proper placement of a future signal head for protected only or protected/permitted operation.

Pedestrian signals and pushbuttons should not be mounted to a mast arm pole. See section 5.4 for more information about placement of pedestrian signals and pushbuttons.

5.5.7 Strain Poles

Strain poles are only to be used in areas where the use of mast arm poles will not allow for the correct location of signs or signal equipment. Wood strain poles are the standard only in the design of temporary signals.

Possible overhead and underground utility conflicts are more of a factor for strain pole placement since the pole is higher and the foundation is typically deeper than a mast arm pole. See Standard Drawings TM653 and TM661.

Illumination is typically included on all the strain poles at an intersection. The orientation of the illumination (location of the illumination with respect to the north arrow) can be located at any degree on a standard strain pole as necessary.

Pedestrian signals and pushbuttons should not be mounted to a strain pole. See section 5.4 for more information about placement of pedestrian signals and pushbuttons.

5.5.8 Pedestals: Vehicle

Vehicle pedestals are used mainly for ramp meter installations, but they also may be necessary at an intersection depending on the geometry and operation (typically used for nearside/supplemental signal heads). Vehicle pedestals shall NOT be used as a substitute for a mast arm or span wire for through movement phases. They also should not be used as a substitute for a mast arm or span wire for the stem of a T-intersection unless there is no other option (such as height limitations due to a bridge). This is because vehicle signals mounted on pedestals are only 12' high (from the ground to the bottom of the signal) which makes them not as visible, especially for vehicles in the back of a platoon, as a standard 18' – 19' overhead mounted signal. If used at the stem of a T-intersection, additional supplemental heads may be required to mitigate the loss of visibility.

5.5.9 Pedestals: Pedestrian

Pedestrian pedestals should be used to mount pedestrian signals and pushbuttons. See section 5.4 for more information about pedestrian pedestals.

5.5.10 Recessed Terminal Cabinet

A new style terminal cabinet that is integral to the pole design was created in 2013. This terminal cabinet should be used for all new poles, with concurrence from the Region Electrical Crew. Standard Detail DET4405, 4410 and 4650 shows the details for this terminal cabinet.

5.5.11 Pushbutton Posts

Pushbutton posts should be used only if the pushbuttons cannot be located on same support as the pedestrian indications. See section 5.4 for more information about placement of pushbuttons.

5.5.12 Non-Standard Design: (SM) Poles, Sign Bridge, Monotube, Luminaire Poles, Etc.

A non-standard structure is any structure that does not meet a standard drawing or new structures that do not have a standard drawing associated with the structure. These types of structures typically include poles for dual mast arms or diagonal structures. They are custom designed by a structural engineer during the construction phase of the project. In the case of sign bridges and monotubes, specially designed mounts for the signal equipment may also be required.

Mounting signal equipment (typically pedestrian equipment) to a stand-alone luminaire poles is discouraged because the use of standard pedestal or pushbutton post is usually

feasible. If the use of a standard pedestal or pushbutton post is not feasible, a stand-alone luminaire may be used to mount signal equipment only if the luminaire is operating from the same service as the traffic signal.

Contact the Traffic Structures Engineer and see the ODOT Traffic Structures Design Manual for more information on non-standard design

5.5.13 Re-using or altering the loading on existing signal supports

Re-using an existing traffic structure is generally not recommended for a number of reasons:

- The age of the structure may make analysis difficult. It will require a lot of assumptions if the necessary information cannot be found. The assumptions must be conservative, which typically leads to the analysis indicating re-use is not an option.
- The structure may be at or near its lifespan or not in great shape.
- Re-using an older pole requires a custom designed foundation (the standard drawings do not apply). This involves more engineering cost and extended review time. An old standard drawing may be used to as a starting point for analysis and design when creating a custom foundation detail sheet, but it cannot just be referenced and used without modification. This is because the old standard drawings (and specification references within) have not been maintained and therefore most likely contain out-of-date and erroneous information which must be modified and sealed by an engineer.
- For span wire installations – moving just one pole or installing just one new pole will often require adjustments to the other poles, thus necessitating more than one new pole anyway.
- Re-using a signal pole often results in more cost due to more extensive workzone traffic control. For example, moving an existing mast arm to accommodate a wider radius will require either a temporary signal while the existing mast arm is moved to its new location (the existing signal must remain in operation) or 24-7 flagging (if a temporary signal is not used).

For more info on how to analyze existing mast arm poles and strain poles, and additional information on when it may be appropriate to re-use an existing structure, refer to the ODOT Traffic Structures Design Manual.

5.5.14 Use of other Agency (non-ODOT) Approved Poles

This practice is typically not allowed. Contact the Traffic Structures Engineer for guidance and approval if use of non-ODOT poles is desired.

Reusing an existing signal support is often less cost effective than installing a new traffic signal structure!

5.6 Illumination

Providing illumination on all traffic signal mast arm poles and strain poles at an intersection is the default standard. A separate stand-alone luminaire pole may be used if a mast arm or strain pole is not located in a quadrant. If a stand-alone luminaire pole is used at the intersection, it should be powered from the same service as the traffic signal and designed according to standard drawings TM629 and TM630. The ODOT Lighting Policy and Guidelines and Traffic Lighting Design Manual contain additional information for illumination design requirements.

The illumination design should completed or verified by an illumination designer to determine the design specifics listed below. They will need a copy of your CADD signal plan and will provide:

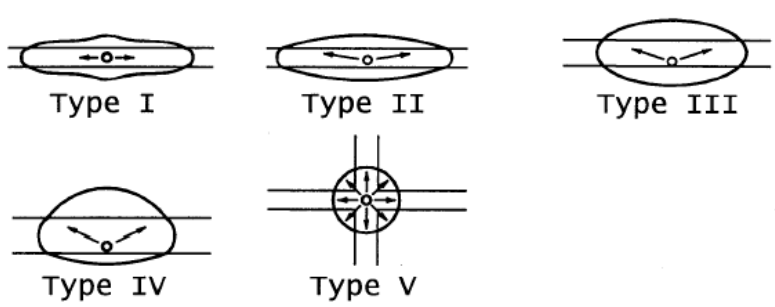
- Length of luminaire arm (as per standard drawing TM629, standard lengths of luminaire arms are 6’, 8’, 10’, 12’, 15’ and 20’)
- Luminaire arm orientation
- Mounting height
- Type and wattage of luminaires
- A copy of the photometric analysis for the project file

The Region Electrical crew shall be contacted to verify the maximum height that can be reached by their equipment and the wattage of the replacement bulbs they normally stock.

Current default standards are:

- 0 degree luminaire arm orientation (in-line with the mast arm)
- 15’ arm length
- 40 feet maximum height
- Light Emitting Diode (LED) fixtures (See Section 5.6.1 for more info). High Pressure Sodium (HPS) fixtures may be used when it is necessary to match the existing illumination system.
- A Type 3 light distribution pattern (See Figure 5-80)

Figure 5-80 | Illumination Engineering Society (IES) Light Distribution Patterns



5.6.1 Light Emitting Diode (LED) fixtures

LED fixtures shall be approved by the Region Electrical Manager and/or the ODOT Illumination Engineer. They may be used on new projects or on modification projects (that are converting/changing existing fixtures). The new special provision for LED fixtures should be used (special provision 02926).

The general guidance for LED power requirements at standard intersections of two-way, two-lane highways to comply with ODOT illumination standards is as follows:

- 250-275 watt LED (2 locations, far corners on the mainline)
- 130-140 watt LED (4 locations, at each corner of the intersection)

Bigger and more complex intersections should be analyzed using computer lighting software to determine the proper illumination design. Contact the Illumination Engineer.

5.6.2 Photo Electric Control Relay

The photo electric control relay is a device used for turning on luminaires based on the ambient lighting conditions. It should be placed on the signal pole that is closest to the Base Mounted Service Cabinet (BMCL). The photo electric control relay should be oriented towards the north sky.

5.6.3 Illumination Wiring

The wiring for the illumination that is part of the traffic signal (located on the signal poles) is wired directly from the BMCL to luminaire and photo electric control relay. Illumination wiring shall not be routed through the signal controller cabinet.

- Three No. 12 AWG THWN wires are needed from the BMCL to the photo electric control relay.
- Two No. 10 AWG XHHW wires are needed from the BMCL to each luminaire (each luminaire must have independent wires directly from the BMCL). Daisy chaining the illumination wiring from luminaire to luminaire is no longer allowed. This wiring will be spliced to the TC cable (see bullet below) via an in-line fuse holder at the pole base.
- TC cable is used from the pole base (splice point using an in-line fuse holder) to the luminaire ballast. This wiring is NOT shown on the plans, but is contained in the specification 00970.42.
- The ground/bond wire to the signal/illumination pole is a No. 6 AWG THWN. This wiring is NOT shown on the plans, but is contained in the specification 00960.50(a).

5.7 Fire Preemption

Fire preemption is often included in new signal installations, however it should only be included if the area/operators have been approved for use. Typically, if fire preemption is present at an existing intersection, it has already been approved and shall be replaced if the signal is re-built. The ODOT Traffic Signal Operations Engineer maintains a list of approved fire preemption areas/operators. The signal designer should contact the Traffic Signal Operations Engineer to verify the approval is documented. If the project scope does not mention fire preemption, verify that fire preemption is not needed or wanted with Region Traffic. Region Traffic will then work with the local operators in the area and submit a request for operation approval to the STRE if needed.

If fire preemption equipment is planned for the intersection, the detector must be located with a clear line of sight for a minimum distance of 1500 feet. Preferred placement of the detector is on the near side of a mast arm or span wire. Remote detectors, multiple barrel devices or alternate locations will be necessary if the roadway curves prior to entering the intersection.

One specialty cable for the fire preemption system is needed from the device mounted in the field back to the signal controller cabinet. No splices are allowed.

All pre-approved (Green Sheets) fire preemption equipment is capable of providing encryption (to assign ID's to those that use the system). However, ODOT does not currently have any jurisdictions using this feature.

5.8 Power Source

Commercial power is used to power all electrical installations (with the exception of some temporary signals). When installing a new traffic signal, the nearest location to draw power from (the power source) should be used. Power can only be tapped off of a transformer. The Figure 5-81 shows a typical example of a transformer.

Figure 5-81 | Transformer Example

It is critical to work with the Region Utility Specialist to determine what type of power is available and the location of the power source. The traffic signal service requires commercial power of 120V (or 120V/240V if illumination will be provided on the traffic signal). If the existing power source is unacceptable or needs modifications to work, the Region Utility Specialist will handle these issues.

Sometimes the project will necessitate moving the existing power source location to a new location. If this is the case, the signal plan sheets will need to depict this.

For all new signals, the wiring from the power source should enter into the service cabinet via a conduit (no aerial connections, with the exception of temporary signals). The design and installation of the conduit and wiring from the power source to the service cabinet is per the requirements of the power company. The plan sheets should just show a reference to the conduit and wiring indicating this. The contractor is responsible for installing the conduit and pull line from the service cabinet to the power source, and the power company is responsible for installing and terminating the wiring from the service cabinet to the power source.

5.9 Battery Back-Up

A battery back-up system can provide uninterruptable, reliable emergency power to a traffic signal in the event of a power outage or interruption. Some intersections, due to their location, and operational characteristics, may experience congestion or be difficult to drive through in the event of a power outage. Battery back-up may be beneficial in the following situations:

- Isolated location (long travel times for electrical crew to get to the signal)
- Conflicting high-speed approaches
- High volume intersections (ADT >20,000 on the mainline)
- Approaches with limited visibility
- Unusual geometry (e.g. single point urban diamonds)
- More than 4 approach legs
- Six or more travel lanes per road
- Railroad interconnection
- History of frequent power outages

The decision to install battery back-up is made at the District level in conjunction with input from the Region Traffic Engineer.

If battery back-up is deemed necessary, the following standard design practices apply:

- The operating electrical load of the intersection shall be calculated to confirm the applicability of battery back-up equipment meeting the current specifications (see the ODOT Standard Specification for Microcomputer Signal Controller and the approved product listed on the Traffic Signal Material "Green Sheets"). Adjustment for a higher capacity battery back-up system to accommodate larger operating loads will be made on an as needed basis.

5.10 Controller Cabinets

5.10.1 Location

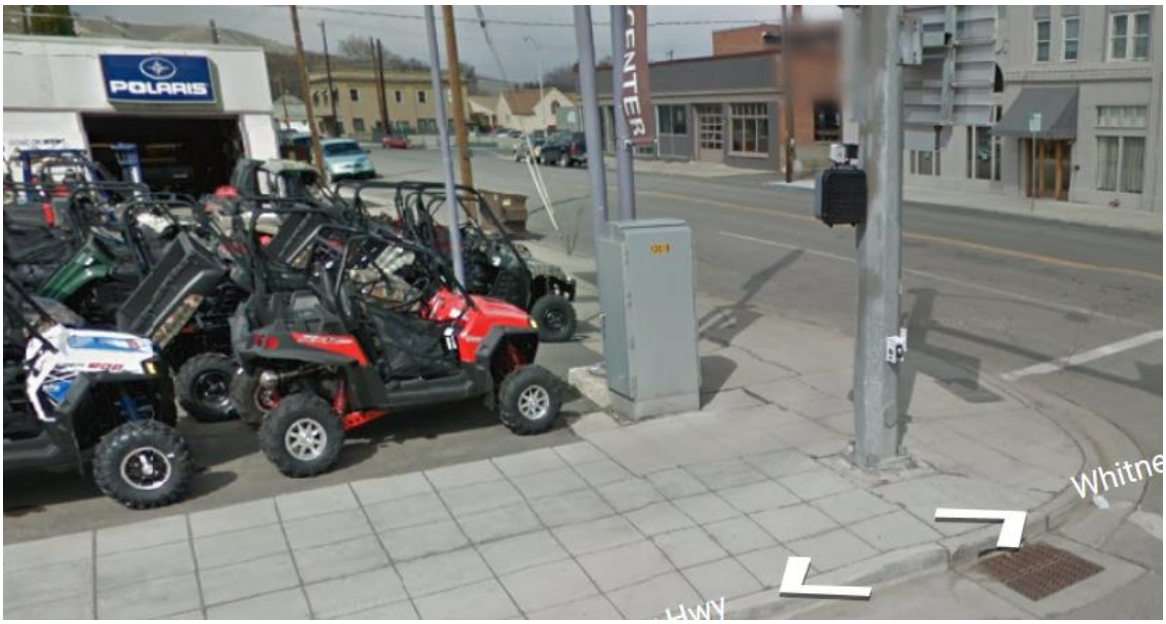
If possible, locate the controller on the right-hand side of a side street approach and try to obtain a power source in that quadrant. There may be limitations that preclude this location such as R/W, power source locations, sidewalk, or businesses located in the quadrant. Always contact the region electrical crew for their preference on the location of the controller cabinet.

The controller cabinet and the service cabinet should always be located in the same quadrant together for ease of maintenance, spaced a minimum of 10 feet apart.

Locate the controller cabinet so that it does not obstruct the view for a side street vehicle turning right-on-red. Standard controller cabinets are constructed such that the controller side cabinet door (front louvered door) swings left. Orient the controller cabinet so that the cabinet doors swing away from traffic. Locate the controller so that when the cabinet is being serviced, the technician can stand facing the louvered door (the front of the cabinet), and see a minimum of two traffic signal phases.

The right-of-way, adjacent properties, and the pedestrian clear circulation path may also have influence on the orientation of the controller cabinet. Figure 5-82 shows an example of controller cabinet that is difficult to open and maintain. Make sure that the cabinet door can fully open and does not encroach on private property when fully open. Also maintain the pedestrian clear circulation path (5’ minimum) when the door is open if possible.

Figure 5-82 | Controller Cabinet Front Louvered Door Encroaching on Private Property



5.10.2 332S Controller Cabinet

The 332S controller cabinet is a ground mounted cabinet which is the new ODOT standard for any new or temporary traffic signal. It provides more room and options than the old 332 cabinet.

5.10.3 332 Controller Cabinet

The 332 controller cabinet is a ground mounted cabinet. It is no longer used in new construction.

5.10.4 336 and 336S Controller Cabinet

The 336 and 336S controller cabinets are pole mounted cabinets, smaller than the 332 cabinet. These cabinets are no longer used for permanent or temporary signals.

In the past, these cabinets were commonly used in downtown corridors where the traffic signals operation is simple and pre-timed. However, there are a few reasons why the pole mounted cabinet is no longer used for a permanent or temporary installation:

- They have limited space inside and still take up the same amount of room (width and depth) as a standard 332S cabinet. The only room that is saved is directly underneath the cabinet, which isn't useable.
- They produce challenges for meeting ADA requirements since it creates a protruding object unless it is placed away from a pedestrian walkway.
- We now have a temporary pre-cast foundation that is easy to install and remove for temporary staging.

5.10.5 Controller Cabinet Power

The controller cabinet is wired to the service cabinet with two No. 6 AWG XHHW wires (shown on the plan sheets) and a ground wire (NOT shown on the plan sheets).

5.11 Service Cabinets

5.11.1 Base Mounted Service Cabinet (BMC)

A Base Mounted Service Cabinet (BMC) shown in Standard Drawing TM485 is the standard service type for traffic signal installations. The BMC should be located in the same quadrant as the controller cabinet. This makes the BMC convenient for maintenance personnel working on the signal. Locate the BMC at least 10 feet away from any other equipment (controller or any poles). The BMC shall be located around the corner on the intersecting side street to mitigate mainline exposure and to avoid obstructing the view of right turn traffic.

5.11.2 Base Mounted Service Cabinet with illumination (BMCL)

Section 5.11.1 still applies; except a Base Mounted Service Cabinet with illumination contains extra circuit breakers and a contactor to run a separate circuit for illumination that is part of the traffic signal (not strip lighting).

5.11.3 Base Mounted Service Cabinet, Flashing Beacons (BMCF, and BMCFL)

Section 5.11.1 still applies; except a base mounted service cabinet for flashing beacons contains contacts for the flashing indications. The BMCFL can accommodate illumination that is part of the flashing beacon. See Chapter 12 for more info on flashing beacons.

5.11.4 Pole Mounted Service Cabinet (SC) and Meter Base (MC)

This type of service is only allowed for temporary signals. See Chapter 11 for more information on temporary signals.

5.11.5 Remote Post Mounted Service (RPS)

ODOT no longer uses this style of service.

5.11.6 Wiring

The service cabinet is wired to the power source according to requirements of the power company. See section 5.8 for more information.

5.12 Junction Boxes

Junction boxes provide pull point for circuits coming from the signal controller cabinet to the various pieces of equipment in the field. They also provide a location for loop wire splices. Junction boxes shall be spaced a maximum of 300 feet between junction boxes on a conduit run.

Junction boxes used for the signal wiring should be located toward the approaching traffic end of the corner's radius. This provides dual use for signal wiring and detector loop access. See chapter 6 for detection specific information on junction boxes.

5.12.1 Junction Box Type and Size

The junction box type/size is determined by the total conduit diameter that is contained within the junction box and the location of where the junction box is located. However, there is default minimum type/size standard. Table 5-5 shows the default minimum standard and

Table **5-6** shows how to determine the types/sizes of junction if the default minimum is not adequate.

The type of surface that a junction box will be installed in is also an important consideration. This determines whether a concrete apron around the junction box is needed or not. The 'A' in the junction box designation (i.e. JB-2A) denotes a 12-inch wide concrete apron surrounding a precast concrete junction box. The concrete apron provides support to the fragile sides of the box. Type "A" boxes have concrete aprons and are to be used in non-paved areas (i.e. unpaved shoulders or landscaped areas) where maintenance vehicles may be present. **Do not use a precast concrete junction box within a travel lane or any access where it may be exposed to traffic.** Placing a junction box within a travel lane or where it is exposed to traffic should be

avoided at all costs. However, where it absolutely cannot be avoided, an approved cast iron junction box rated for traffic is required (JB-4 through JB-8).

Table 5-5 | Default Minimum Junction Box Type/Size

Type/Size	Location/use
JB-3T: Two (Tandem) 30”x17”x12” boxes	The same quadrant as the signal controller: first access point for all signal, detector and interconnect circuits.
JB-2: Single 22”x12”x12” box	All quadrants without the signal controller: secondary access point for signal, detector, and/or interconnect circuits
JB-1: Single 17”x10”x12” box	All approach legs: detector and/or interconnect circuits

Table 5-6 | Sizing for Junction Box Type/Size

Type*	Size	Total Conduit Diameters Allowed (Inches)	Remarks	Material
JB-1	17”x10”x12”	12	Non-traffic areas only	Concrete
JB-2	22”x12”x12”	18	Non-traffic areas only	Concrete
JB-3	30”x17”x12”	34	Non-traffic areas only	Concrete
JB-4	8”x6”x6”	5	No loop splices	Cast Iron
JB-5	12”x10”x6”	8	No loop splices	Cast Iron
JB-6	12”x10”x8”	8	Loop spices OK	Cast Iron
JB-7	16”x12”x6”	13	No loop splices	Cast Iron
JB-8	16”x12”x8”	13	Loop splices OK	Cast Iron

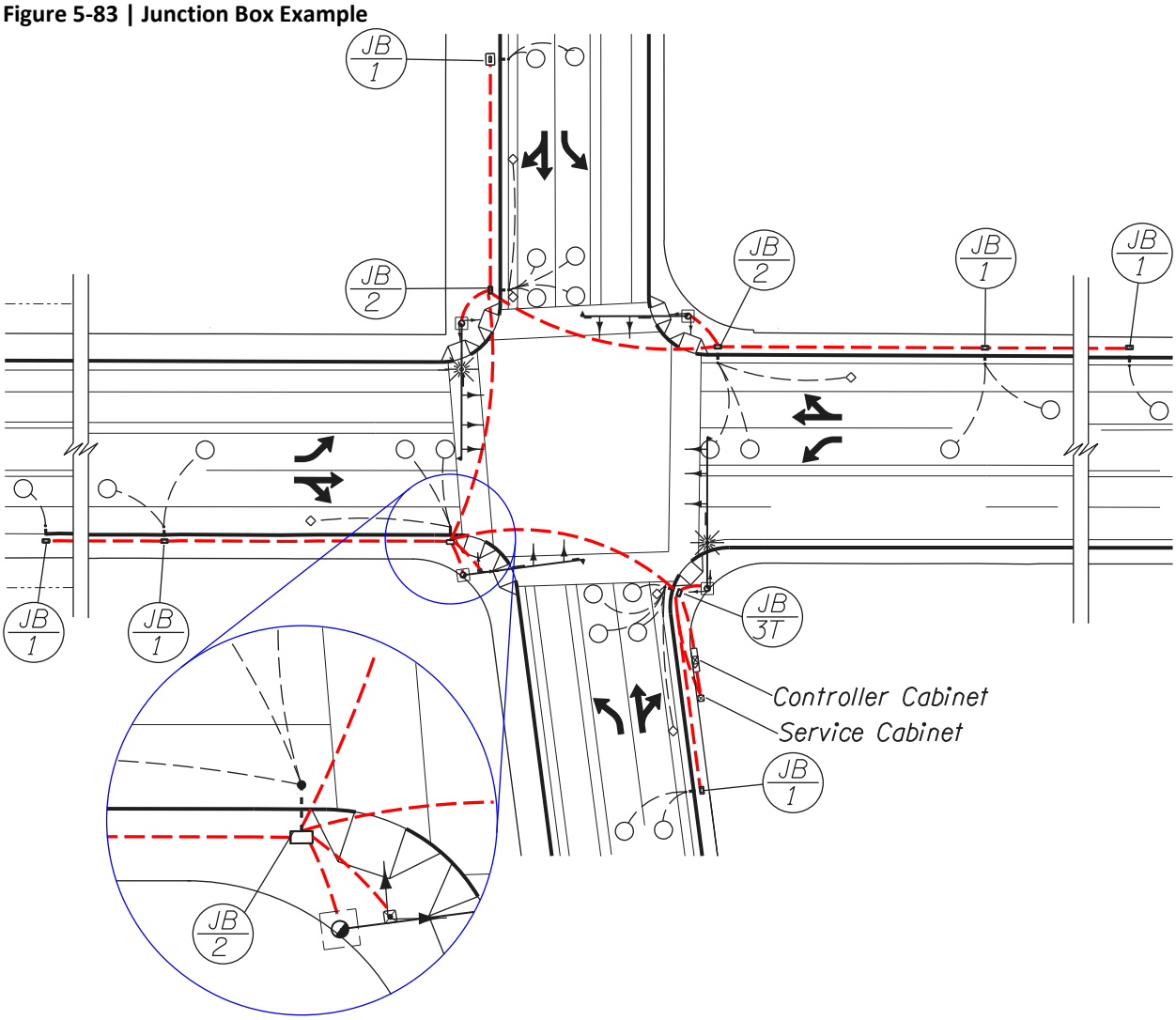
*JB-1 through JB-3 all have the option to be installed with an apron (JB-1A, JB-2A, and JB-3A)

Do not place junction boxes in the slope or the landing area of an ADA Ramp. Junction boxes shall be placed in or behind sidewalks in a flat area that can be easily accessed by maintenance crews.

Junction boxes and the guidelines for general use are shown on Standard Drawing TM472. See section 5.14.4 for more information on grounding/bonding requirements.

Figure 5-83 shows a base map that has correct placement of the junction boxes (and conduits) in relation to the signal poles, pedestrian ramps, and detector loops using the minimum default standard types/sizes.

Figure 5-83 | Junction Box Example



5.12.2 Use of Existing Junction Boxes

Use of existing junction boxes is allowed if all of the following statements are true:

1. the junction box is relatively new, in good condition, and in a good location,
2. the junction box is the appropriate size,
3. the junction box itself will not have to be adjusted due to the adjacent construction work, and
4. the junction box will not have any new conduit installed within.

Junction boxes are a very low cost item and it is more cost effective to remove an old junction box and install a new one if any of the above statements are false. A common construction

change order on preservation projects is additional payment for the contractor to adjust of install new junction boxes as a result of the work done on the roadway shoulder. Change orders should be avoided as they are generally more expensive than having the contractor bid the same work. Therefore, if there is a good chance that an existing junction box will be damaged, need adjustment, or is just a maintenance headache, you should remove it and install a new one. If, during construction, the contractor is able to use the existing junction box they can submit a Cost Reduction Proposal (as per specification 00140.70) that can be considered (which should result in a credit to the contract if the existing boxes can indeed be used).

5.13 Conduit

Once the junction box placement is complete, conduits can be planned to connect all equipment to the signal controller cabinet. Standard practice is to cross mainline in only one area (see Figure 5-83). This shall be accomplished with conduits installed by Horizontally Directional Drilling HDD (preferred method) or run in a common trench.

The illumination circuit and photoelectric cell wiring is contained in a separate conduit for safety reasons. Illumination wiring is never routed through the controller cabinet.

5.13.1 Conduit Size

To determine the proper size of conduit, two criteria need to be considered: ODOT requirements and the wire fill calculation. The larger of the two criteria governs. See Section 5.14 for information on wiring.

ODOT Requirements:

- Conduit crossing mainline or side street shall be 2-inch diameter minimum
- One spare 2-inch conduit from the controller cabinet to the nearest junction box shall be installed for future use, shall contain a poly pull line and be capped at each end
- 1½-inch minimum conduit
- 3-inch maximum conduit
- One spare 2-inch conduit from the signal pole to the nearest junction box shall be installed for future use of alternate detection, shall contain a poly pull line and be capped at each end. This spare conduit shall be omitted when a conduit will be installed for current use of an alternate detection system.

The ODOT minimum design standard for new construction allows a maximum wire fill of 70 percent of the NEC maximum allowed wire fill. This provides ample room for additional wires if needed in the future. For existing signals where new wire is being installed into existing conduit, the NEC maximum allowed wire fill is acceptable to use.

To calculate wire fill, use Table 5-7 through Table 5-9**.**

Table 5-7 | Wire Area

Cable *AWG*	Cable Area (in^2) THWN	XHHW	Cable Type	Cable Area (in^2)
18	n/a	n/a	**FPC**	0.0784
16	n/a	n/a	**LF**	0.0908
14	0.0097	0.0139	**LF 18awg**	0.0616
12	0.0133	0.0181	**6/P**	0.3117
10	0.0211	0.0243	**12/P**	0.4902
8	0.0366	0.0437	**CC 4/14**	0.1257
6	0.0507	0.0590	**CC 5/14**	0.1452
4	0.0824	0.0814	**CC 6/14**	0.1698
3	0.0973	0.0962	**CC 7/14**	0.1735
2	0.1158	0.1146	**CC 10/14**	0.2922
1	0.1562	0.1399		
1/0	0.1855	0.1825		
2/0	0.2223	0.2190		
3/0	0.2679	0.2642		
4/0	0.3237	0.3197		

Table 5-8 | Conduit Fill Table (NEC & ODOT Max Fill: RMC Article 344 in NEC Chapter 9, table 4)

Conduit size Inch	*Internal Dia inch*	NEC % Max Fill (in^2) 1 wire 53%	2 wire 31%	3+ wires 40%	ODOT % Max Fill (in^2) 1 wire 53%	2 wire 31%	3+ wires 40%
1/2	0.632	0.166	0.097	0.125	0.116	0.068	0.088
3/4	0.836	0.291	0.170	0.220	0.204	0.119	0.154
1	1.063	0.470	0.275	0.355	0.329	0.193	0.248
1 1/4	1.394	0.809	0.473	0.610	0.566	0.331	0.427
1 1/2	1.624	1.098	0.642	0.829	0.768	0.449	0.580
2	2.083	1.806	1.056	1.363	1.264	0.739	0.954
2 1/2	2.489	2.579	1.508	1.946	1.805	1.056	1.362
3	3.090	3.975	2.325	3.000	2.782	1.627	2.100
3 1/2	3.570	5.305	3.103	4.004	3.714	2.172	2.803
4	4.050	6.828	3.994	5.153	4.779	2.796	3.607

Table 5-9 | Wire Fill Requirements

Wire Fill Requirements	
Existing conduit:	Sum of Cable Area (in^2) within conduit **<** NEC % Max Fill (in^2)
New conduit:	Sum of Cable Area (in^2) within conduit **<** ODOT % Max Fill (in^2)

Figure 5-84 | Conduit Sizing Example 1

Conduit Sizing Example No. 1

Given: How large of a new conduit is needed if the conduit has to carry the following cables?

1.) Thirteen No. 14 AWG THWN
2.) Two Loop Feeder Cables*
3.) One 6/P (interconnect cable)*
4.) One No. 8 AWG THWN (signal system common)
5.) One No. 6 AWG THWN (Ground/Bond wire. Not shown on) plans, but required by specification)

Step 1: Determine Total cable area using Cable Area Chart:

13*(0.0097) =	0.1261	1*(0.0366)=	0.0366
2*(0.0908) =	0.1816	1*(0.0507)=	0.0507
1*(0.3117) =	0.3117		

*Note - loop feeder cables and interconnect cable are normally installed in separate conduits from the signal system.

Total Sum = (0.1261+0.1816+0.3117+0.0366+0.0507) = **0.7067**

Step 2: Use the ODOT % Max Fill Chart to compare calculated total sum to max. allowable fill (use column for 3+ wires - since the total # of wires in this conduit is 18)

0.7067 > 0.580, therefore, a 1.5" conduit is too small

0.7067 < 0.954 , therefore a 2" conduit is OK**

**check to make sure that a 2" conduit will meet the other ODOT requirements for conduit size

Figure 5-85 | Conduit Sizing Example 2

Conduit Sizing Example No. 2

Given: An existing 2" conduit has the following existing cables, can 4 additional Loop Feeder cables be installed?

1.) Thirteen AWG No. 14 THWN
2.) Two Loop Feeder Cables*
3.) One 6/P (interconnect cable)*
4.) One No. 8 AWG THWN (signal system common)
5.) One No. 6 AWG THWN (Ground/Bond wire. Not shown on) plans, but required by specification)

Step 1: Determine Total cable area using Cable Area Chart:

13*(0.0097) =	0.1261	1*(0.0366)=	0.0366
2*(0.0908) =	0.1816	1*(0.0507)=	0.0507
1*(0.3117) =	0.3117		
4*(0.0908) =	0.3632 } New Cables		

*Note - loop feeder cables and interconnect cable are normally installed in separate conduits from the signal system.

Total Sum =(0.1261+0.1816+0.3117+0.3632+0.0366+0.0507+0.3632) =1.0699

Step 2: Use the NEC % Max Fill Chart to compare calculated total sum to max. allowable fill (use column for 3+ wires - since the total # of wires in this conduit is 22)

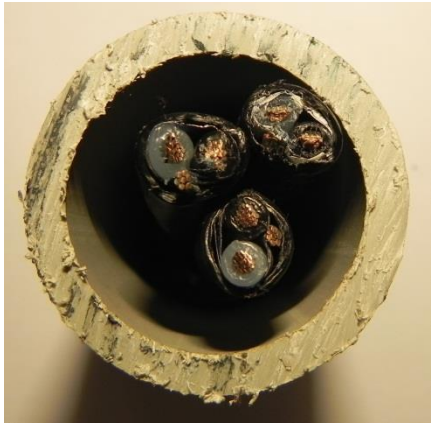
1.0699 < 1.363 , therefore the existing 2" conduit is big enough to allow the new cables**

** note that for a new conduit installation, a 2.5" conduit would be required based on ODOT's Max Fill Chart

Wire fill rates can be visually deceiving if you are not accustomed to working with conduit and wire. The following photos should be helpful in providing some perspective (note: the conduit bushing has not been installed for better photo clarity):

1” conduit w/5 loop feeder cables
Exceeds NEC max fill
Exceeds ODOT max fill

1” conduit w/4 loop feeder cables
Exceeds NEC max fill
Exceeds ODOT max fill



1” conduit w/3 loop feeder cables
Does NOT exceed NEC max fill
Exceeds ODOT max fill

1” conduit w/2 loop feeder cables
Does NOT exceed NEC max fill
Does NOT exceed ODOT max fill

1½” conduit w/control cables
Does NOT exceed NEC max fill
Does exceed ODOT max fill

2” conduit w/control cables
Does NOT exceed NEC max fill
Does NOT exceed ODOT max fill

1½” conduit w/9 loop feeder cables

Does NOT exceed NEC max fill
Does exceed ODOT max fill

1½” conduit w/9 loop feeder cables
+1 video cable
Exceeds NEC max fill
Exceeds ODOT max fill

2½” conduit w/22 loop feeder cables
Exceeds NEC max fill
Exceeds ODOT max fill

3” conduit w/22 loop feeder cables
Does NOT Exceed NEC max fill
Does NOT Exceed ODOT max fill

For new wire installations in existing conduit, the signal designer MUST check the existing conduit size and wire count in the field to make sure the proposed new wires will not exceed the NEC maximum allowed wire fill. Failure to check this is a fatal flaw.

5.13.2 Conduit Materials

There are several different types of conduit materials that can be used for traffic signal installations. The conduit material is NOT specified on the plan sheets as this information is contained within the standard drawings and section 00960.42 of the Oregon Standard Specifications for Construction. The following information is some basics on conduit materials. Refer to the specifications and standard drawings for detailed info.

- **Rigid Metallic Conduit**
  - Rigid galvanized metallic conduit should be used in all locations where there is the potential for damage, which includes any conduit located above ground (on poles or structures).
  - For conduit located under railroad tracks, there is a requirement to place the conduit holding wires within a rigid metallic conduit “sleeve” as per standard specification 00960.41(e).
- **Rigid Non-Metallic Conduit**
  - Fiberglass (schedule 40) – used for elbows and in foundations as per standard specification 00960.42(f) and 00960.42(d) respectively. Fiberglass can also be used instead of Rigid Metallic Conduit in above ground locations.

- PVC (schedule 40) – typically the type of rigid nonmetallic conduit used in most applications.
- High density polyethylene (HDPE) – typically used when installing conduit by horizontal directional drilling.

5.13.3 Expansion Fittings

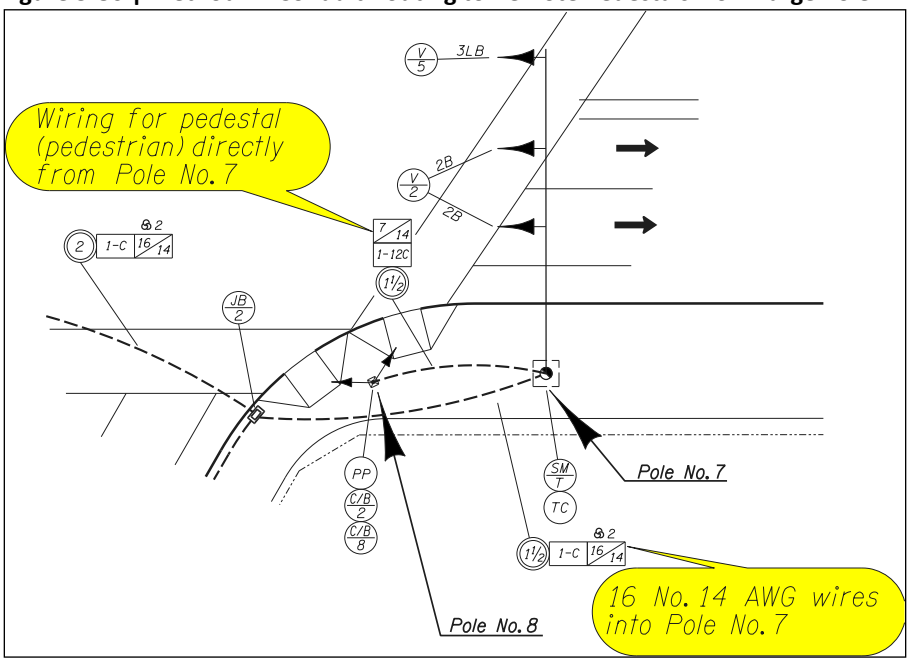
Whenever traffic signal conduit must be placed on or in a structure, conduit expansion fittings are required. The structure will experience expansion/contraction depending on the stresses subjected to it, and so the conduit must also allow for movement too. Therefore, expansion fittings are used on the conduit run at all structure expansion joints as per standard specification 00960.42(k). Because the standard specification states this requirement, it is not necessary to show this detail on the plan sheets.

5.13.4 Routing Conduit to Remote Pedestals (Vehicle, Pedestrian and Pushbutton)

Two methods for routing conduit to a remote pedestal when a large pole is located in the same quadrant are described below. Contact the Region Electrical Crew to determine their preference.

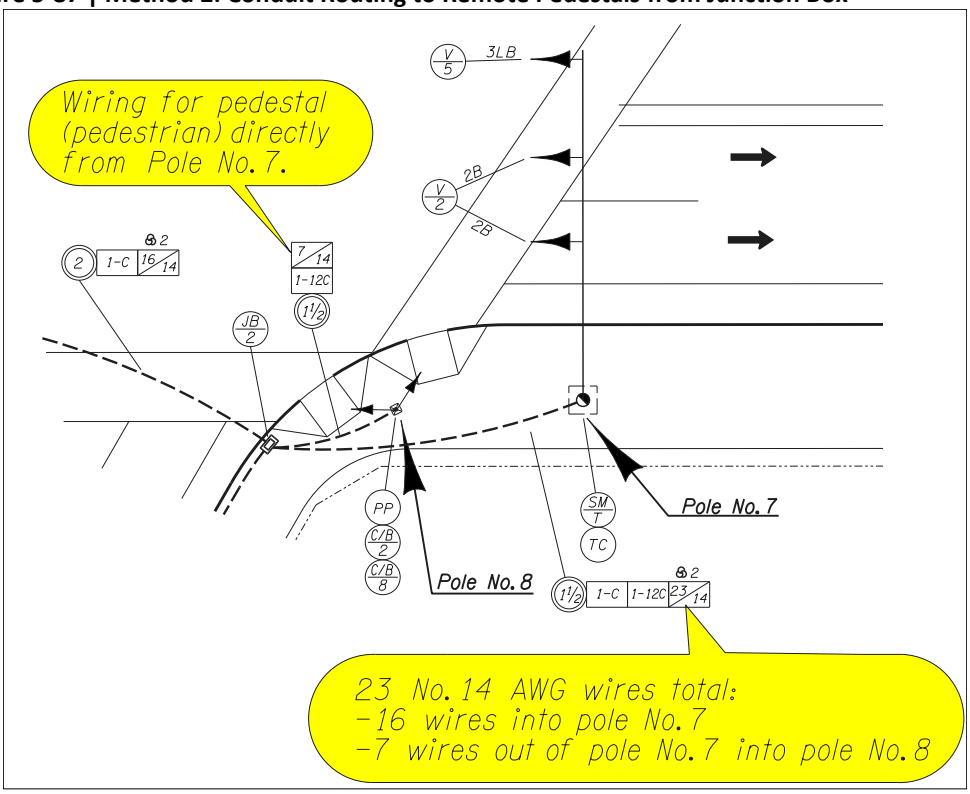
1. Route the conduit from the junction box in the same quadrant to the large pole, then from the large pole to the remote pedestal. The wiring for the remote pedestal will be spliced in the terminal cabinet of the large pole. Routing the conduit and wiring this way allows for easy replacement of the pedestal and wiring to the pedestal in the event of a pedestal knock-down (all pedestals are designed to break-away) due to the splice point in the terminal cabinet. See Figure 5-86.

Figure 5-86 | Method 1: Conduit Routing to Remote Pedestals from Large Pole



2. Route the conduit from the junction box in the same quadrant directly to the remote pedestal. The wiring for the remote pedestal will be spliced in the terminal cabinet of the large pole. Routing the conduit and wiring this way still allows for easy replacement of the pedestal and wiring to the pedestal in the event of a pedestal knock-down, but contains one additional access point (the junction box) rather than a direct connection to between the pedestal and large pole. See Figure 5-87.

Figure 5-87 | Method 2: Conduit Routing to Remote Pedestals from Junction Box



When a large pole is NOT located in the same quadrant as the remote pedestal (e.g. T-intersection), the conduit should route from a junction box in that quadrant to the remote pedestal, shown in Figure 5-88. Do NOT route conduit directly to the remote pedestal. See Figure 5-89.

Figure 5-88 | Conduit Routing to Remote Pedestal Not Located in Same Quadrant as Large Pole

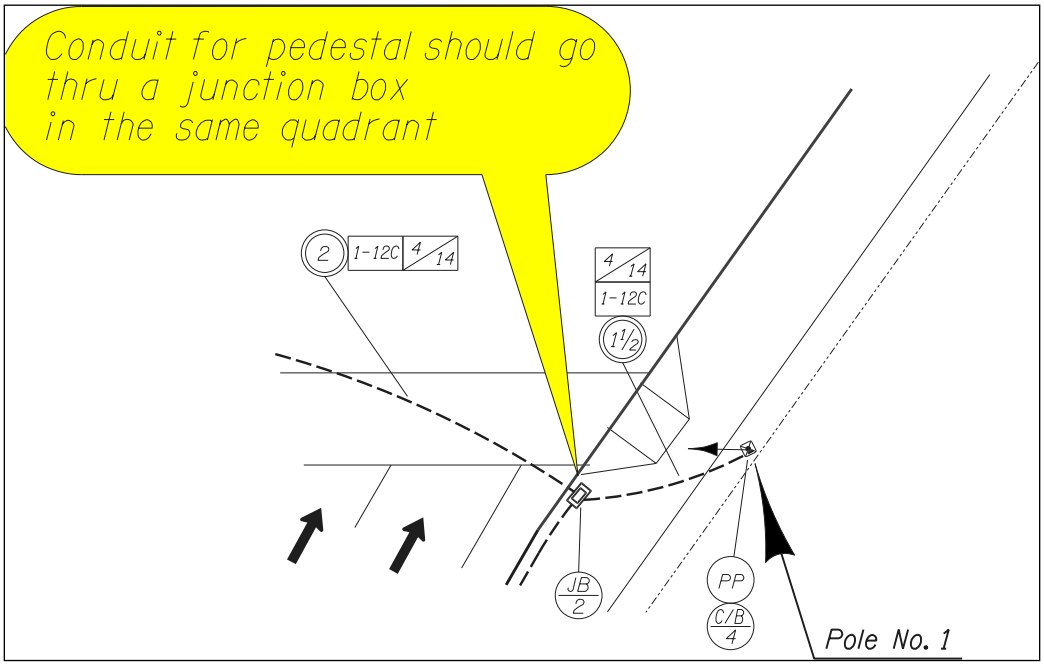
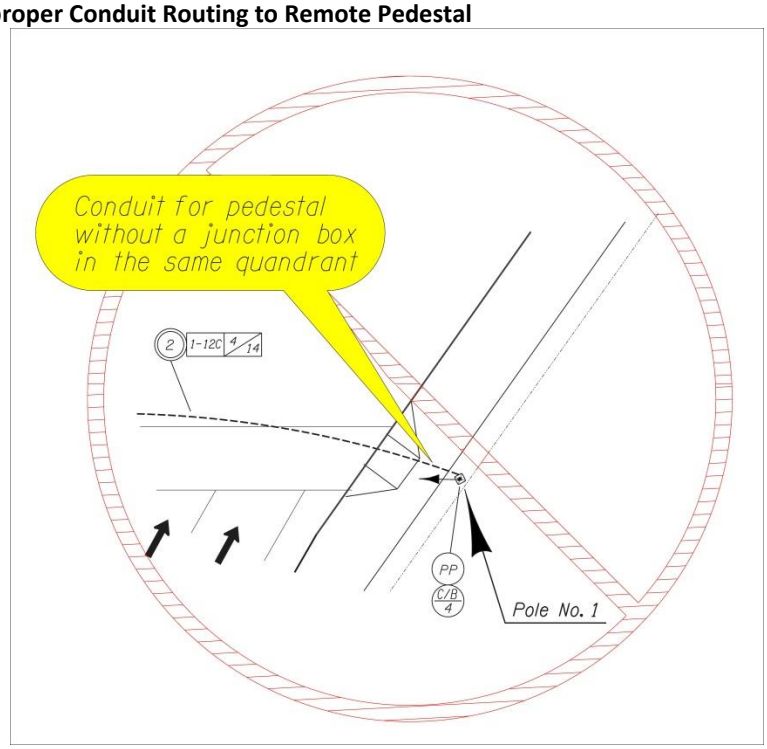


Figure 5-89 | Improper Conduit Routing to Remote Pedestal



5.14 Wiring

Traffic signals have three distinct systems for wiring based on the voltage used:

- 120V AC for all signal indications (includes both vehicle and pedestrian indications)
- 240V AC for illumination that is part of the traffic signal
- 24V DC for pedestrian pushbuttons and vehicle detection system

When wiring a traffic signal, NO SPLICING IS ALLOWED! The only exception to this rule is splicing loop wire to loop feeder cable in the junction box.

5.14.1 Wire Types

The following wire types are used for traffic signals:

Single Conductor Wire

Single conductor wire is the standard for wiring located within conduits (i.e. from the controller cabinet to the pole's terminal cabinet). See Standard Drawing TM470 for the color code. However, control cables may be used in conduits with concurrence from the ODOT Region Electrical Crew.

THWN

THWN stands for:

- T: Thermoplastic insulation
- H: High temperature (usually 75 °C when dry or damp)
- W: Moisture resistant (usually 60 °C when wet)
- N: Nylon jacket

This wire consists of a stranded copper conductor with thermoplastic installation and nylon jacket. This type of wire is the standard for providing electricity to:

- signal heads
- pedestrian signal heads
- pushbuttons
- system commons
- photo control electronic relay
- flashing beacons

XHHW

XHHW stands for:

- X: Cross-linked synthetic polymer insulation
- HH: Higher temperature (usually 90 °C when dry or damp)
- W: Moisture resistant (usually 60 °C when wet)

This wire consists of a stranded copper conductor with cross-linked synthetic polymer insulation. This type of wire is the standard for providing electricity to:

- loop wires
- illumination
- power from BMCL to signal controller cabinet

Control Cable (multi-conductor cable)

Control cables are multi-conductor cable with assorted stranded copper wires of a particular gauge (No. 14 AWG, No. 12 AWG, etc.). The standard material (wire and insulation) are defined by IMSA (International Municipal Signal Association). They are the standard for aerial installations, such as a temporary signal. Control cables may be used within conduits (rather than single conductor wires) with concurrence from the Region Electrical Crew. See Standard Drawing TM470 for color code.

ODOT's standard is to use control cable from the terminal cabinet to each of the signal heads, in both mast arm and span wire installations. The control cables are shown and labeled on all span wire plan sheets between strain poles. The cables within a mast arm are not shown on the plans, but are instead detailed in the specifications. See Standard Drawing TM470 for wiring guidance on single conductor and control cable color codes.

Interconnect Cable

Interconnect cable consists of a shielded cable containing 6+ twisted pairs of No. 19 AWG wires. This cable is used solely for the purposes of communication between traffic signals. 12+ twisted pair of No. 19 AWG wires may also be used if additional wires are needed. See Chapter 7 for more information on interconnect design.

5.14.2 Wire Gauge

The American Wire Gauge (AWG) is a standardized wire gauge system for the diameters of round electrically conducting wire. The cross-sectional area of each gauge is an important factor for determining its current carrying capacity. Increasing gauge numbers give decreasing wire diameters.

The standard wire gauges used by ODOT for traffic signal installations are shown below:

- No. 6 AWG is used for:
  - power from the BMCL to the signal controller
  - Ground/bond wire
- No. 8 AWG is used for the traffic signal system neutral
- No. 10 AWG is used for illumination
- No. 12 AWG is used for:
  - Pedestrian signal system neutral (for use with pedestrian pedestals only)
  - Traffic signal system neutral (for use with vehicle pedestals only)
  - Power from BMCL to the photo control electronic relay
  - PTR signs

- No. 14 AWG is used for powering:
  - Signal heads (vehicle/bike)
  - Pedestrian signal heads
  - Pushbuttons
  - Pushbutton system common
  - Flashing beacons

5.14.3 Voltage Drop

In certain circumstances, such as a temporary one-lane, two-way traffic signal where the distance between the signal controller and the signal equipment is excessive, a larger gauge wire (than the ODOT standard) may be needed to power the equipment due to the voltage drop that occurs over the distance of the wire. Voltage drop should not exceed three percent. However, with the use of LED signal heads (which do not require as many watts as an incandescent signal head) the need to use larger gauge wire is now rarely a necessity, even with temporary one-lane, two-way traffic signals.

5.14.4 Bonding/Grounding Requirements

All ground rods, metal conduit, metal poles, grounding wire, metallic junction boxes, metallic junction box covers, and cabinets shall be mechanically and electrically secure to form a continuous, effectively grounded and bonded system. Typically, a No. 6 AWG stranded copper wire is used for grounding/bonding.

The ODOT Standard Drawings, Section 00960.50 of the Oregon Standard Specifications for Construction, and National Electric Code contain all the requirements for bonding and grounding. Because of this, the signal plan sheets typically do NOT show or detail any grounding/bonding requirements. It is recommend that the signal designer consult these sources or contact the ODOT Region Electrical Crew for additional information on grounding/bonding.

5.14.5 Common/Neutral (Shared) Wire

A neutral/common wire is needed for each signal system to complete the circuit. There are three separate wiring systems used in traffic signals:

1. 120V AC for signal indications – Includes both pedestrian & vehicle indications
2. 24V DC for pedestrian pushbuttons
3. 240V AC for illumination on signal poles (two hot 120V wires, No. 10 AWG XHHW wire, therefore no common/neutral required)

One common/neutral wire is required from the signal controller cabinet to each pole that has signal indications attached to it, regardless of the number of signal indications or phases. One common/neutral wire is required from the signal controller cabinet to each pole that has a pedestrian pushbutton attached to it, regardless of the number of pushbuttons. For example, a vehicle pedestal with a signal indication, two pedestrian

indications, and two pushbuttons will require a total of two common/neutral wires; one for the signal indications (120V AC) and one for the pushbuttons (24V DC).

When using single conductor, the size of the common/neutral wire used for signal indications varies depending on the size of the pole that it will be going into:

- For large signal poles (those over 4” in diameter, i.e. mast arm poles and strain poles) with signal indications, one No. 8 AWG THWN wire is required.

- For small signal poles (those 4” in diameter, i.e. pedestals) with signal indications, one No. 12 AWG THWN wire is required.

When using control cable, the common/neutral is inclusive, therefore the size of the common/neutral is based on the AWG of the control cable (typically No. 14).

The size of the common wire used for pedestrian pushbuttons does not vary with pole size:

- For pedestrian pushbutton, one No. 14 AWG THWN wire is required.

The common/neutral wire from the signal cabinet is terminated at the terminal cabinet located on the signal pole (this is the common/neutral wire that is shown and detailed on the signal plan sheet). From there, additional common/neutral wires are used as necessary from the terminal cabinet on the signal pole to each signal indication (this wiring is NOT shown or detailed on the signal plan sheet). For small poles that do not have a terminal cabinet, such as vehicle and pedestrian pedestals, the common/neutral wire is terminated in a terminal block within the signal indication.

5.14.6 Wiring Signal Heads (From Head to Terminal Cabinet)

Each signal indication in a signal head requires a “Hot” wire and a “common/neutral” wire in order to complete the circuit. Refer to Figure 5-91 when reading the bulleted text below for a description of the wiring diagram that is used in Figure 5-91 through Figure 5-98 for each signal head type:

- The Type 2 signal head shows the hot wiring for each indication (red, yellow, green) entering the signal indication from right side and the common/neutral wiring entering from the left side. This wiring is contained within the signal head itself and NOT shown or detailed on the plan sheets.

- The wiring from the terminal block within the signal head connects to the terminal cabinet located on the signal pole. This wiring is accomplished with a 7 conductor control cable; one for each signal head regardless of type (See Standard Drawing TM470, See Figure 5-90). It is located within the mast arm

or along the span wire. Note that use of a 7 conductor control cable results in one to three spare wires depending on the type of signal head that is used. This wiring is NOT shown or detailed on the plan sheets for mast arm installations, as the specifications and standard drawing TM470 detail this information, but it is shown and detailed on the plan sheets for span wire installations.

- From the terminal cabinet on the signal pole, individual conductor wire (default standard) or control cable (if requested by the Region Electrical Crew) is routed back to the signal controller cabinet (in conduit, for both mast arm and span wire installations) to power each signal phase. See 5.14.8 for more info. This wiring is shown and detailed in the plan sheets. Note that the No. 8 AWG common/neutral wire used in each example for the individual conductors assumes that the signal head is attached to a large pole (over 4” in diameter). If the signal head was attached to a small pole, such as a vehicle pedestal, then a No. 12 AWG common/neutral wire would be used instead.

Figure 5-90 | Standard Drawing TM470 Signal Head Wiring

			SIGNAL HEAD TYPES			
7 CONDUCTOR CONTROL CABLE			6L or 3LBF	5 or 7	1R, 1Y 2, 3L, 3LCF, 3R 4 or 9	10
CONDUCTOR NUMBER	BASE COLOR	FIRST TRACER				
1	WHITE	—	NEUTRAL	NEUTRAL	NEUTRAL	NEUTRAL
2	BLACK	—	YELLOW	YELLOW	YELLOW	YELLOW
3	RED	—	RED	RED	RED	RED 1
4	ORANGE	—	FLASHING YELLOW	TURN YELLOW	SPARE	RED 2
5	GREEN	—	GREEN	GREEN	GREEN	GREEN
6	BLUE	—	SPARE	TURN GREEN	SPARE	SPARE
7	WHITE	BLACK	SPARE	SPARE	SPARE	SPARE

Figure 5-91 shows the wiring required for a type 2, 3L, 3R, or 3LCF signal head. These signal head types contain one phase and three functions (Red, Yellow, and Green). The 3LCF signal head yellow indication performs two functions (flashing arrow and solid arrow) via software programming. One "hot" wire for each function and one common/neutral wire is required.

Figure 5-91 | Wiring for Type 2, 3L, 3R, and 3LCF Signal Heads

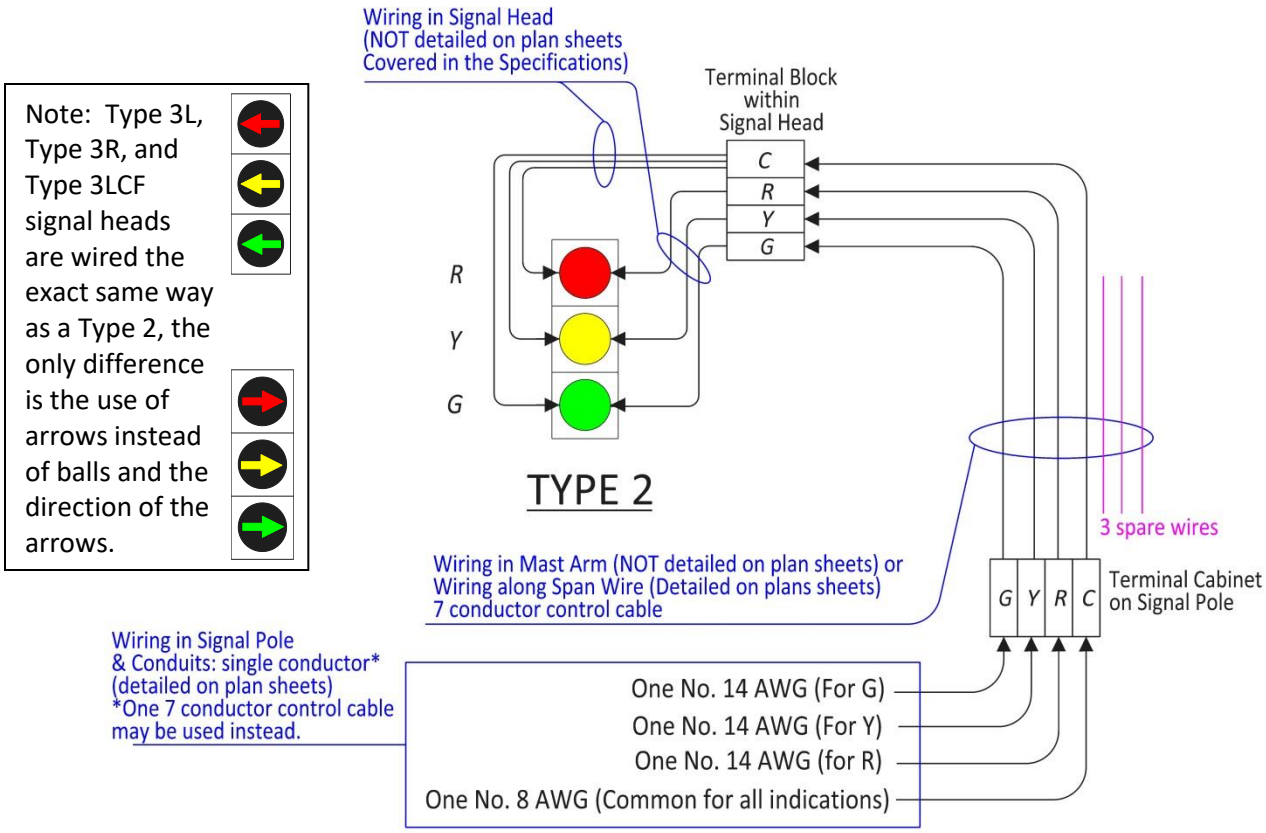


Figure 5-92 shows the wiring required for a Type 3LBF signal head. This signal head type contains one phase and four functions (Red, Yellow, Flashing Yellow and Green). All of the solid arrow indications are wired to the protected left turn phase (typically 1, 3, 5, or 7) and the flashing yellow arrow is wired to an unused pedestrian yellow phase (typically ped phase 2, 4, 6, or 8) which via software is linked to the opposing through movement. This results in a total of four No. 14 AWG wires (plus a common/neutral) to power this type of signal head.

Figure 5-92 | Wiring for Type 3LBF Signal Head

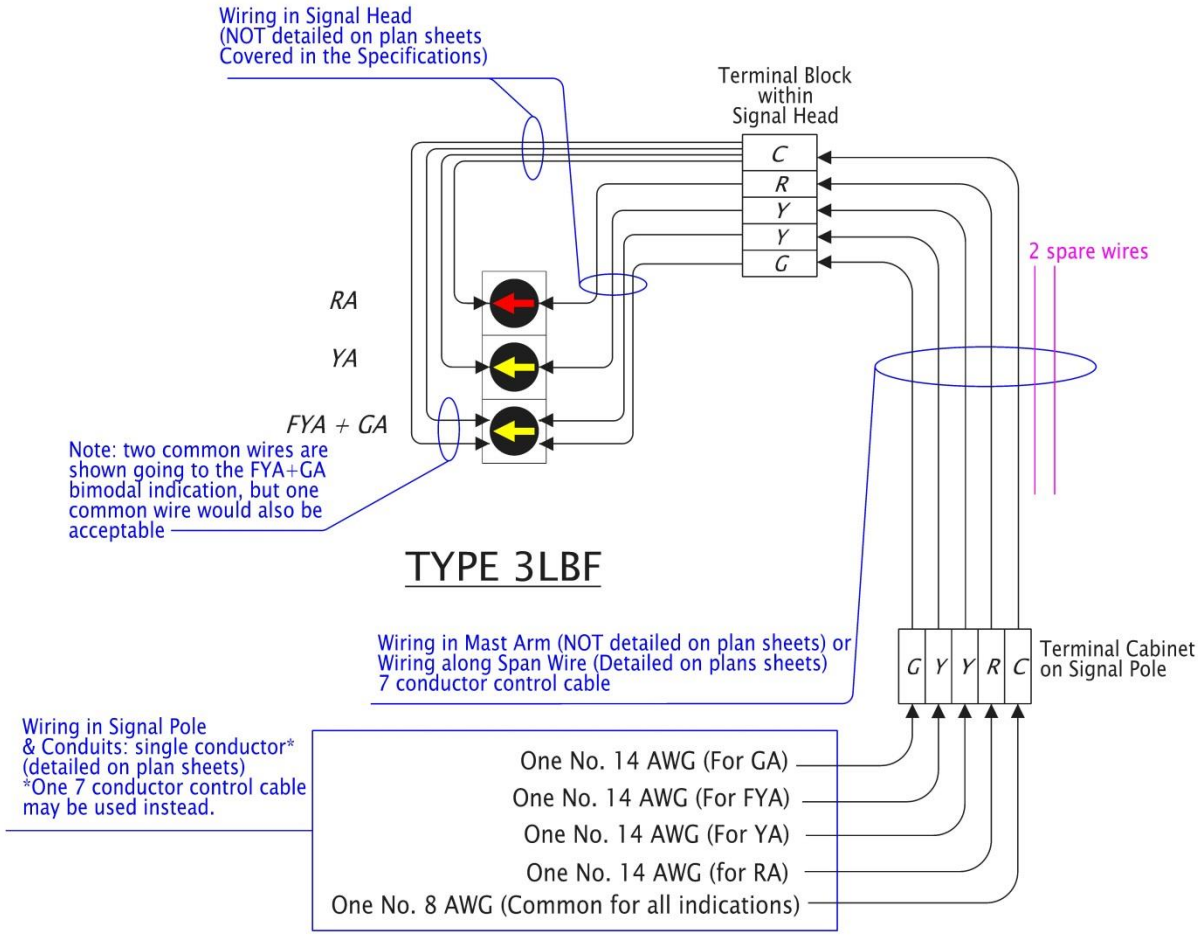


Figure 5-93 shows the wiring required for a type 4 or type 9 signal head. These signal head types contain one phase and three functions (Red, Yellow, and Green). The two green indications (one ball and one arrow) always operate together on the same phase. Because of this, the wiring shown and detailed on the plan sheets looks no different than for a type 2 signal head. The additional wires needed to power each green indication occur within the signal head, which is not shown or detailed on the plan sheets.

Figure 5-93 | Wiring for Type 4 & 9 Signal Heads

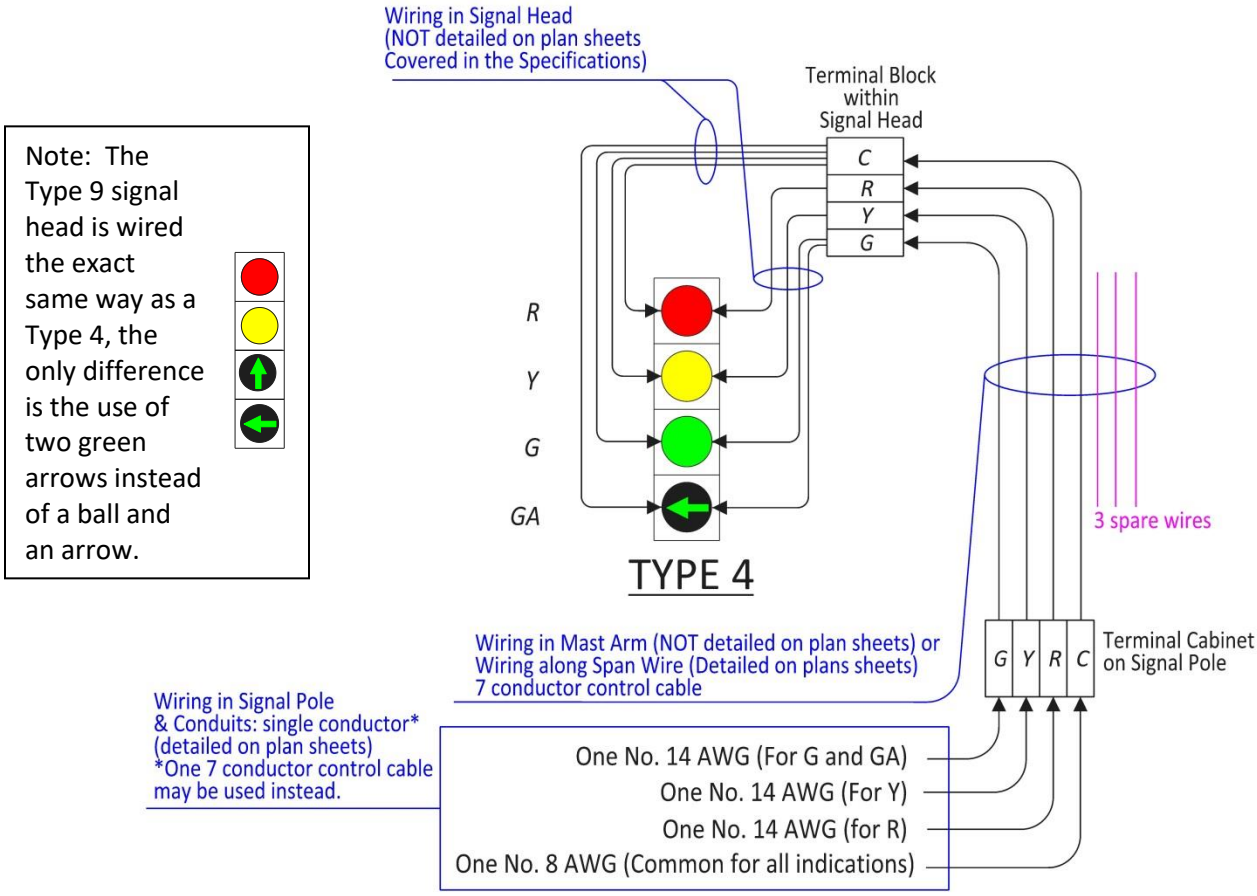


Figure 5-94 shows the wiring required for a Type 5 signal head. This signal head type contains two separate phases (the arrow indications are for the protected right turn phase and the ball indications are for the through phase/permissive right turn) and five functions total (Red, Yellow, and Green for one phase. Yellow and Green for the second phase). All of the ball indications are wired to the through movement phase (typically 2, 4, 6, or 8) and the two arrow indications are wired to the complimentary protected left turn phase (typically 1, 3, 5, or 7). This results in a total of five No. 14 AWG wires (plus a common/neutral) to power these types of signal heads.

Figure 5-94 | Wiring for Type 5 Signal Heads

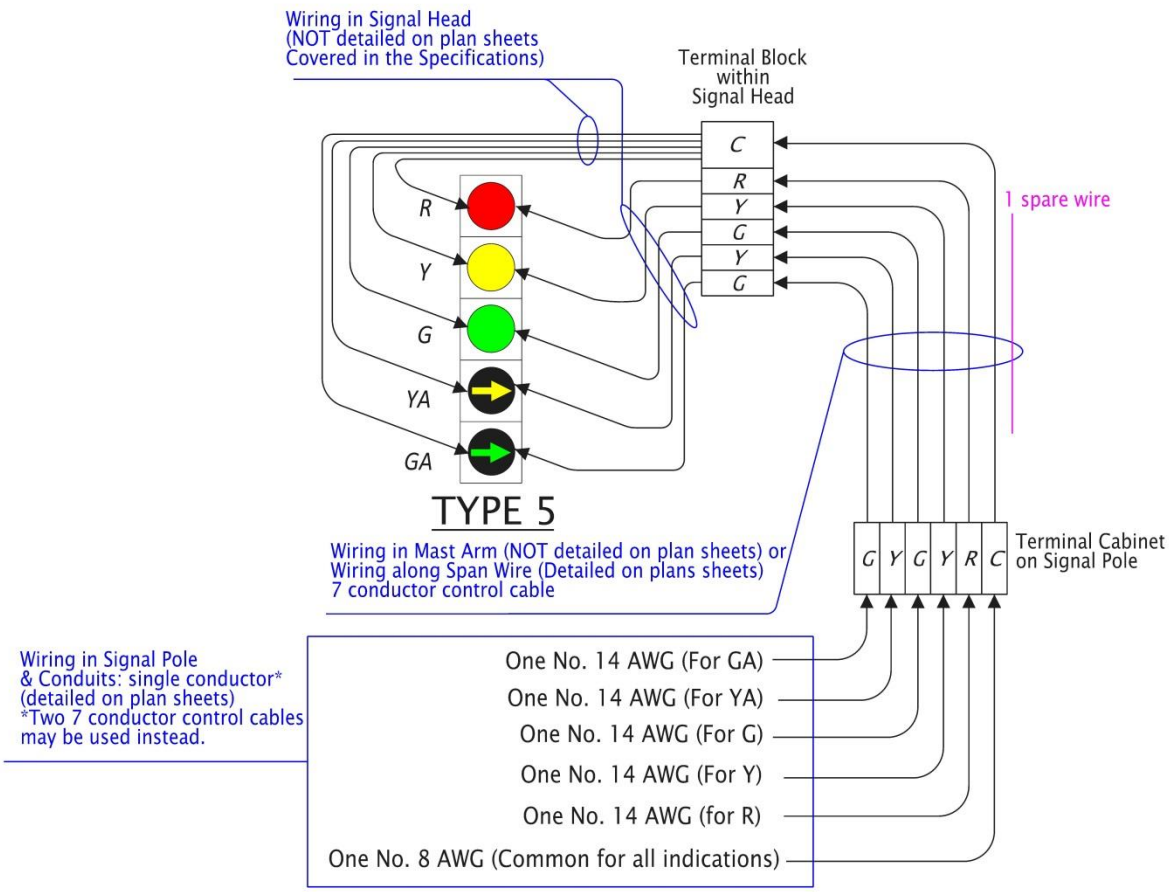


Figure 5-95 shows the wiring required for a Type 6L signal head. This signal head type contains one phase (the left turn) and four functions (Red, Yellow, Flashing Yellow, and Green). All of the solid arrow indications are wired to the protected left turn phase (typically 1, 3, 5, or 7) and the flashing yellow arrow is wired to an unused pedestrian yellow phase (typically ped phase 2, 4, 6, or 8) which via software is linked to the opposing through movement. This results in a total of four No. 14 AWG wires (plus a common/neutral) to power this type of signal head.

Figure 5-95 | Wiring for Type 6L Signal Head

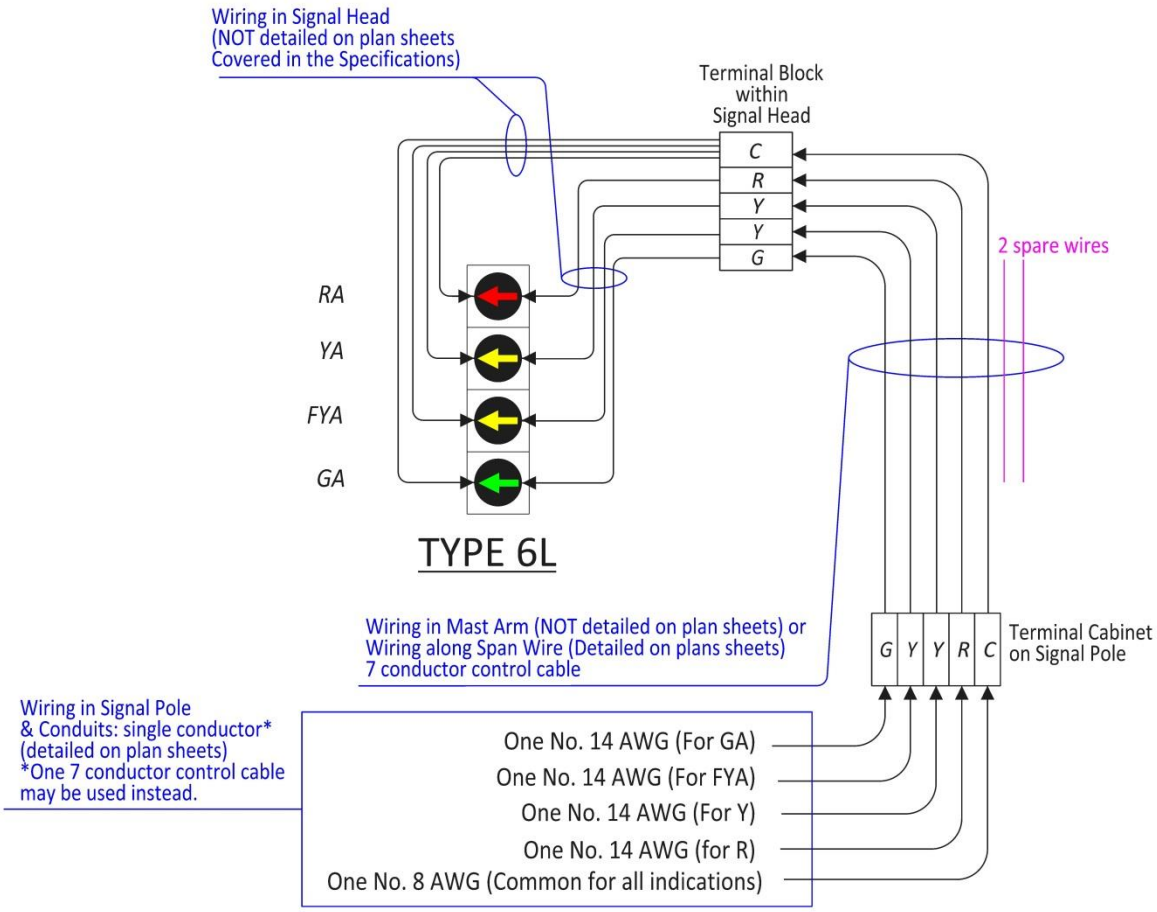


Figure 5-96 shows the wiring requirements for a type 7 signal head. This signal head type contains two separate phases and a total of four functions (Red, yellow, Green for one phase. Green for the second phase). Unlike the type 4 signal head, the green arrow and green ball operate on the different phases. All of the ball indications are wired to the through movement phase (typically 2, 4, 6, or 8) and the green arrow indication is wired to the adjacent protected left turn phase (typically 1, 3, 5, or 7). This enables the green arrow to only be displayed during railroad preemption and remain dark during normal phase rotation. This results in a total of four No. 14 AWG wires (plus one common/neutral) to power this type of signal head.

Figure 5-96 | Wiring for Type 7 Signal Head

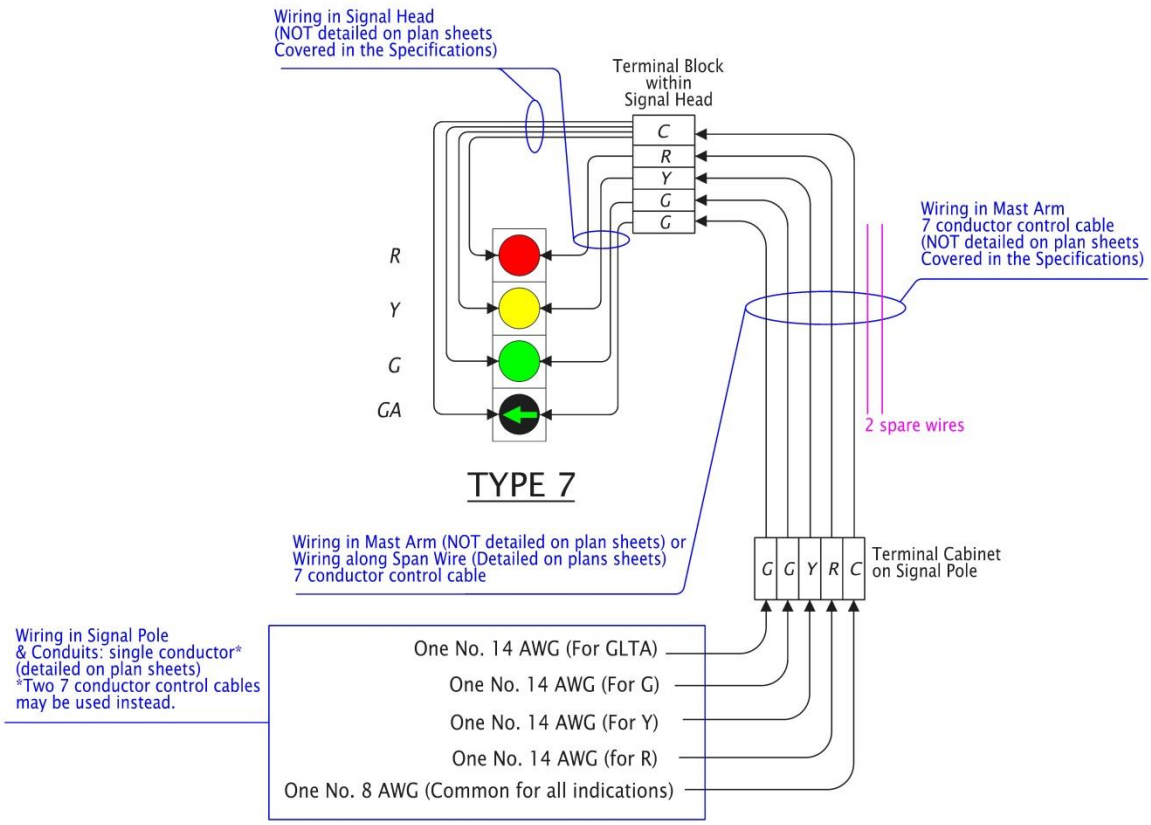


Figure 5-97 show the wiring requirements for a type 8 signal head. This signal head type contains one phase and two functions (red and green), resulting in a total of two No. 14 AWG wires (plus one common/neutral) to power it. This signal head type is always mounted on a vehicle pedestal as per standard drawing TM497.

Figure 5-97 | Wiring for Type 8 Signal Head

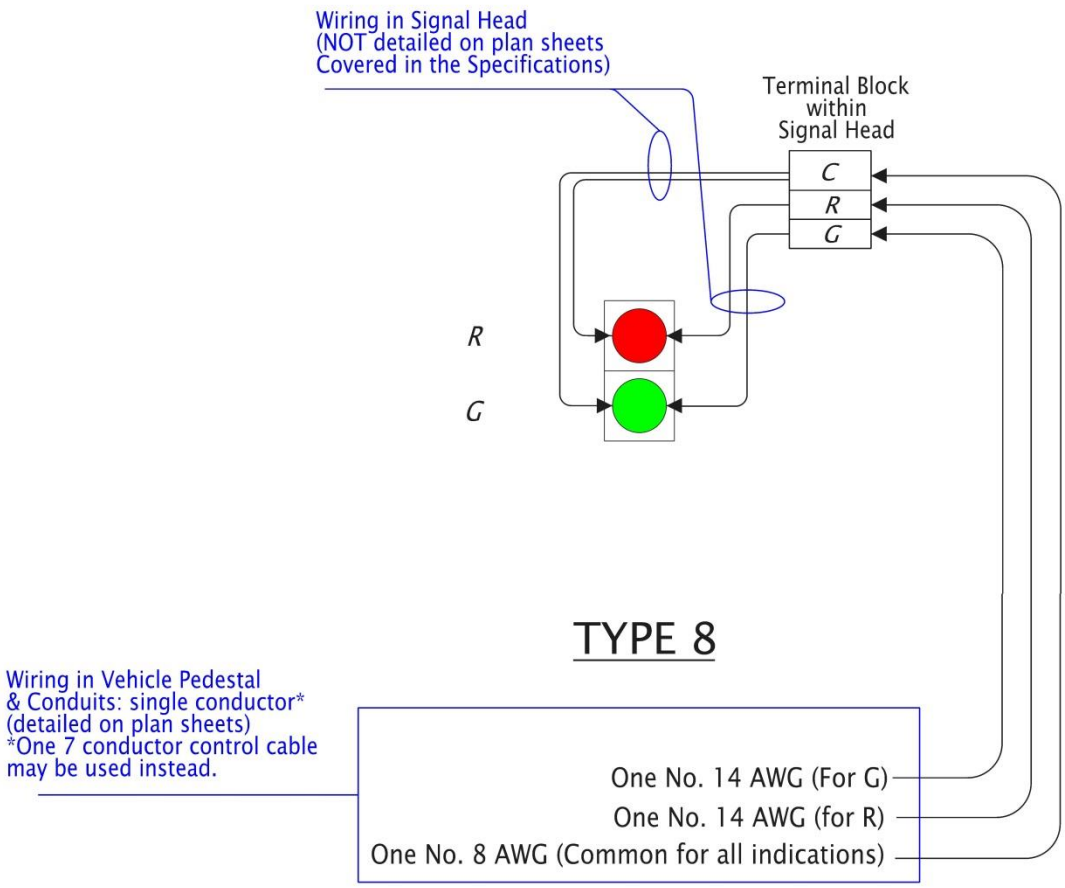
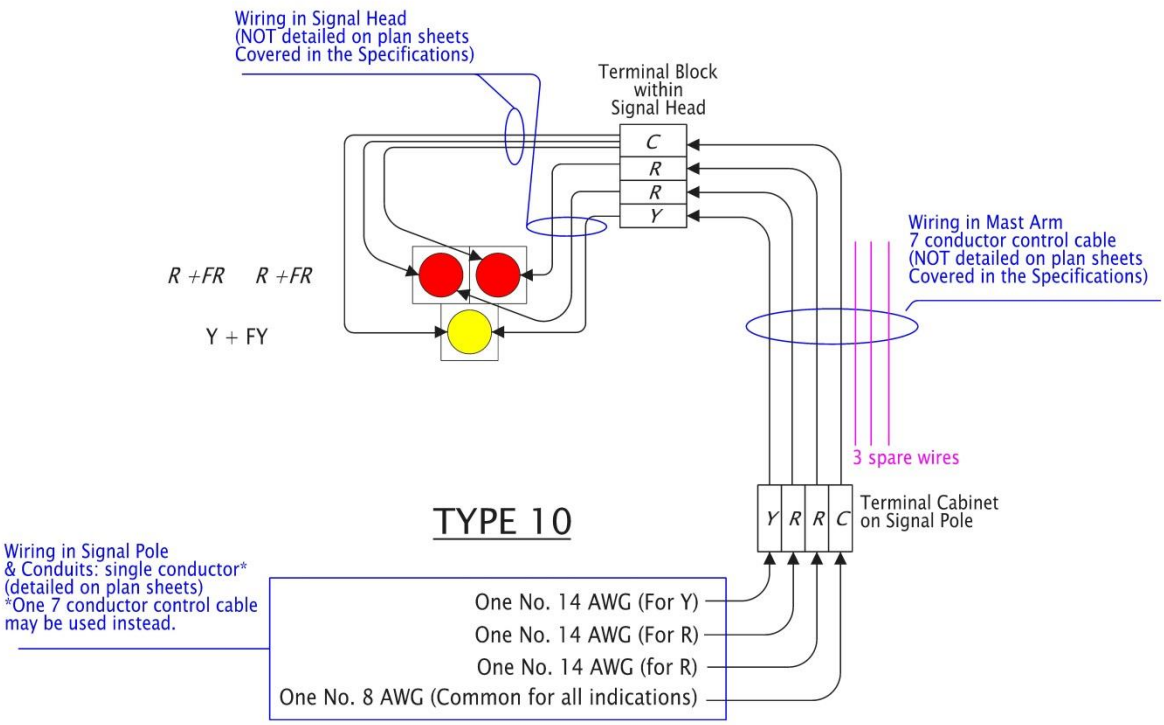


Figure 5-98 shows the wiring requirements for a type 10 signal head. This signal head type contains one phase and two functions (Red and Yellow). However, the red function is comprised of two indications that must operate in a “wig-wag” pattern (one off, one on and visa-versa) and therefore requires a separate wire for each indication. This results in a total of three No. 14 AWG wires (plus one common/neutral) to power this type of signal head.

Figure 5-98 | Wiring for Type 10 Signal Head

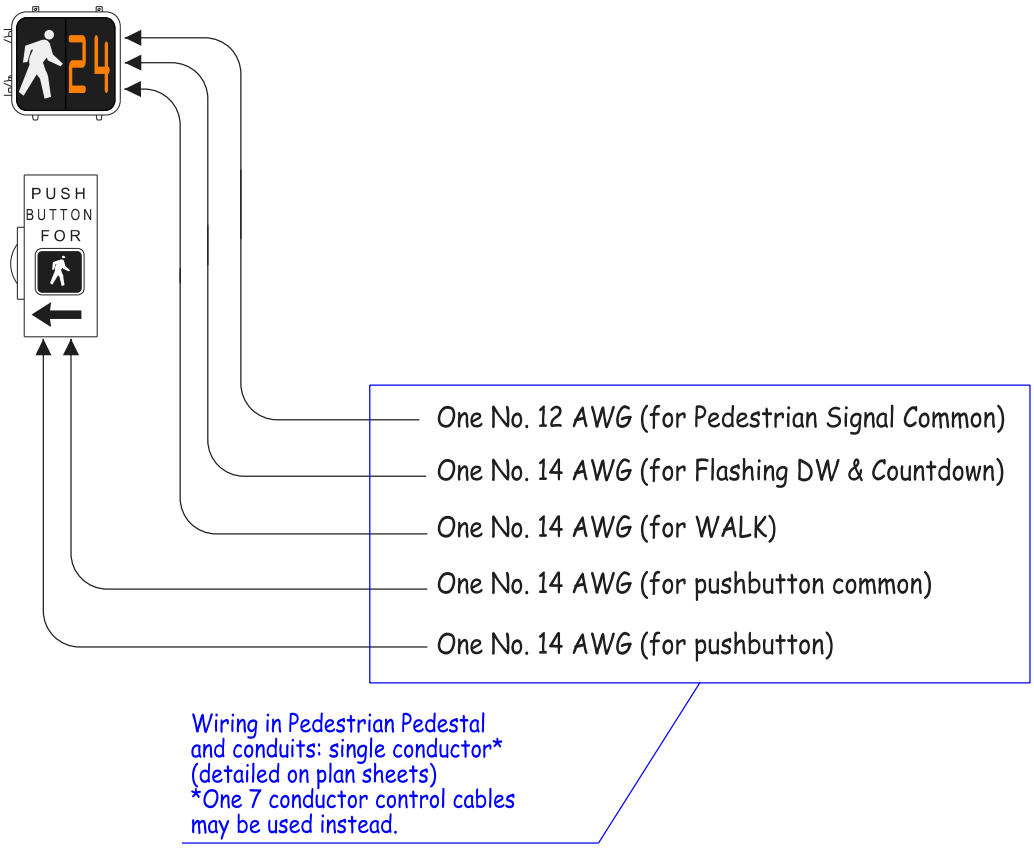


5.14.7 Wiring Pedestrian Indications and Pushbuttons

Pedestrian indications include WALK and FLASHING DON'T WALK, which require two No. 14 AWG wires. The standard countdown style pedestrian head does not require any additional wiring. Depending on the size of the pole that the pedestrian head is mounted on, the common/neutral wire for the pedestrian indications will either be a No. 12 AWG (for poles 4" in diameter, i.e. pedestals) or a No. 8 AWG (for poles larger than 4", i.e. mast arm or strain pole). Figure 5-99 assumes the indications are mounted on a pedestrian pedestal.

The only function of the pedestrian pushbutton is to provide one input to the traffic signal controller to indicate a pedestrian call. Therefore, only two No. 14 AWG wires are needed to make the pushbutton function; one wire for the pushbutton and one wire for the common to complete the circuit. The pushbutton common is terminated independent of the signal indications because the pedestrian pushbuttons operate on a different voltage (24V) than the signal indications (120V, pedestrian & vehicle).

Figure 5-99 | Pedestrian Indication and Pushbutton Wiring

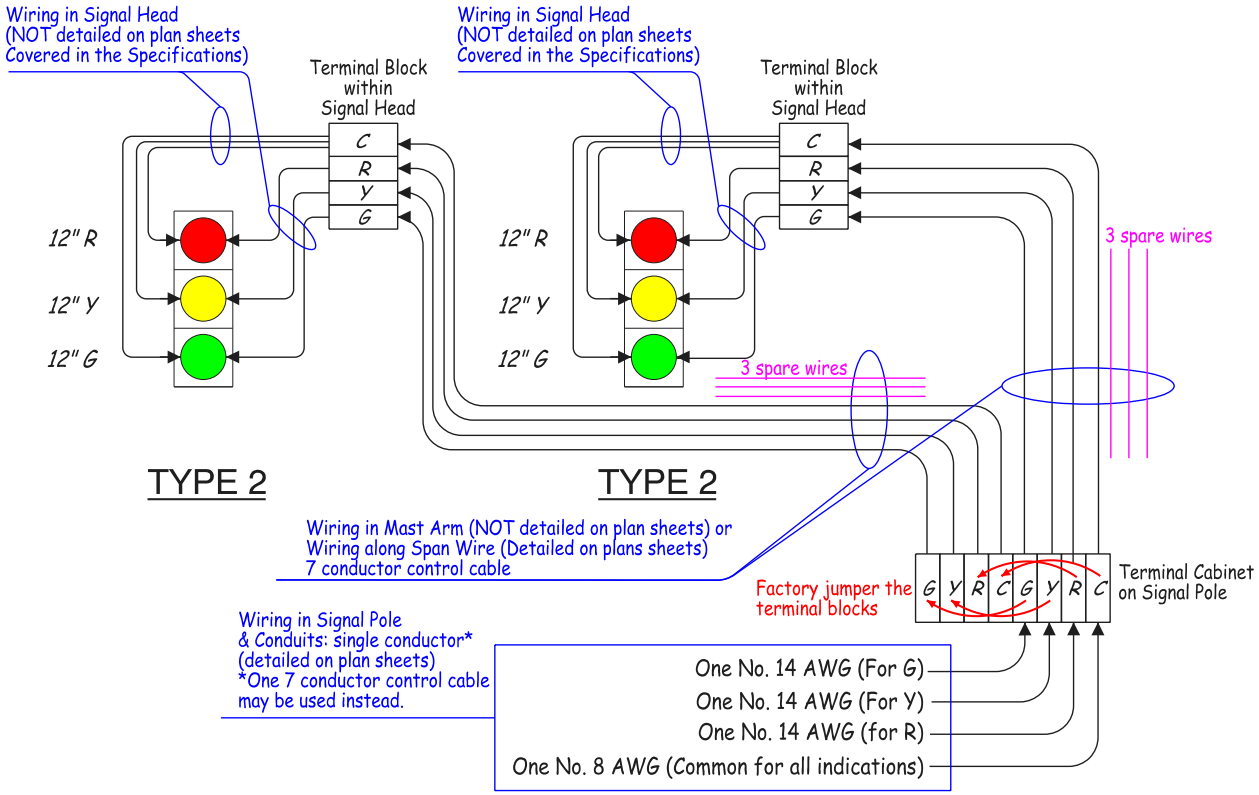


5.14.8 Wiring Signal Phases (from Terminal Cabinet to Controller)

The previous section detailed how each signal head needs to be wired, while this section focuses on how each signal phase is wired (wiring from the terminal cabinet on the signal pole to the controller). This section is applicable to both mast arm and span wire installations as both installations shall use conduit routed to each pole from the controller.

Typically multiple signal heads (located on the same pole) are needed for one phase. Figure 5-100 shows one of the most common applications, two signal heads for one through movement phase (Typically phases 2, 4, 6, or 8). Note that only three No. 14 AWG wires (plus a common/neutral) are needed from the signal controller cabinet to the terminal cabinet on signal pole and "factory jumpers" are used on the terminal block within the terminal cabinet on the signal pole to provide power to the additional signal head. If a third signal head was added to the same phase, the same three No. 14 AWG wires and one No. 8 AWG common/neutral would be used from the signal controller cabinet to the terminal block on the signal pole, but an additional set of jumpers in the terminal cabinet on the signal would be used to power the third signal head. This principle of using jumpers in the terminal cabinet on the signal pole applies to any number of signal heads that are intended to operate on the same phase (on the same pole).

Figure 5-100 | Wiring Multiple Signal Heads for the Same Phase on the Same Pole



Using individual conductors is the default standard for wiring phases from the controller to terminal cabinet (in conduits) for both span wire and mast arm installations. See Figure 5-102 for an example. However, at the request of the Region Electrical Crew, control cables may be used according to standard drawing TM470. See Figure 5-101. One 7 conductor control cable is required per phase (vehicle and pedestrian) from the controller to the pole terminal cabinet. See Figure 5-103 for an example.

Span wire installations shall use conduit to each pole. Aerial wiring on the messenger cable is only allowed for wiring from the terminal cabinet to each signal head and for temporary signal installations.

Figure 5-101 | Standard Drawing TM470 Signal Phase Wiring

			PEDESTRIAN PHASES	VEHICLE PHASES
7 CONDUCTOR CONTROL CABLE			1 PEDESTRIAN PHASE	1 VEHICLE PHASE
CONDUCTOR NUMBER	BASE COLOR	FIRST TRACER		
1	WHITE	—	NEUTRAL	NEUTRAL
2	BLACK	—	WALK	YELLOW
3	RED	—	DONT WALK	RED
4	ORANGE	—	P.B. COMMON	SPARE
5	GREEN	—	PUSHBUTTON	GREEN
6	BLUE	—	SPARE	SPARE
7	WHITE	BLACK	SPARE	SPARE

Figure 5-102 | Wiring Phases with Individual Conductors

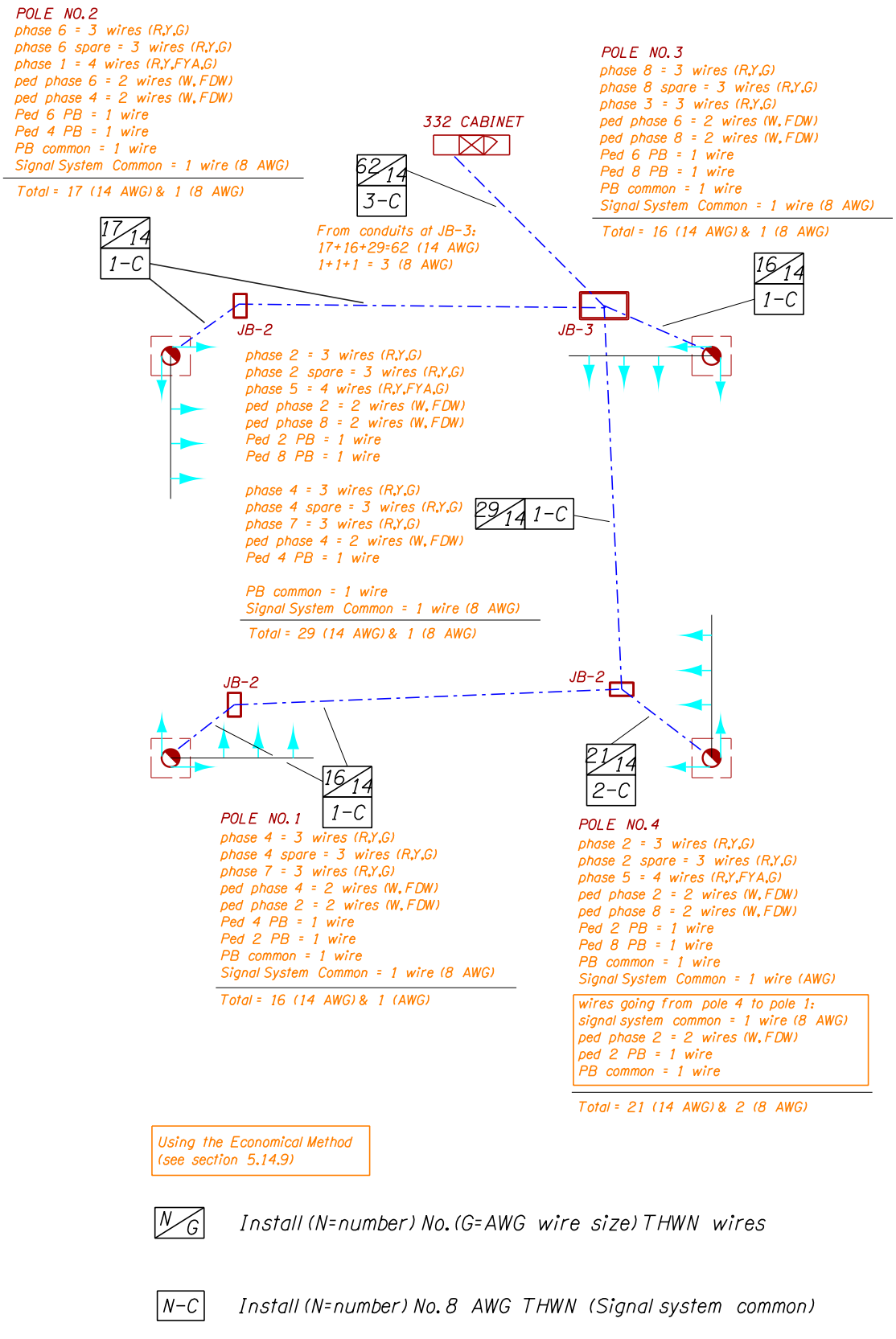
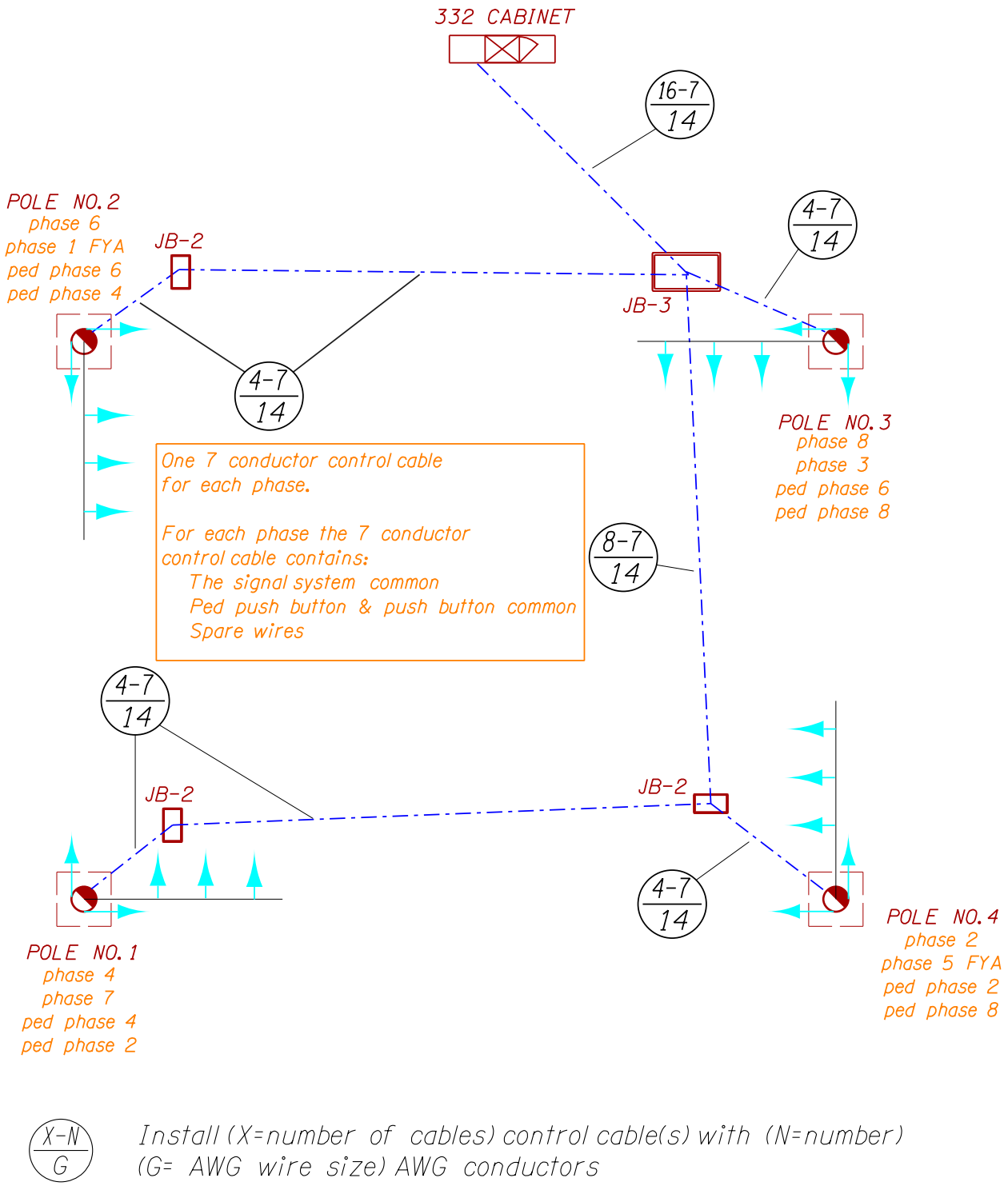


Figure 5-103 | Wiring Phases with Control Cables



5.14.9 Verifying Wire Fill at the Terminal Cabinet Entrance and Mast Arm Connection

There are two critical locations on the mast arm pole that limit the amount of control cables that can be used within the pole:

- the terminal cabinet entrance
- the mast arm connection

If the mast arm has an external terminal cabinet and is using control cables from the terminal cabinet to the signal controller cabinet, both critical locations should to be verified. See Figure 5-104. If the mast arm has a recessed terminal cabinet or if individual conductors are used from the terminal cabinet to the signal controller cabinet, only the mast arm connection should be verified. See Figure 5-105.

- External Terminal Cabinet Entrance: The terminal cabinet entrance dimension is through a 2 ½ inch diameter factory installed hub. This can accommodate a maximum of 16, 7-conductor control cables with No. 14 AWG conductors, using a 60% max fill rate as per the NEC for conduit and tubing nipples that do not exceed 24 inches in length. The external terminal cabinet entrance will contain control cables going into the terminal cabinet (from the signal controller cabinet) and control cables going out of the terminal cabinet (to the equipment mounted on the pole and mast arm).

- Mast arm Connection: The mast arm connection dimension is a 2 inch diameter pipe sleeve. This can accommodate a maximum of 11, 7-conductor control cables with No. 14 AWG conductors, using a 60% max fill rate as per the NEC for conduit and tubing nipples that do not exceed 24 inches in length. The mast arm connection will contain all control cables from the terminal cabinet to the equipment located on the mast arm.

Figure 5-104 | Verify Wire Fill at Terminal Cabinet and Mast Arm Connection (control cables with external terminal cabinet)

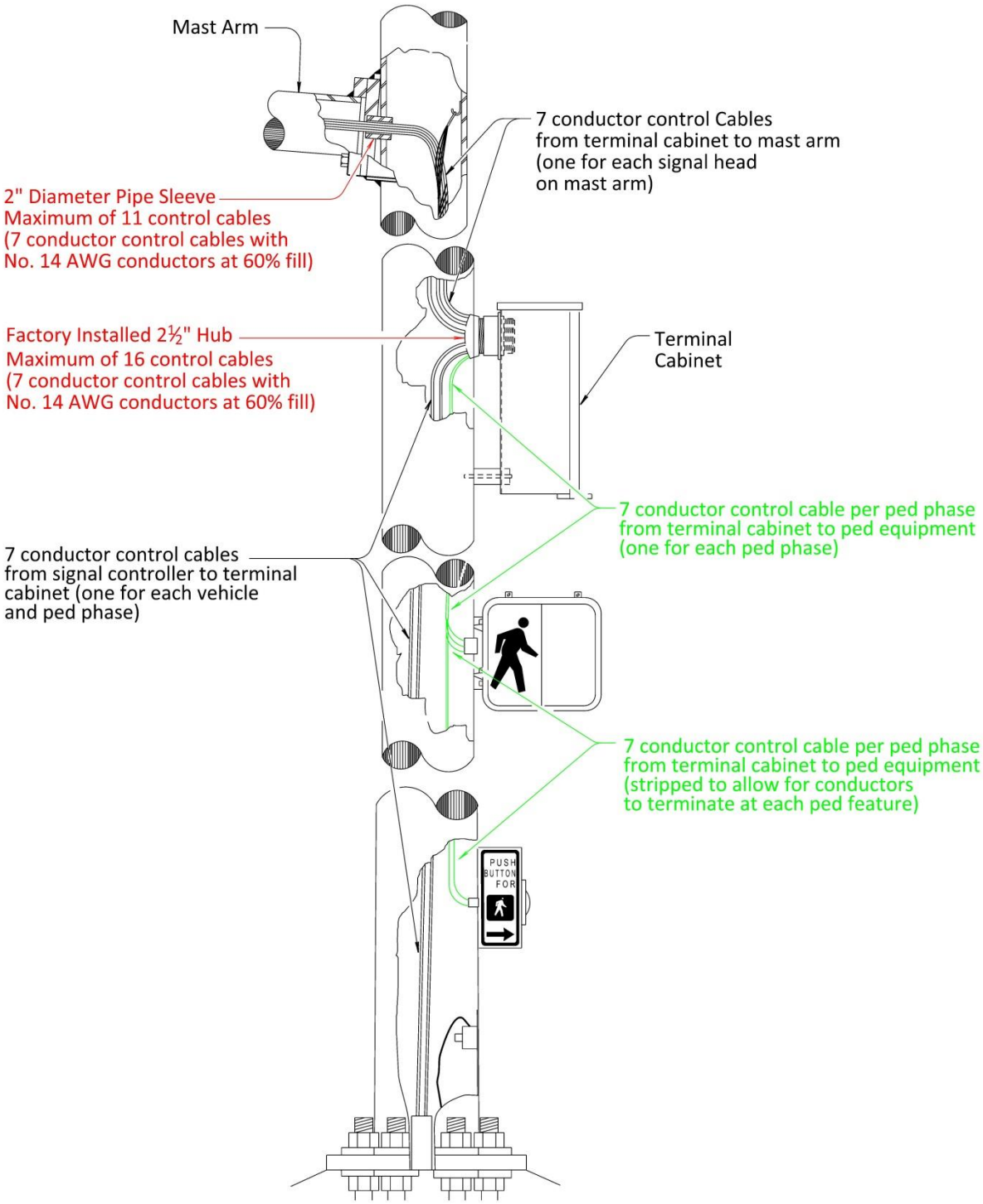
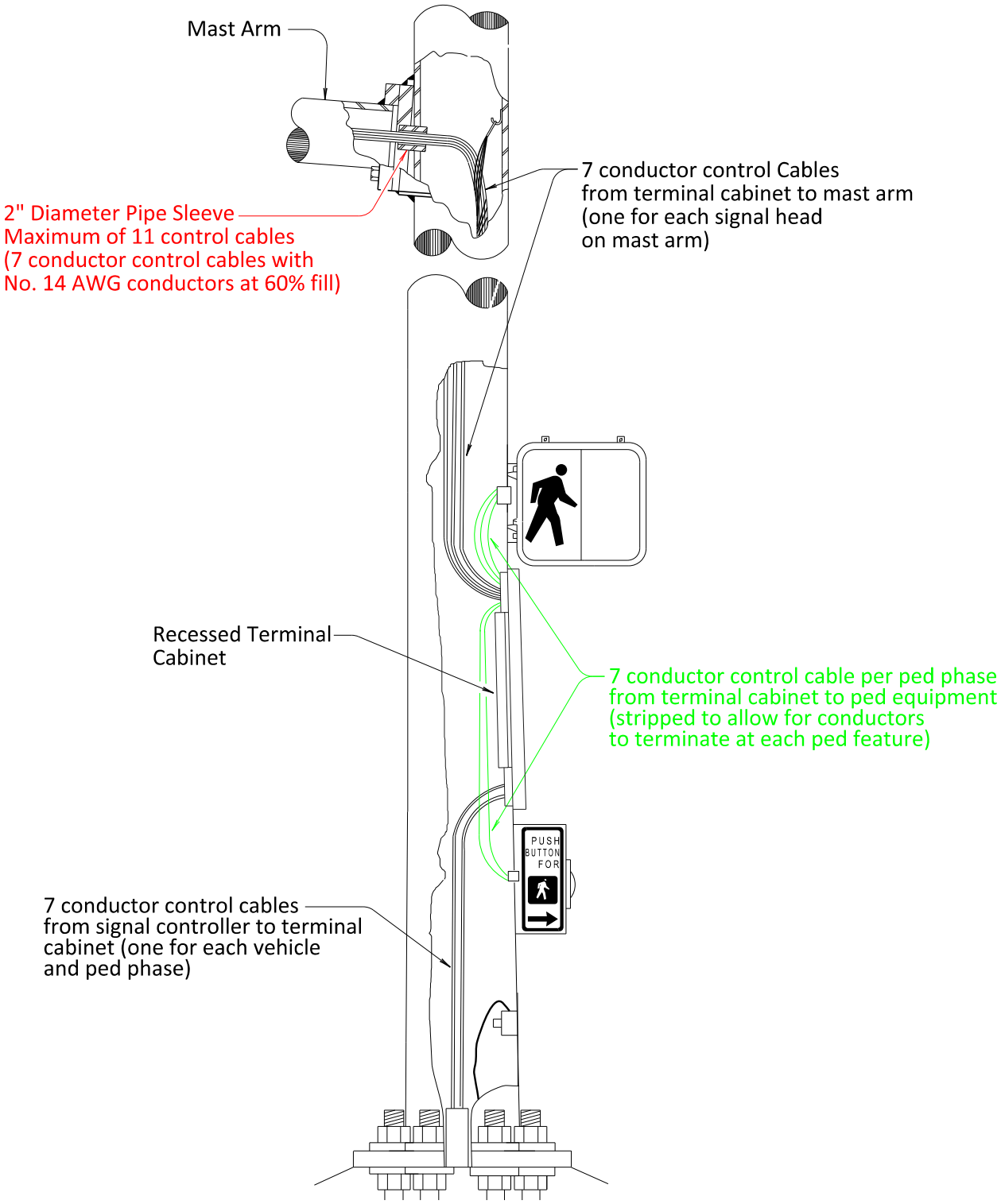


Figure 5-105 | Verify Wire Fill at Mast Arm Connection (recessed terminal cabinet)



5.14.10 Wire Economy – Individual Conductors

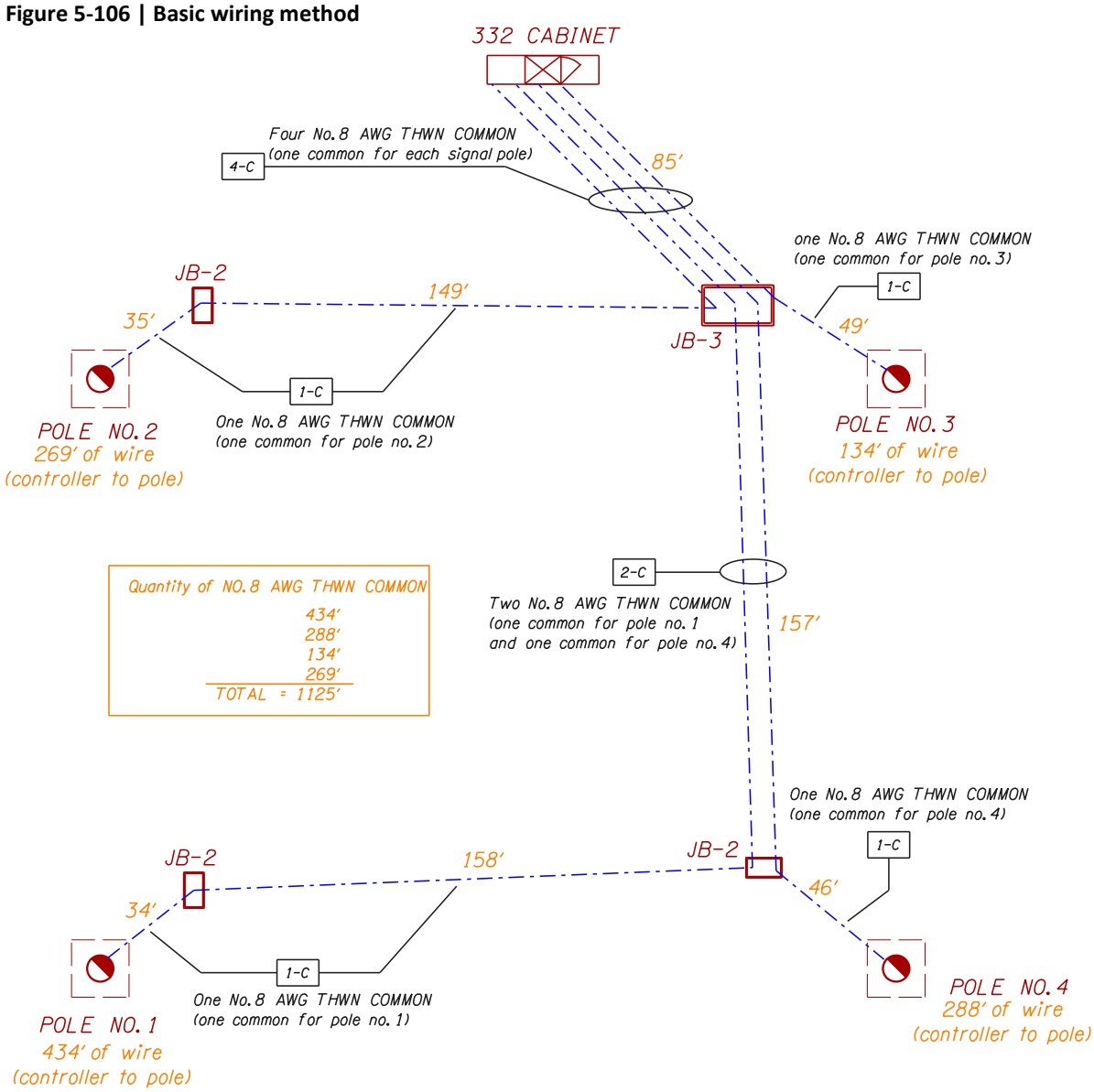
Traffic signals can be wired a number of different ways and function correctly. However, in an effort to be more economical, there is a preferred method of routing wiring.

Figure 5-106 shows the basic method for wiring the common/neutral and Figure 5-107 shows the economical method for wiring the common/neutral. While these figures only show wiring for the commons, the same principle can be applied to any traffic signal wiring that share a common system/phase (e.g. No. 14 AWG THWN that is used for the signal phases). A typical scenario for using the economical method is for pedestrian indications of the same phase, as each pedestrian phase will have two indications located on different poles. There may also be opportunities to use the economical method for pedestrian pushbuttons, pushbutton common, and overlap phases (opportunity for indications that are part of the same system/phase but located on different poles).

To understand the preferred economical method, it is necessary to understand the basic method first. The basic method is a direct connection for each wire from the origin (signal controller cabinet) to the destination (the terminal cabinet on the pole). Figure 5-106 shows the basic method for the signal system common wires. This results in 4 common wires from the signal cabinet to the first junction box (JB-3), with each wire then routing directly to the appropriate signal pole, resulting in a total of 1125’ of wire needed.

This section is NOT applicable to control cables or Illumination Wiring!

Figure 5-106 | Basic wiring method

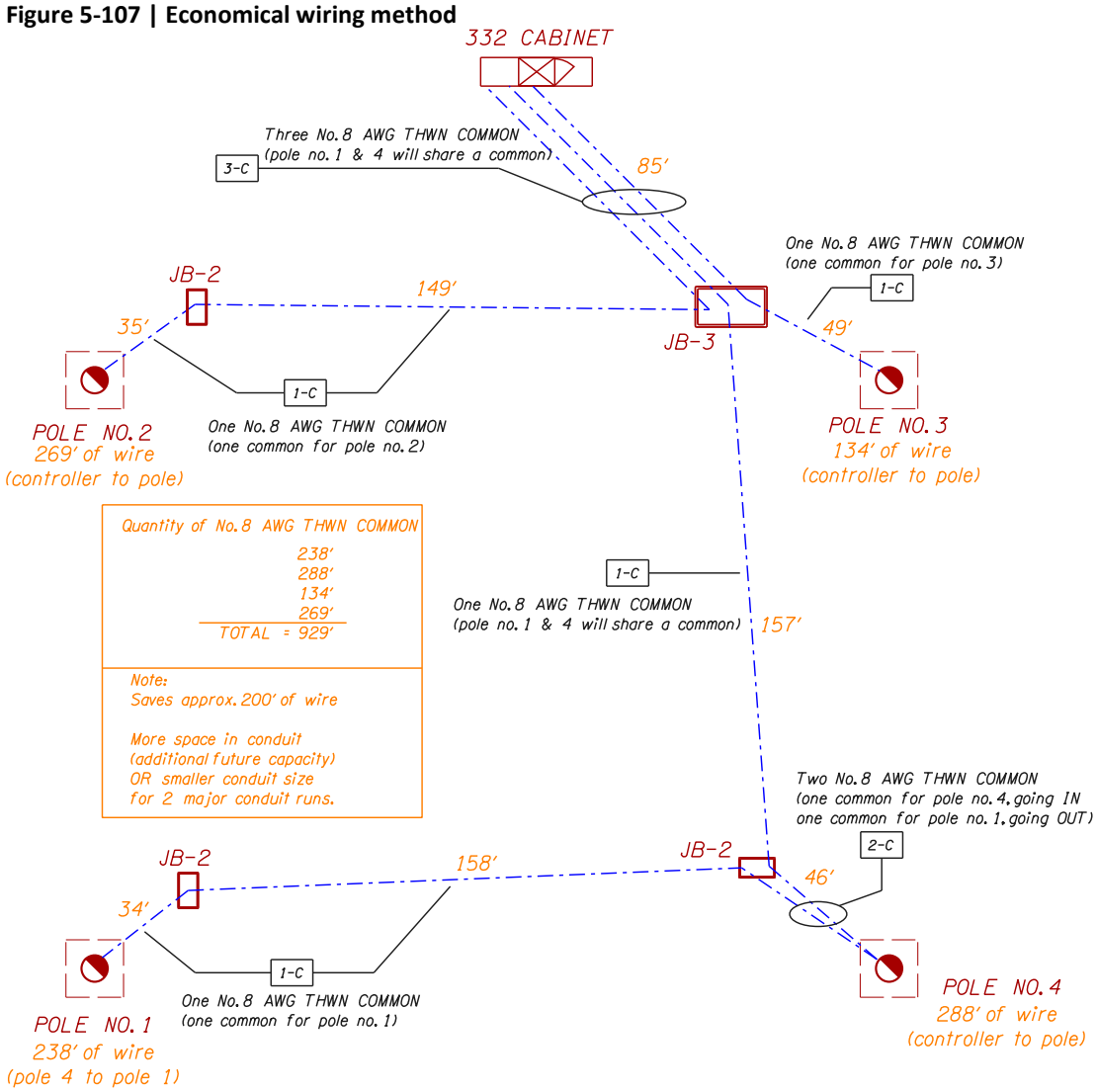


The economical method, by contrast, makes efficient use of the terminal cabinets. Figure 5-107 shows the economical method for wiring the common/neutral. The economical method takes advantage of the terminal cabinet located on Pole No. 4, supplying the common/neutral wire to Pole No. 1 from the terminal cabinet on Pole 4. This is possible because the common/neutral wire from Pole No. 4 goes back to the origin and the all the common/neutral wires are part of the same system, so pole no. 1 doesn't have to have a separate common/neutral wire going back to the origin. This saves approximately 200' of total wire when compared with the basic method, as the common/neutral wire as pole no. 1 doesn't go all the way back to the signal cabinet, but instead terminates at pole no. 4. It also creates additional space in the conduit (future capacity) or might allow the use of a smaller conduit for two of the major conduit runs

(from the signal controller cabinet to the JB-3 and from the JB-3 to the JB-2 next to pole no. 4).

Note that in the economical method, the goal is not to achieve 100% wire efficiency, such that the total wire quantity is as low as it can possibly be, but rather to only take advantage of the large gains in efficiency. For example, in Figure 5-107, there is additional wire efficiency that can be gained by routing just one common/neutral wire from the controller cabinet to pole no. 3, and using the terminal cabinet on pole no. 3 to supply the common/neutral wire to pole no. 2 and pole no. 4. If that was done, it would result in a total of 857' of wire, which is only 72' less wire and doesn't result in any net gain for conduit space (instead of the conduit run from the signal cabinet to the JB-3 having 3 common/neutral wires, the conduit run from the JB-3 to pole no. 3 would have 3 common/neutral wires). This is an example of diminishing returns; not a lot of benefit for the added complexity.

Figure 5-107 | Economical wiring method



5.14.11 Span Wire Installations: Wiring Signal Heads

The same basic principles discussed in section 5.14.6 for wiring signal heads on a mast arm apply to span wire installations. The one main difference between wiring signal heads on mast arms verses span wires:

- The control cable used to wire the signal head from the terminal cabinet on the pole to the signal head (this is the same for both span wires and mast arms) is NOT detailed on the signal plan sheet for mast arm installations, while it IS detailed on the signal plan sheet for span wire installations. The standard specifications and standard drawing TM470 completely cover installation for mast arms, which is why it is not detailed for a mast arm installation.

On a span wire, the signal heads should be wired from the pole where a mast arm would be attached if a mast arm was used. There is an exception to this preference that applies to temporary signals with multiple construction stages (See Chapter 11). Figure 5-108 illustrates the preferred method and Figure 5-109 illustrates the non-preferred method.

Figure 5-108 | Preferred Method for Wiring Signal Heads on a Span Wire

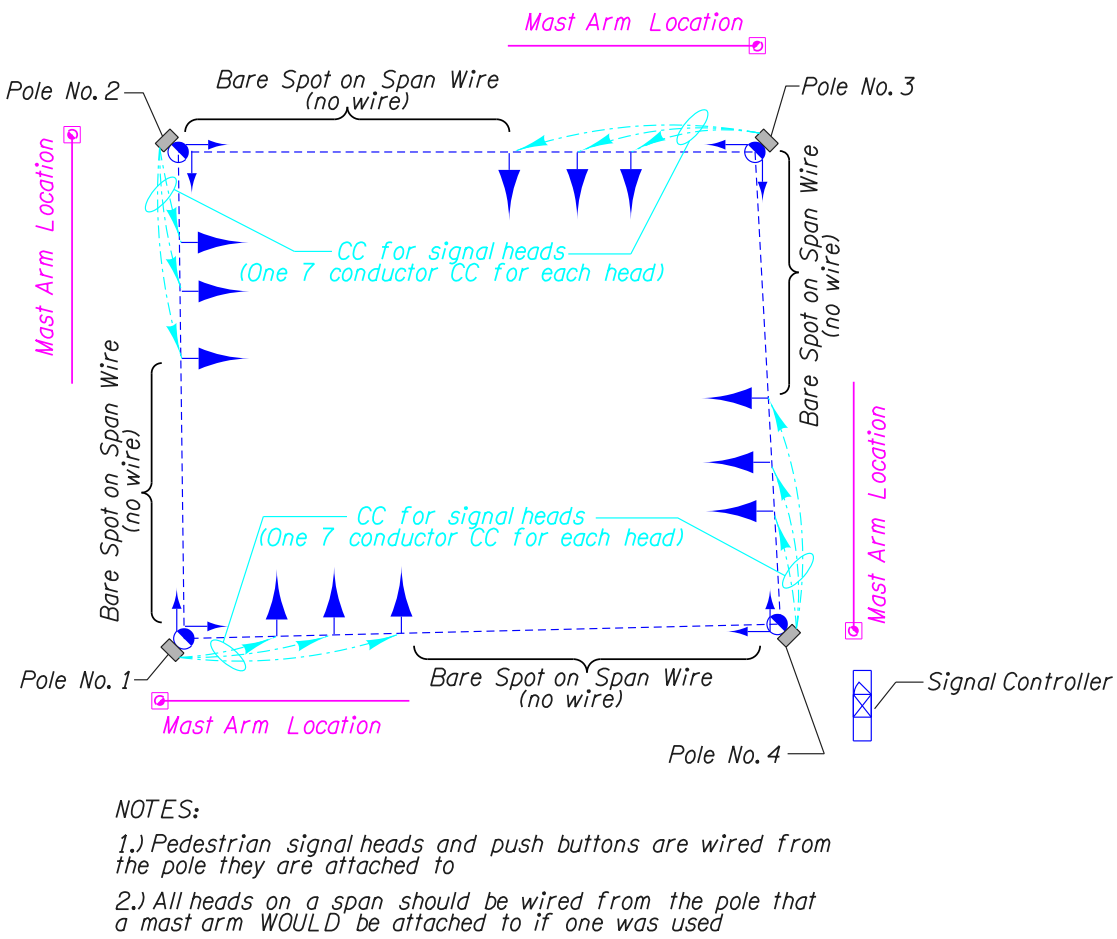
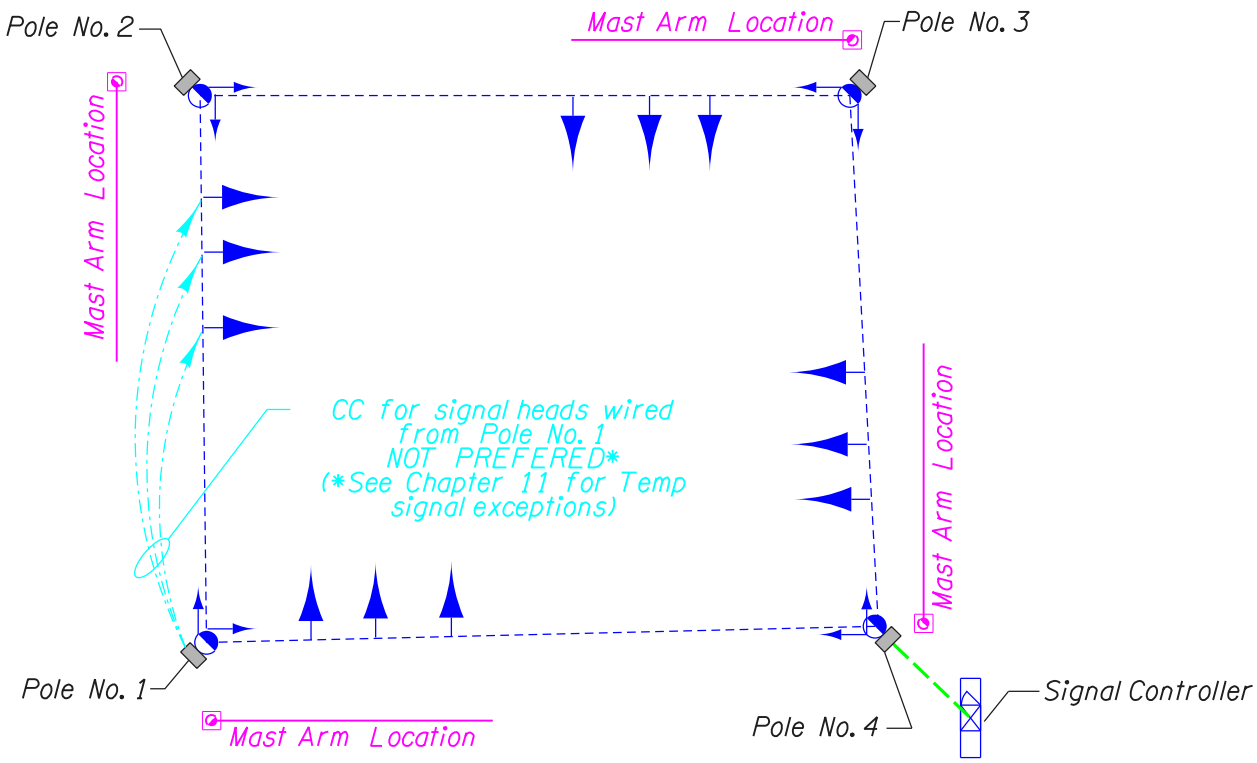


Figure 5-109 | NON-PREFERRED method for Wiring Signal Heads on a Span Wire



5.14.12 Wiring Part Time Restriction (PTR) signs

The only function of the Part Time Restriction (PTR) sign is on or off. Therefore, only two THWN No. 12 AWG wires are required for it to function; one "hot"wire for the PTR sign and one wire for the common/neutral to complete the circuit. If using a control cable, a No. 12 AWG two conductor control cable is used. Using a No. 12 AWG wire helps easily identify the PTR wiring at a glance in the field.

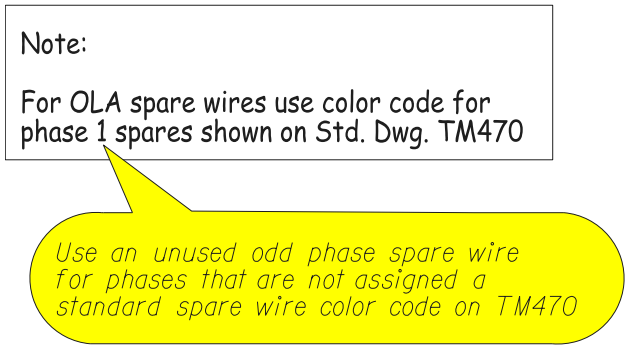
5.14.13 Spares Wires

ODOT standard is to include 3 spare wires for each thru phase (ø2, ø4, ø6, and ø8) when using individual conductors. These spare wires are for future use. These wires shall be color coded as shown in the table on Standard Drawing TM470 and shall not be spliced at any point from the controller cabinet to the terminal cabinet on each pole.

Three spare wires should be installed to a mast arm pole terminal cabinet if a thru phase is not located on a mast arm. For example, a dual right turn often requires a separate mast arm pole for the right turn overlap phase. In this case, 3 spare wires for the overlap phase should be provided. When providing spare wires for overlap phases, be

aware that spare wires for overlap phases have not been assigned a standard color code in Std. Dwg. TM470 and will need to be defined on the plan sheet with a custom note. Define the color code for these spare wires as an unused, odd phase spare wire (such as phase 1, 3, 5, or 7 spare). See Figure 5-110.

Figure 5-110 | Spare Wire Custom Note



The spare wires for are already built-into the control cable (although, not as many spares as used for a mast arm installation).

5.15 Background/Reference Information

This section contains more in-depth information to aid in understanding guidance presented in this chapter.

5.15.1 Wiring History

This section has been provided for information and documentation purposes only.

Control cable with a variety of conductors (i.e. four, five, six, ten, twelve, and fifteen conductor control cables) have been used in the past for certain signal heads and certain combinations of phases to be more efficient (result in less cost and less spare wires). The decision to use 7 conductor control cables for all signal wiring was made for the following reasons:

- the cost savings between a four, five and six conductor control cables (for signal heads) verses a seven conductor control is not significant (less than a dollar/foot difference)
- the additional spare wires are beneficial (for future signal head changes such as a Type 3L to a Type 6L the additional wire is already in place)
- Consistency
- Ease of construction (only need to buy and use one type of control cable for all signal heads)
- Large quantity unit pricing (instead of needing several different sizes of control cable for the various types of signal heads, seven conductor control cable can be purchased in a larger quantity for all signal heads)

5.15.2 Type 3LCF Signal Heads for Flashing Yellow Arrow

On August 12th 2014 FHWA issued Interim Approval for the optional use of three section flashing yellow arrow signal faces (IA-17): https://mutcd.fhwa.dot.gov/resources/interim_approval/ia17/ia17.pdf

On December 11th 2014 ODOT received approval from FHWA to install three section center flashing arrows as part of IA-17:
https://www.oregon.gov/ODOT/Engineering/Documents_TrafficStandards/FHWA-IA-17_Oregon-Use.pdf

The following list contains the reasons why three section center flashing arrows were pursued as the ODOT standard:

1. Physical characteristic of the 3 section center flashing arrow signal head
    a. Structural loading between 3 section protected only and 3 section center flash are the same.
        i. This is not the case when using a four section FYA signal head which is 14 inches taller.
    b. Vertical clearance between 3 section protected only and 3 section center flash are the same.

        i. This is not the case when using a four section FYA signal head which is 14 inches taller.
    c. Maintenance is allowed to standardize parts since the three section head can be used for protected only, P/P, and permissive only operation.
        i. This is not the case when using the four section head.
    d. Maintenance is allowed to standardize LED modules. They only need six LED modules to allow any operation: Red/Yellow/Green balls and Red/Yellow/Green arrows.
        i. This is not the case when using bimodal green/yellow arrow LED modules.
            1. Note: The bimodal green/yellow arrow LED modules are not supported by the ITE specification for LED modules.
    e. Outputs from the controller cabinet remain the same to run protected only or center flash P/P: Three wires.
        i. This is not the case when using the four section head: Requires four wires.
        ii. This is not the case when using the bimodal LED module: Requires four wires.
    f. Three section center flash is an easy conversion from 3 section protected only. Requires cabinet modifications only.
        i. This is not the case when using the four section head: Requires a head change out and adding one wire from the cabinet
        ii. This is not the case when using the three section bimodal green/yellow LED module: Requires the change out of one LED module and adding one wire from the cabinet.
2. Safety and Operational characteristic of the 3 section center flashing arrow signal head
    a. Research completed on the 3 section center flash as noted in IA-17: http://apps.trb.org/cmsfeed/trbnetprojectdisplay.asp?projectid=2763
    b. Quote from IA-17 "The research results demonstrated that a three-section FYA signal face in which the middle yellow arrow signal indication is used to display both the steady change interval and the flashing yellow permissive interval provides a safe and effective operation for road users"

3. Currently there are three options for flashing yellow arrow head types: Three section center flash, three section bottom bimodal green/yellow, and four section. All three are acceptable options and are considered equals for operations and safety. But when considering physical characteristics and ease of maintenance for the 1,500 traffic signals and numerous personnel that work on them on the State Highways the three section center flash is the best option.

5.15.3 Sign History

Below shows a list of signs that are no longer used. It is by no means all inclusive, but is included in this manual for historical purposes.

Figure 5-111 | Signs No Longer Used

SIGNS NO LONGER USED	
OR10-10L 30"x36"	"LEFT TURN SIGNAL" sign
OR10-10R 30"x36"	"RIGHT TURN SIGNAL" sign
OR17-1 30"x36"	"LEFT TURN YIELD TO ONCOMING TRAFFIC" sign replaced by R10-12
OR22-14 30"x36"	"RIGHT TURN YIELD TO PEDS ON GREEN ball symbol" sign replaced by OR10-15

6 DETECTOR PLAN

This chapter will discuss all the design elements that are needed for detection system, in order of the recommended process for designing a new traffic signal. Design of the detection system typically begins after the signal design.

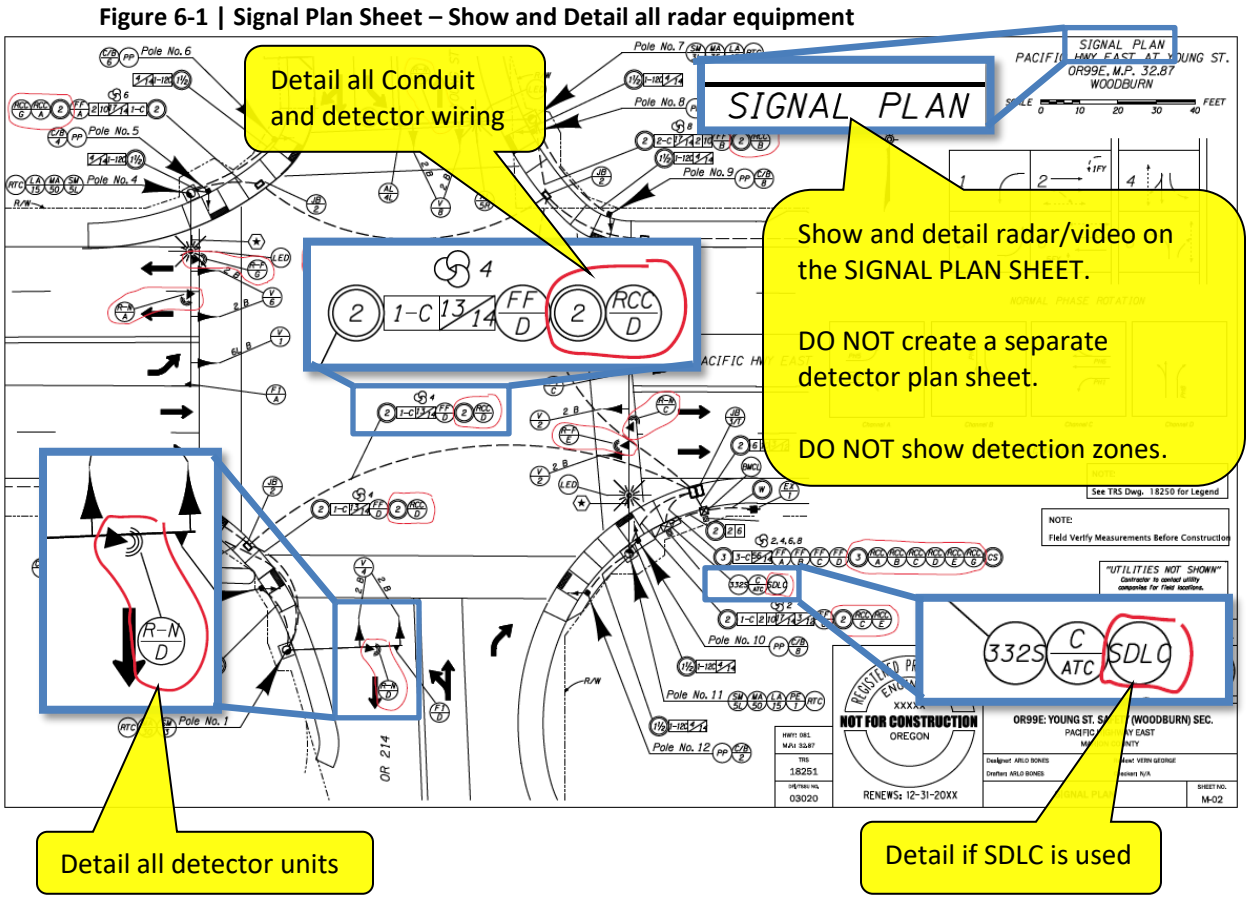
Detection is required for all vehicle phases to enable the use of Automatic Traffic Signal Performance Measures (regardless if any vehicle phases are recalled).

A separate detection plan sheet is no longer required for radar/video detection. It is still required if loops are approved for use (See Section 6.1).

Show radar/video equipment on the signal plan sheet <u>only</u> (only show the detector unit, detector conduit, and detector wiring). See Figure 6-1.

Radar/video detection zones and coverage areas are shown on the cabinet print only AT THE SIGNAL TIMERS REQUEST. The Region Signal Timer will configure the zone set up. Provide the cabinet print at DAP for the signal timer to review and provide a preliminary configuration. See Chapter 20 for more information on coordinating with the Signal Timer and the process for creating the cabinet print.

Figure 6-1 | Signal Plan Sheet – Show and Detail all radar equipment



6.1 Detection Type

ODOT's default standard detection type is radar. Video detection may also be used with concurrence from the Region Signal Operations Engineer (Section 6.9 contains specific information for video detection that is in addition to, or differs from the information contained in this chapter that is for radar). ODOT has selected these non-invasive forms of detection as the standard for the following reasons:

- Ease of moving detection zones (future paving projects and temporary lane configurations can be accommodated)
- Cost effective for providing Automatic Traffic Signal Performance Measures (ATSPM) (which can require significantly more points of detection than traditional detection layouts)
- Ability to easily maintain detection zones (repairing damaged inductive loops requires a contractor. Historically, ODOT has not been successful repairing damaged loops in a reasonable timeframe due to limited maintenance funding)
- Simplifies the controller cabinet hardware and improves troubleshooting ability (when using the standard SDLC connection)
- Ability to accommodate dynamic entry speeds to the intersection for improved dilemma zone protection (i.e. red/green extension)

No form of detection is without drawbacks, and non-invasive forms can have issues with occlusion, less accurate counting, weather, etc. Non-invasive forms of detection may not be the perfect solution in every case, however, these drawbacks will be tolerated to achieve the higher level benefits listed above.

Non-invasive forms of detection are typically mounted on the mast arm, luminaire arm or vertical signal pole and should work well in the majority of locations. However, there are situations where additional detection devices or unique mounting locations (e.g. stand-alone vehicle pedestals):

- roadway/intersection geometry that limits the line of sight for the detection device
- low illumination levels
- occlusion
- existing conduit condition/fill rate will not allow adding new wiring

Non-invasive detection devices used on the project must be listed on the approved traffic signal product lists (Green Sheets and/or Blue Sheets). Devices not listed on the Green and/or Blue sheets require approval from the State Traffic Signal Engineer.

Other forms of detection, such as inductive loops and preformed inductive loops may be used as a last resort if an investigation finds that non-invasive detection is not feasible. For example:

- retro-fit situations where conduit condition/fill rate limits installation of additional cables *and* installing stand-alone vehicle pedestals to mount the devices is not an option
- Controller Cabinet space limitation *and* replacing the controller cabinet is not an option

This investigation should be done as early as possible in the design process, ideally before DAP. In these cases, the Region Traffic Engineer should concur with the investigation to use loops and send justification to the State Traffic Signal Engineer for approval via e-mail. If the State Traffic Signal Engineer approves use of loops, these locations will be tracked in the Traffic Signal Asset Management Program to enable proper scoping and funding of future projects.

When a project impacts ANY existing loop detection, it should be replaced with non-invasive detection.

Installing loops should only be considered as a last resort!

6.1.1 Inductive Loop Detection

Loop detection is no longer the ODOT standard as advances in controller cabinet hardware and software are making it less desirable from an efficiency, cost effectiveness, and maintenance standpoint: Loop detection is not compatible with an SDLC connection in the 332s controller cabinet and limits the ability to implement Automatic Traffic Signal Performance Measures (which is a high priority for the Agency).

If the State Traffic Signal Engineer approves the use of loops on your project, information will be provided for how to detail and show loops on a detector plan sheet.

6.1.2 Multiple Detection Technologies at a Single Intersection

Use of multiple detection technologies at a single intersection is highly discouraged as it can be challenging to configure the hardware in the controller cabinet, resulting in non-standard arrangements that are more difficult to maintain and troubleshoot.

If the State Traffic Signal Engineer approves the use of multiple detection technologies on your project (e.g. loops and radar or loops and video), information will be provided for how detail and show loops on a detector plan sheet.

6.2 Detection Basics

Detection allows the signal controller to service signal phases and provide variable amounts of green time based on the demand. Detection needs are determined by the desired signal operation; therefore it is important to have a basic understanding of the signal operation standards that dictate the standards for vehicle detection design.

Each signalized intersection is the result of side street (typically city or county road) intersecting with a mainline (state highway). In the case where a state highway intersects with another state highway one route must be designated the mainline and the other route will be the side street. This is usually easy to determine based on traffic volumes, posted speeds and the presence of stop/yield control at the intersection prior to signalization. There cannot be two mainlines or two side streets, there must be one of each designated for each intersection. This fundamental principle results in signal operations that will meet driver expectation; drivers DO NOT expect to stop on a mainline roadway and DO expect to stop on a side street. This designation is shown in the operational approval based on how the phases are labeled (phases 2 and 6 are mainline through phases and phases 4 and 8 are side street through phases).

6.2.1 Presence Detection

Presence detection is used for each vehicle lane (except mainline right turn only lanes that do not have an overlap phase) and each bicycle lane. The length of the presence detection and its use varies slightly depending on the lane use and phasing (See Figure 6-2 for the standard presence zone layout):

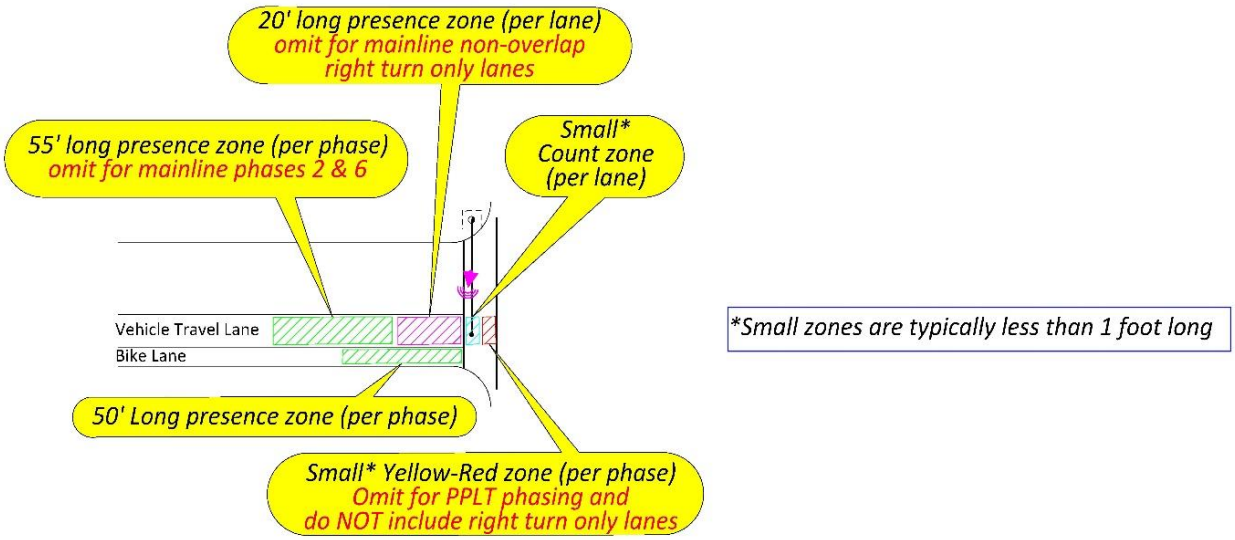
- When used on the side streets (phases 3, 4, 7, and 8) and mainline left turn phases (phases 1 and 5), it is placed at the stop bar, covers a total of approximately 75 feet, and is designed to place a call into the signal controller when a vehicle approaches on a red indication and extend the green time based on the vehicle demand of queued vehicles proceeding on a green indication. Side street phases and left turn phases are NOT recalled like the mainline through phases, and therefore will not turn green unless there is vehicle demand. Side street phases and left turn phases are also not designed to extend the green time for vehicles traveling at posted speed. Presence detection does not allow the same degree of dilemma zone protection as advance detection because of the fundamental difference between driver expectations on a mainline verses a side street/left turn.

- When used for mainline through phases (phases 2 and 6), it is placed at the stop bar, covers approximately 20 feet, and is designed to provide additional data needed for Automatic Traffic Signal Performance Measures.

- When used for a bicycle lane, it is placed at the stop bar, covers approximately 50 feet, and is designed to place a call into the signal controller when a bike approaches on a red indication (for bike lanes on the side street) and extend the

green time based on the slower traveling speed of a cyclist approaching on a green indication (for bike lanes on the side street and mainline).

Figure 6-2 | Detection Basics – Presence Detection (including Count and Yellow-Red detection) Standard Layout



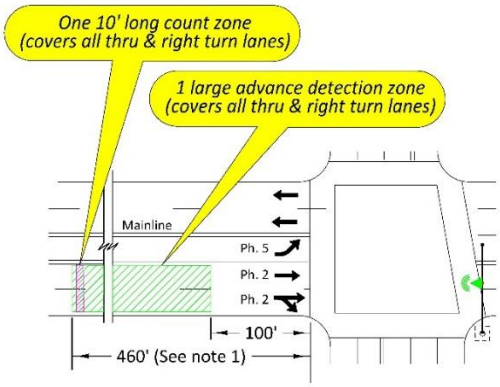
STANDARD PRESENCE DETECTION (Near-Range Unit)

6.2.2 Advance Detection (or Volume Density Detection)

Advance detection is used for the mainline through phases (phases 2 and 6) and interchange off-ramps. See Figure 6-3 for the standard advance detection zone layout. It can detect vehicles approximately 600 feet away from the stop bar (Note: only 460 feet from stop bar is required to adequately detect vehicles approaching from **any** posted speed. However, detecting vehicles approximately 900 feet from the stop bar is possible and desirable for approaches with high speed and high semi-truck volumes. Verify with Region Traffic if additional detection beyond 600 feet is needed). It is designed to extend green time and protect the dilemma zone for a vehicle approaching the intersection at posted speed (where a vehicle is too close to properly stop at the intersection and too far away to properly get thru the intersection before the yellow terminates). Each vehicle actuation during the mainline green phase will extend the green time such that the vehicle may continue thru the intersection at the posted speed without stopping.

Advance detection is NOT used to put a call into the controller when the vehicle approaches on a red indication. This is because the standard for signal timing is to always recall the main through phases (e.g. a vehicle actuation is NOT required to bring up the mainline through phases). When only the mainline phases are recalled, the signal will "rest" in green on the mainline when there are no vehicle actuations.

Figure 6-3 | Detection Basics – Advance Detection Standard Layout



STANDARD ADVANCE DETECTION (Far-Range Unit)

Notes:

1. Detection that starts 100' from the stop bar and extends a minimum of 460' from the stop bar is acceptable for all posted speeds. However, the standard far-range unit is likely to start detection prior to 100' and is capable of reaching 600'. The alternative far-range unit is capable of reaching 900' if necessary (verify with Region Traffic).

2. If MaxAdapt is used (Verify with Region Traffic), add a Near-Range Unit to provide advance Count Detection Zones as shown below

Note: If MaxAdapt (adaptive signal timing) is used, use advance detection layout shown in Figure 6-5 instead.

6.2.3 Signal Timing Functions That May Be Used With Detection

The following functions are used by the signal timer to make the traffic signal operate efficiently and collect data:

- **Extend/Carryover/Stretch** – this function is only active during the green phase of the associated signal phase. It allows the green time to be extended based on the parameters within the signal timing. It also allows the input of a detector to remain "ON" for a pre-defined amount of time after the actual vehicle actuation; effectively elongating the size of the detection zone.

- **Call** – this function is only active during the red phase of the associated signal phase. It allows the signal controller to service the associated signal phase within the parameters of the normal phase rotation; signal phases other than the mainline through phase are only serviced if there is demand.

- **Delay** – this function is only active during the red phase of the associated signal phase. It allows the input of a detector to remain "OFF" for a pre-defined amount of time during the actual vehicle actuation; reducing the chance of unnecessarily serving a phase from unintended actuations (e.g. vehicles turning right on red).

- **Count** – this function simply counts the number of actuations. The ability to count actuations provides critical volume data to the signal timer developing the appropriate signal timing parameters throughout the life of the traffic signal. Count detection is also needed for certain Automatic Traffic Signal Performance Measures.

6.3 Beyond Basic Detection

Depending on the location, desired signal operation and other unique circumstances at the intersection, additional detection beyond the basics may need to be considered.

6.3.1 Interchange Ramps

For interchange ramps, the detection is treated similar to the detection for a side street phase (See Section 6.2.1). The only exception is advance detection is also used (See 6.2.2), based on the higher prevailing speed of a vehicle that has just exited the freeway.

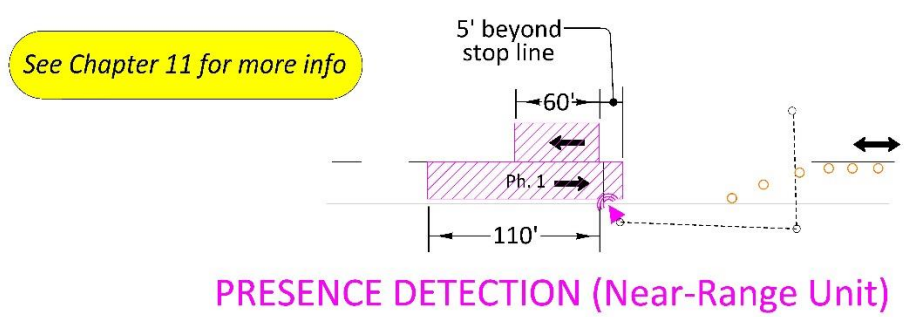
In addition to standard presence and advance detection, "dump" detection may also be desired. Dump detection may be necessary for an interchange ramp to prevent ramp queues from backing up onto the freeway by allowing the signal controller to give priority and extended green time to the ramp phase if the queue reaches a certain point for a certain period of time. Dump detection may be used if engineering judgment determines a need. Verify dump detection needs with Region Traffic.

It is always preferable to have the ramp alignment be designed to accommodate the calculated design life 95 percentile queue length, which would eliminate the need for dump detection. However, this is not always feasible. An operational analysis is always required to determine if dump detection is needed and to determine the optimal placement of the detection. This will likely require a stand-alone near-range detector unit mounted on vehicle pedestal within 20 feet of the where the detection zones are needed.

6.3.2 Temporary Bridge Signals (one-lane, two-direction)

Temporary bridge signals are used to allow travel in both directions in one lane. Presence detection is used as shown in Figure 6-4.

Figure 6-4 | Temporary Bridge Signal Presence Detection



6.3.3 Bicycle Detection

Bicycle detection should be installed at an intersection where bike lanes are present. See Section 6.2.1. If no bike lanes are present, but there is a high volume of bike riders,

bike detection may be used on the shoulder or other locations if engineering judgment determines a need. Verify bike detection needs with Region Traffic.

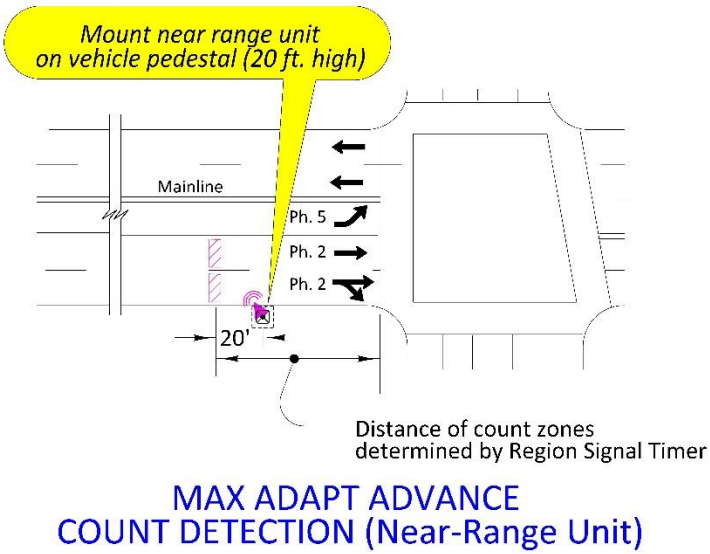
Note that properly detecting bicycles is challenging for most forms of detection due to bike material composition (problematic for loops), detecting the difference between vehicles and bikes (problematic for non-invasive), and paths that cyclists choose take (problematic for all forms of detection).

6.3.4 Adaptive Signal Timing Detection

Adaptive signal timing detection works much differently than the standard detection discussed in Section 6.2. Typically more detection is needed for adaptive to work properly, as the adaptive software collects more data to use in determining how to operate the signal. When designing a detection system that will be using adaptive signal timing, it is important to follow the software manufacturer's recommendations for detection placement.

Advance detection zone layout when using MaxAdapt adaptive signal timing is shown in Figure 6-5.

Figure 6-5 | MaxAdapt Advance Detection Zone Layout for Radar Detection



Region Traffic Engineer Approval is required for use of Adaptive Signal Timing.

6.3.5 Railroad Detection

Depending on the location of the railroad crossing, the intended signal operation, and rail crossing order requirements, additional vehicle detection zones may be necessary. See Chapter 16 for more information on railroad related signal design.

6.3.6 Automatic Traffic Signal Performance Measures (ATSPM)

ODOT has committed to implementing ATSPMs as part of FHWA's Every Day Counts 4 initiative. Certain detection zones are included solely for ATSPM data collection which can be used to track performance measures at signalized intersections and assess impacts of timing and operation decisions in real time. The presence detection and advance detection standard shown in Figure 6-2 and Figure 6-3 will be able to capture the following ATSPM (See Traffic Signal Management Plan for more information):

- Red light running (Safety)
- Split failure (Safety and Operations)
- Purdue Coordination (Operations)
- Arrival on red/green (Safety and Operations)

6.4 Detection Zone Layout Considerations

Standard detection zone layout is shown Figure 6-2 and Figure 6-3. These zones should be used as an initial starting point when deciding where to mount the detector units, but keep in mind that site specifics may require the signal timer to make some adjustments to the zones, mounting location, or signal timing parameters in order to operate as intended (see Section 6.1.1 for more info on modifying placement of detection). Always discuss any site specific considerations with the Region Signal Timing staff to ensure the concern can be properly addressed, but keep in mind that sometimes the occurrence of the event in question may not happen frequently enough to warrant any signal timing or detection coverage area modification.

6.4.1 Mainline Posted Speeds

The advance detection is located according to the posted speed. If the range/view that the detector unit can cover is between 460 feet to 100 feet of the stop bar, all posted speeds will be adequately accommodated. In the past with loop detection, the mainline posted speed was a much greater concern for detection layout as loops had to be installed at different distances based on the approach speed and they could not be easily changed. Non-invasive detection provides great flexibility for detecting vehicles within the range/view of the device and is also capable of using algorithms to better protect the dilemma zone even for vehicles that are accelerating or decelerating when approaching the traffic signal.

6.4.2 Advance Stop Bars

If a crosswalk is present, the near side of the crosswalk bar functions as the stop line for vehicles. Separate, advance stop bars prior to a crosswalk are only used when the geometry of the intersection cannot accommodate the design vehicle's turning path

without them. That said, advance stop bars should not be used in lieu of proper geometric design; the roadway should be designed to accommodate the design vehicle without use of advance stop bars whenever feasible. If an advance stop bar is used, detection should not be placed between the advance stop bar and the crosswalk marking.

6.4.3 Bridge Decks

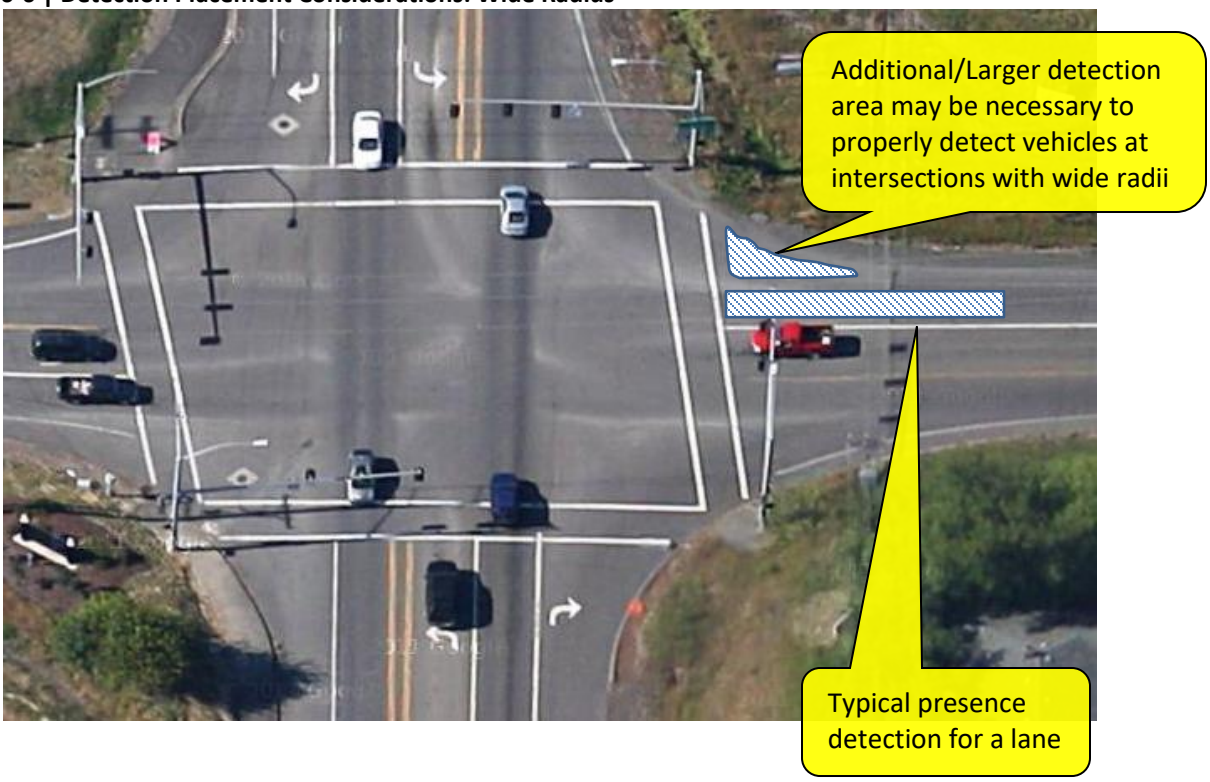
There are only two types of detection that can be used on a bridge deck:

- Non-invasive (e.g. video, radar, etc.) is the default standard. This type of detection is the only viable solution for existing bridge decks.
- Preformed loops, which are installed on top of the bridge rebar prior to the deck pour. This type of detection should be avoided if possible. If used, the signal designer will need to coordinate with the bridge designer. See Standard Detail DET 4435.

6.4.4 Wide Corner Radius

An intersection with wide radii (typically rural locations that do not have a bike lane), may need a larger detection coverage area to properly accommodate vehicles and bikes. For non-invasive detection, this is very easy to implement if the device is mounted and aimed to cover the radius.

Figure 6-6 | Detection Placement Considerations: Wide Radius



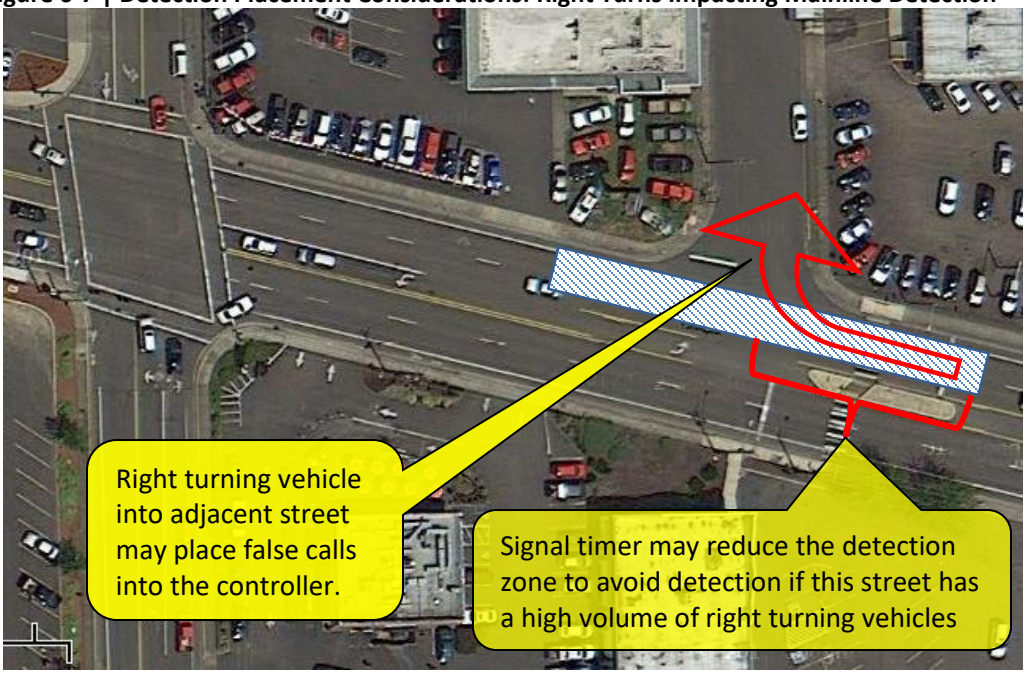
6.4.5 Accesses: Driveways, Streets, and Alleys

Vehicles accessing driveways streets or alleys near signal detection may result in unintentional actuations that adversely affect the efficiency of the intended signal operation. This can lead to motorist frustration, longer queue lengths, and more traffic congestion. One of the best solutions to improve signal operations and overall safety is to remove or restrict certain movements of any access that is within the influence area of the signalized intersection. Coordinate with the Region Traffic and Access Management Staff to discuss the possibility of removal or restriction of movements. If removal or restriction is not an option, the following alternative option should be considered for mainline advance detection.

Note: Unintentional actuations are less of a problem for non-invasive forms detection as the detection zones can be configured for a specific direction of traffic (i.e. they will not activate if a vehicle drives over the zone the wrong way). Loop detection cannot distinguish direction of travel and therefore has more potential for unintentional actuations.

- The mainline advance detection is located within the travel path of vehicles turning right onto the adjacent side street. See Figure 6-7. The main concern is that these right turning vehicles will unnecessarily extend the green phase on the mainline. In this case, the advance detection could be adjusted slightly closer to the stop bar so that the detection is located outside the travel path of those right turning vehicles (approx. 30 feet or less). ***Note: this may still be an issue for non-invasive forms of detection as the directionally programmed detection zones will not solve this type of unintended actuation.***

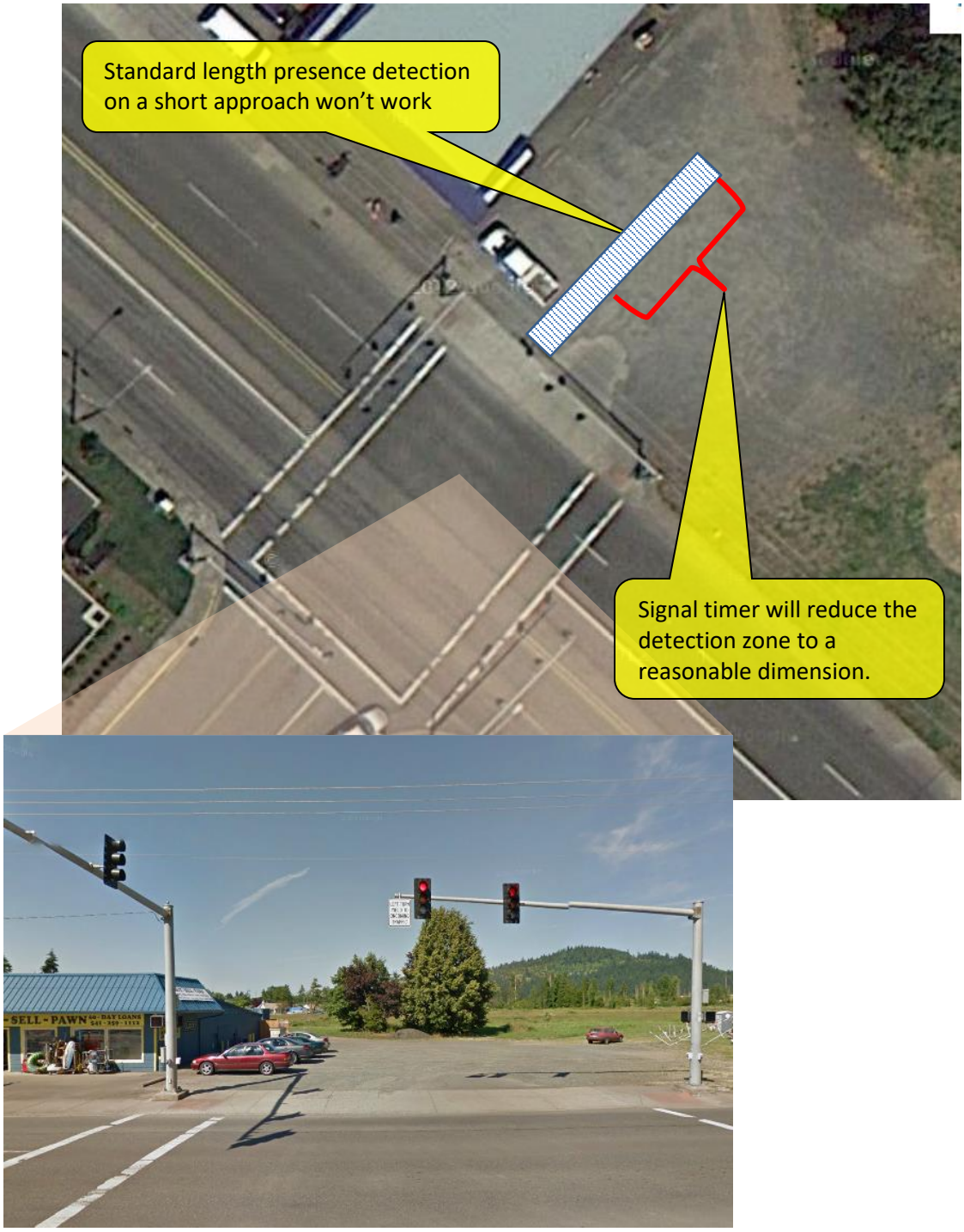
Figure 6-7 | Detection Placement Considerations: Right Turns Impacting Mainline Detection



6.4.6 Short Minor Street/Driveway Signalized Approaches

The standard placement for presence detection covers approximately 75 feet. However, if the minor phase approach is short in distance (i.e. to a driveway) or the pavement doesn't extend very far past the radius, the signal timer will shorten the actual detection zone to reasonable distance based on site conditions. See Figure 6-8.

Figure 6-8 | Detection Placement Considerations: Short Minor Street/Driveway Signalized Approaches



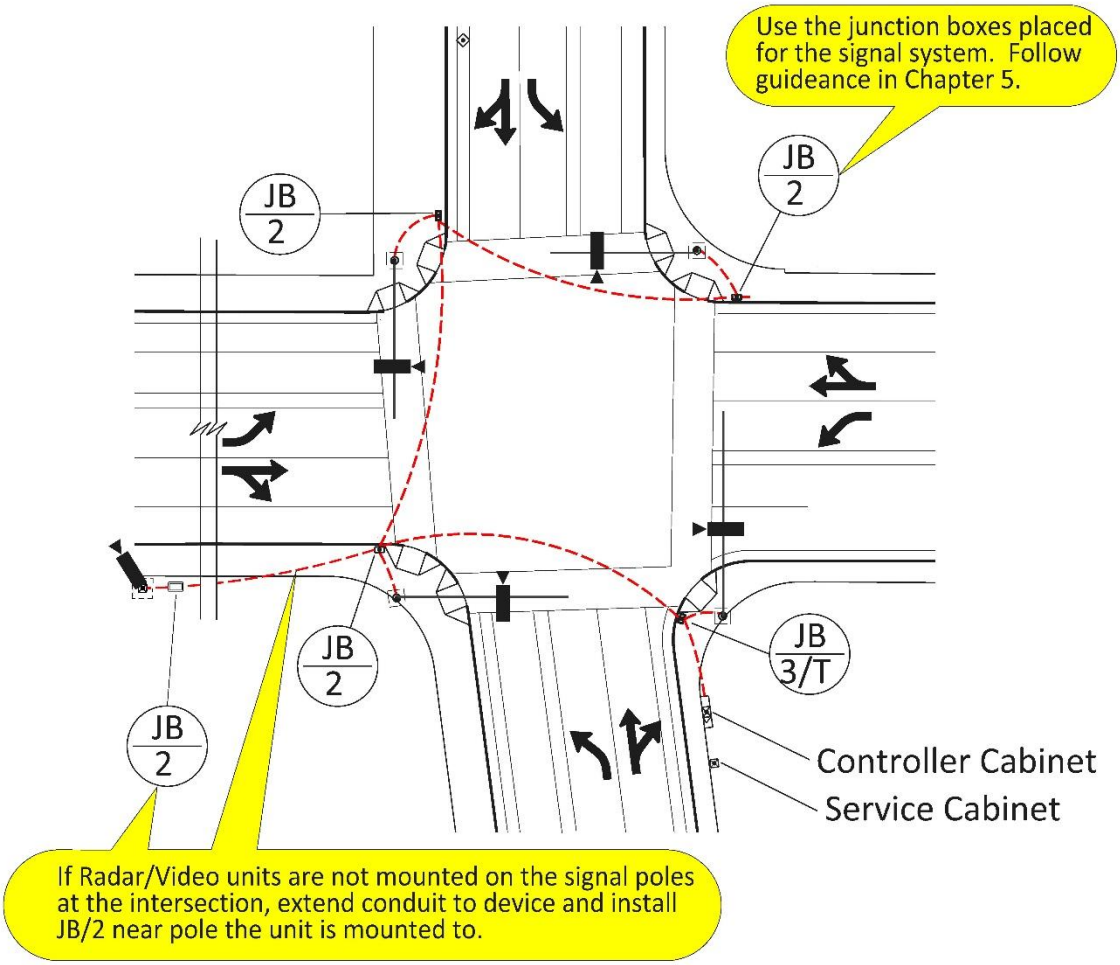
6.5 Conduit and Junction Box System

Detection equipment wiring should be placed in a conduit exclusively used for detection. The conduit system for detection equipment is separate from the signal conduit system, but it follows the same route (in the same trench) and size requirements as the signal system conduit to each pole where radar/video units are mounted. The junction boxes placed in each quadrant for signal system conduits should be used for the detection system conduit. See Figure 6-9 and Chapter 5 for additional information on conduit and junction boxes.

If detector units are mounted at locations other than the signal poles, extend conduit and place a JB/2 size junction box next to the pole/pedestal it is mounted on. See Figure 6-9 .

In retro-fit situations, the radar/video detection wiring may be contained within the same conduit as the signal system if the maximum wire fill rate (see Chapter 5) is not exceeded.

Figure 6-9 | Radar/Video Detection Conduit and Junction Box System



6.6 Synchronous Data Link Control (SDLC) – Bypassing the Detection Input File

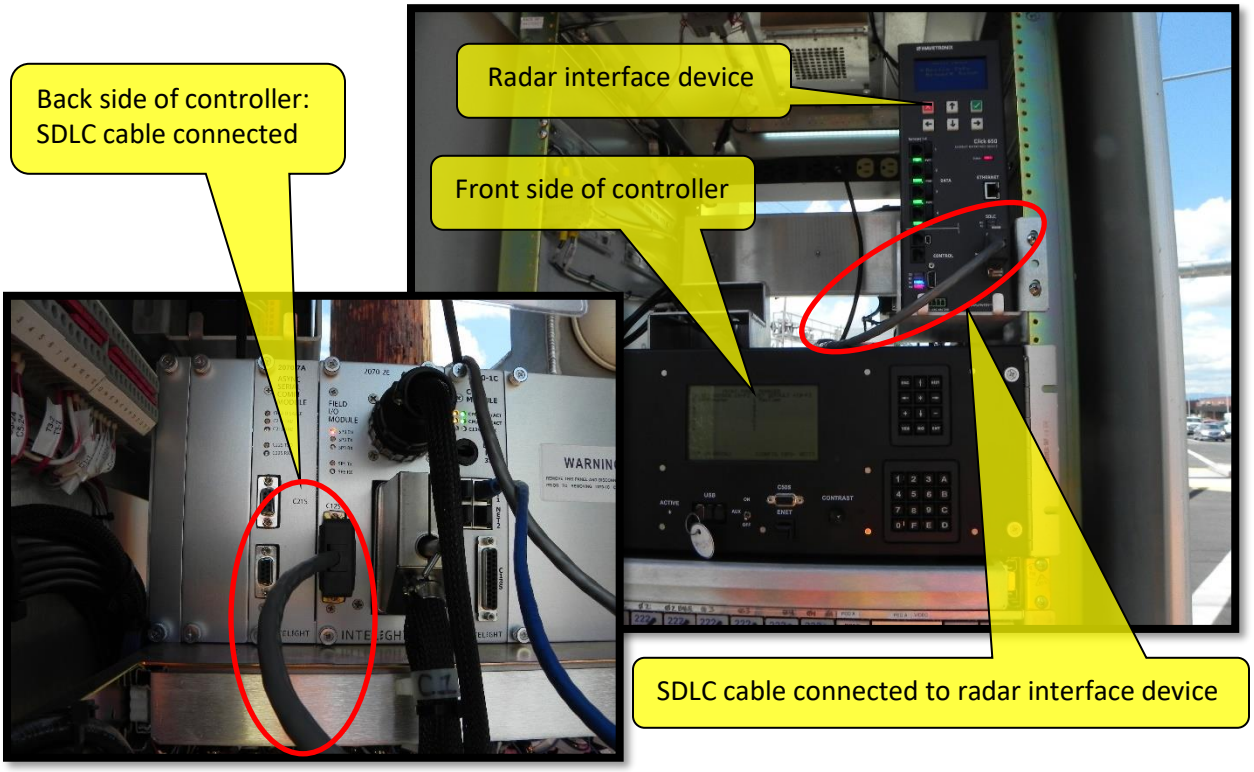
SDLC is a serial communications standard for transmitting data and is the new standard for wiring radar and video hardware in the controller cabinet. It is used to pass information directly between the controller and radar/video interface devices (an SDLC cable plugs into the controller and into the radar/video interface device). This communication bypasses the input file and the C1 and C11S controller connectors. See Figure 6-10.

SLDC cannot be used with the 2070 and Voyage as the software is unfinished for SDLC communication.

SDLC cannot be used for loop detection.

Existing controller cabinets should update the controller cabinet equipment (An ATC controller and radar/video interface devices) to accommodate the SDLC connection if possible.

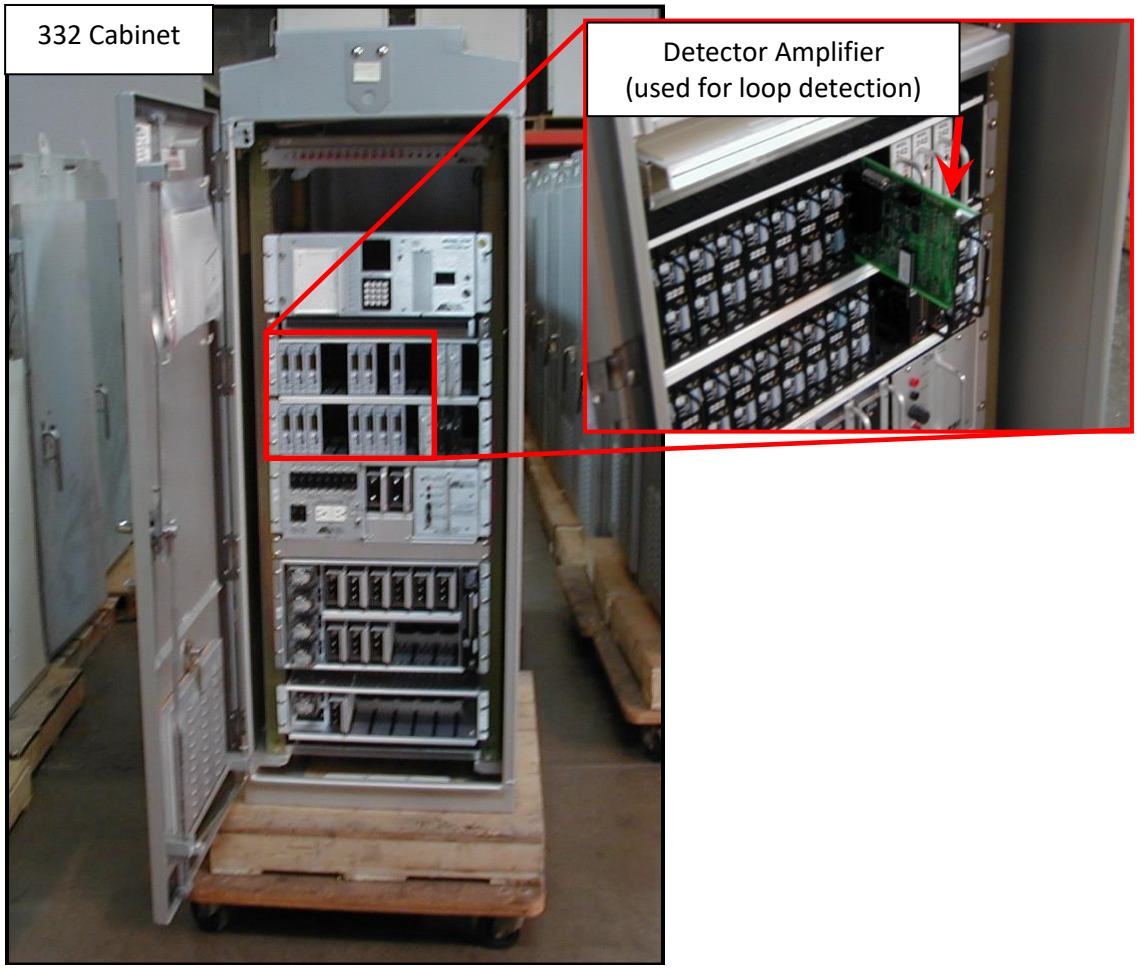
Figure 6-10 | Signal Controller Cabinet Detection with SDLC



6.7 Detection Input File

The signal timer is responsible for configuring the detection input file and this information is now only shown in the cabinet prints. Detector input files and information associated with input file terminations are no longer shown on the contract plan sheets. See Chapter 20 for more information about coordinating with the Signal Timer and creating the cabinet print.

Figure 6-11 | 332 Signal Controller Cabinet Detection Input File Location



6.8 Radar Detector Unit Placement and Labeling

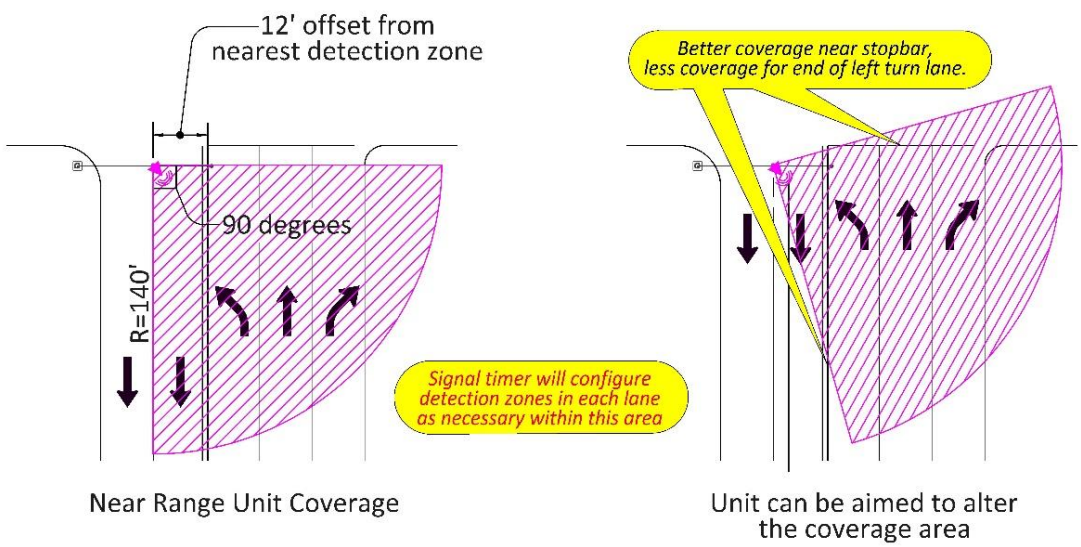
The type of radar unit and the detection zone area will determine the best mounting location for the unit. A few general rules of thumb for the three different types of radar units:

- **Near-range radar units** – Typically used for presence detection, it has an arc shaped detection area that extends 140' from the device. This can provide detection inputs for multiple phases and can separate detection inputs for adjacent lanes/phases. Make sure that this arc shaped detection covers the basic zones of detection shown in Figure 6-2.

  It is recommended for counting at low speeds (less than 35 mph); it is not as accurate at higher speeds, but still performs adequately with an accuracy around 95%. The backside of the mast arm with at least a 12 foot offset from the nearest detection zone is the recommended location, but other locations may be acceptable as per the manufacturer. See Figure 6-12.

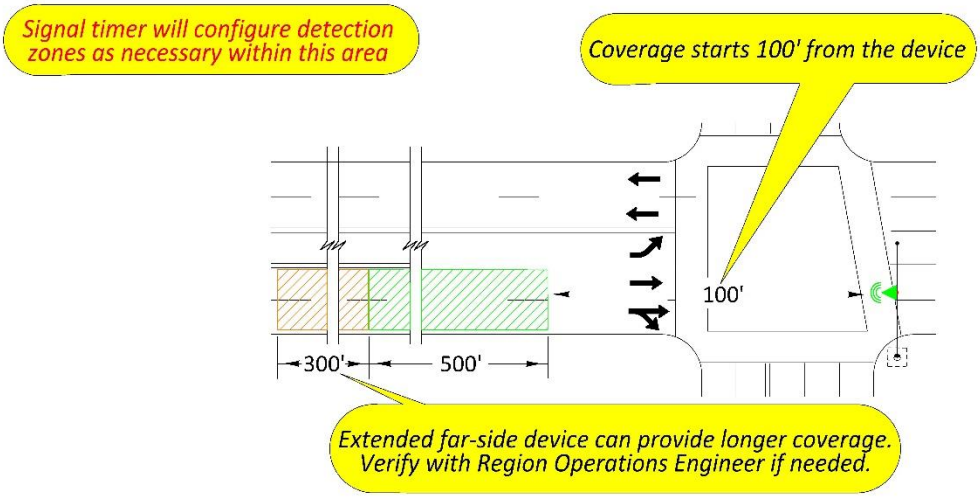
  For large intersections, bike lanes may be blocked by occlusion of the adjacent through lane. Bike detection is critical when a bike phase is provided or the bike lane is on the side street (i.e. any bike lane that does not operate with a recalled phase needs detection to bring up a green indication). In these cases, an additional near-range unit to detect the bike lane may be considered. Verify bike detection needs with the Signal Timer.

Figure 6-12 | Near Range Unit Coverage Area



- **<u>Far-range radar units</u>** – Typically only used for the mainline, recalled thru phase, it has a long cigar shaped detection area that extends 600' (an extended range radar unit can provide a range of up to 900' for large vehicles). Each unit can only be used for a single phase and it cannot provide separate detection inputs for adjacent lanes (i.e. one big zone configuration will cover *<u>all</u>* lanes for phase 2). The units track vehicle speed and can calculate an estimated time of arrival to prevent vehicles from being caught in the dilemma zone. The units can also be set up to include Purdue count zones in pulse mode at between 350 feet and 600 feet to collect arrival-on-green data. The Purdue count zone should be placed as far back as possible to avoid queues degrading the data quality. The far side mast arm is the preferred mounting location for these units because the sensor cannot detect vehicles in the first 100 feet. The unit may also be mounted in several different locations, as per the manufacturer. See Figure 6-13.

Figure 6-13 | Far Range Unit Coverage Area

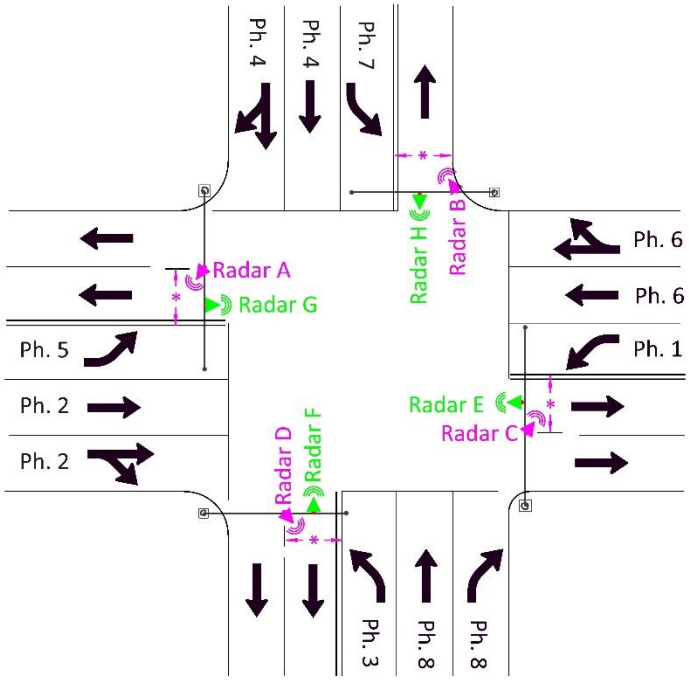


Far Range Unit Coverage Area

- **<u>Side-fire radar units</u>** – Should not be used for signalized intersections as the near-side and far-side units adequately address the detection needs. Also, these units require additional equipment in the traffic signal controller cabinet that doesn't integrate well. As such, they shall only be used if approved by the Traffic Standards Unit. The unit is aimed perpendicular to traffic with the detection zone spanning the entire approach. This device is accurate at counting all vehicles, even at high speeds (greater than or equal to 35 mph). This unit should be mounted according the manufacturer's recommendations for the offset/height requirements.

The radar units should be placed and labeled by phase as shown in Figure 6-14.

Figure 6-14 | Standard Radar Labeling & Typical Placement



Radar Label	Phase	Radar Type
A*	2 & 5	Near/Matrix
B*	4 & 7	Near/Matrix
C*	6 & 1	Near/Matrix
D*	8 & 3	Near/Matrix
E	2	Far/Advanced
F***	4	Far/Advanced
G	6	Far/Advanced
H***	8	Far/Advanced
I Thru Z**	Misc.	Misc.

*12' device offset from lane that will have a detection zone

** If a detector does not fall into the standard label/phase shown above, then assign it a letter alphabetically between I and Z

*** Not typically installed for the side street. Verify with Region Signal Operations Engineer.

6.9 Video Detection Camera Placement and Labeling

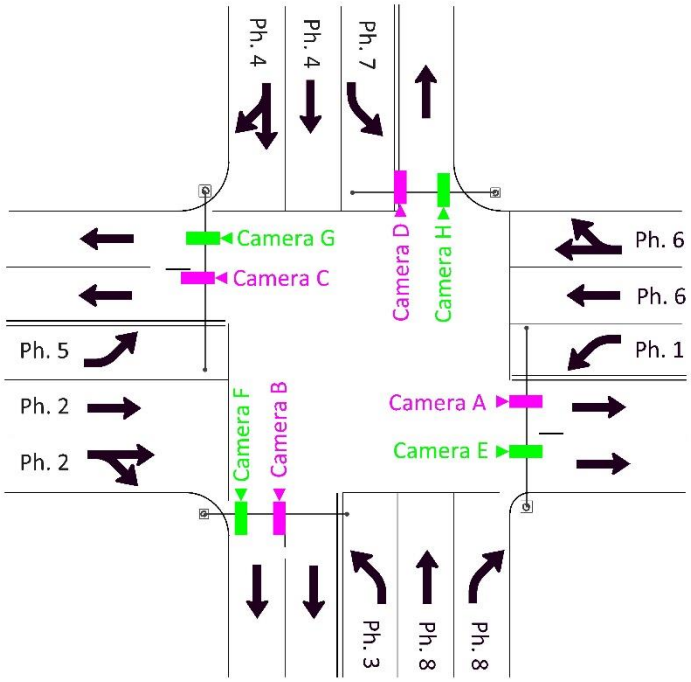
On the mainline, one camera is used for the detection zones within 200 feet of the stop line (typically mounted on the mast arm for presence detection) and another camera is used for detection zones located more than 200 feet from the stop line (typically mounted on the luminaire arm for advance detection).

On the side street, one camera is typically used per approach (usually only presence detection is needed on the side street).

Cameras should be mounted on as stable a fixture as possible. Cameras should be able to view 450 feet if mounted at 45 feet. Typical mounting is on a luminaire arm or mast arm. Accurate vehicle detection is optimized by placing the camera directly over the lane(s) it will be monitoring. Otherwise, occlusion may cause false or missed calls. Each detection zone (See sections 6.2 and 6.3 for standard detection zone layout) should be adequately illuminated for detection at night.

The cameras should be placed and labeled by phase as shown in Figure 6-15.

Figure 6-15 | Standard Camera Labeling & Typical Placement



Camera Label	Phase	Typ. Mount Location
A	2 & 5	mast arm
B	4 & 7	Luminaire arm or mast arm
C	6 & 1	mast arm
D	8 & 3	Luminaire arm or mast arm
E	2	Luminaire Arm
F***	4	Luminaire Arm
G	6	Luminaire Arm
H***	8	Luminaire Arm
I Thru Z**	Misc.	Misc.

** If a detector does not fall into the standard label/phase shown above, then assign it a letter alphabetically between I and Z

*** Not typically installed for the side street. Verify with Region Signal Operations Engineer.

7 INTERCONNECT & ITS COMMUNICATION PLAN

This chapter will discuss the design elements that are shown on an interconnect plan sheet.

Information regarding the Intelligent Transportation Systems (ITS) communication plan sheet will also be included for reference only, as these plan sheets are produced by the ITS unit.

7.1 When is Communication Needed?

There are two main types of communication used for traffic signals:

- **Central communication** is required for all traffic signals. This allows remote access for manipulation of the signal timing and ability to implement Automatic Signal Performance Measures. Central communication is achieved through an interconnect system that connects the one (or more) controller cabinets to a network server.

- **Local communication** may be required for signals located in an urban corridor. This allows multiple signals to operate in coordination to help provide an uninterrupted flow of traffic along that route. Local communication is achieved through an interconnect system that connects one controller cabinet to another controller cabinet. Always contact Region Traffic to discuss the need for local communication if other signals are located less than ½ mile away. Often, the Operational Approval will indicate if this is a requirement.

7.2 Background and Design Responsibilities

Traffic signal communications have been rapidly changing in the last several years. Migration from the 170E/HC11 controller to the 2070L controller to the current Advanced Transportation Controller (ATC) has resulted in advanced methods of communication between the devices in the field and also communication from the field back to a central control. The 170 controller used twisted pair copper interconnect for communication between signals with dial up telephone service for remote communication. The ATC is capable of being connected to a network and uses MaxView central software to remotely monitor and manage traffic signal timing performance.

At the present time, Region Traffic and the Traffic-Roadway Section do not have the staff and expertise to design networking of traffic signals and all the forms of communication available. Until the Traffic-Roadway Section is able to provide this expertise the Intelligent Transportation Systems Unit (ITS Unit) is responsible for determining the form of communication to be used on the project (See Section 7.3). The ITS Unit will design certain portions of the work, with the traffic signal designer responsible for other portions of the work. ITS Unit is also responsible for ordering the network and radio equipment, coordinating the installation and turn-on of the network circuits with the Information Services Branch (ISB) Staff.

7.3 Forms of Communication

The ITS Unit, in conjunction with Traffic-Roadway Section, will determine the proper form of communication based on the Region Traffic's needs. Fiber optic is the preferred form. If fiber optic is not feasible, other acceptable options include 4.9GHz radio (back to a nearby ODOT facility), cellular broadband, and leased dedicated Ethernet.

Twisted pair copper (VDSL) is no longer allowed for new installations. Existing signals with twisted pair copper should be replaced with fiber optic (or one of the other acceptable options). In rare circumstances, existing twisted pair copper for VDSL networking may still be allowed if the ITS support coordinator tests and determines the cabling will meet performance specifications.

7.4 Scoping the Traffic Signal Communication System

Scoping the traffic signal communication system can be rather simple or very complex depending on the methods and equipment used. It is critical to contact the Traffic-Roadway Section and the ITS Unit at the scoping phase of the project. The Traffic-Roadway Section and ITS Unit will work with Region Staff and signal designer to determine the best option for the communications needed. Once the methods of communications are determined, the staff responsible for design will be determined.

As an example, fiber optic local communications is scoped for the project. The traffic signal designer is typically responsible for the site plan & standard specifications (junction box/hand hole locations, conduit, and type of wire in the conduit) shown on the interconnect plan sheet. The ITS Unit is typically responsible for the details (splice diagrams, fiber specifications, anticipated items, LPIF, etc.) shown on the ITS communication plan sheet.

The ITS Unit, in conjunction with the Traffic-Roadway Section, will determine the proper form of communication to use on the project. Contact us early in the design phase.

7.5 Use of Communication Equipment based on Project Type/Location

7.5.1 Locations maintained and Operated by ODOT (Projects by Local Agency or Permit)

The ITS Unit should be contacted early during scoping for involvement with the project requirements and the development of the Intergovernmental Agreement (IGA). The security of the network is extremely important to the operation of the traffic signals and needs to be described within the IGA.

The design must use ODOT approved communications equipment. If possible this will be ODOT supplied and the cost reimbursed.

7.5.2 Locations Maintained and Operated by Local Agencies on State Highways

These locations must use industrial hardened communications equipment approved by the Traffic-Roadway Section. If possible this will be ODOT supplied and the cost reimbursed.

Local Agency central communication is acceptable, but no direct connection from the traffic signals to the ODOT Network (only center to center communication)

7.5.3 Locations off the State Highway

These locations cannot use the ODOT Communications Price Agreement contract to purchase equipment.

7.6 Long Term Communication Planning

Efforts are underway in several regions between the ITS Unit and the Region Traffic offices in creating long term communication plans for traffic signal projects. These plans will help identify high level communication options and identifying the costs to develop traffic signal projects.

7.7 Design Considerations

7.7.1 Controller

The standard ATC controller can accommodate all types of communication.

7.7.2 Junction Boxes and Conduit Location and Sizes

Fiber optic installations use a "Hand Hole" instead of a junction box. See standard drawing TM472 for a general depiction. There are 3 different handhole sizes shown on the standard drawing. Contact the ITS unit to determine the appropriate size.

For non-fiber optic installations, the interconnect system typically uses the same junction boxes that have been placed for the traffic signal wiring. Beyond the intersection, the interconnect system requires junction boxes spaced a maximum of 300 feet apart. See Section 5.12.1 for more information on junction boxes.

7.7.3 Conduit

A separate, exclusive two-inch (minimum size) conduit is used for the interconnect system. See section 5.13 for more information on conduit requirements.

The designer should take into account controller locations, detector conduit construction, and physical features of the roadway when deciding where to route the interconnect conduit between controller cabinets. By using detector and signal conduit trenches, you can greatly reduce the quantity of trenching needed for the interconnect conduits.

Aerial installation using existing utility poles is not recommended as this requires more maintenance and reoccurring fees for using the poles that belong to others. It is more economical in the long run to install the interconnect system underground. However, this option may be considered if the initial cost of going underground is prohibitive and approval from the utility is received.

7.7.4 Fiber Optic Wiring

The number of fiber optic strands needed for interconnection is determined by the ITS Unit. This is typically shown on the interconnect plan created by the Signal Designer. See Figure 7-1. Fiber optics are spliced as necessary in the hand holes as determined by the ITS Unit. This is typically shown on the Fiber Optic Cable Splice Diagram created by the ITS Unit. See Figure 7-2.

Figure 7-1 | Fiber Optic Installation – Example of Interconnect Plan created by the Signal Designer

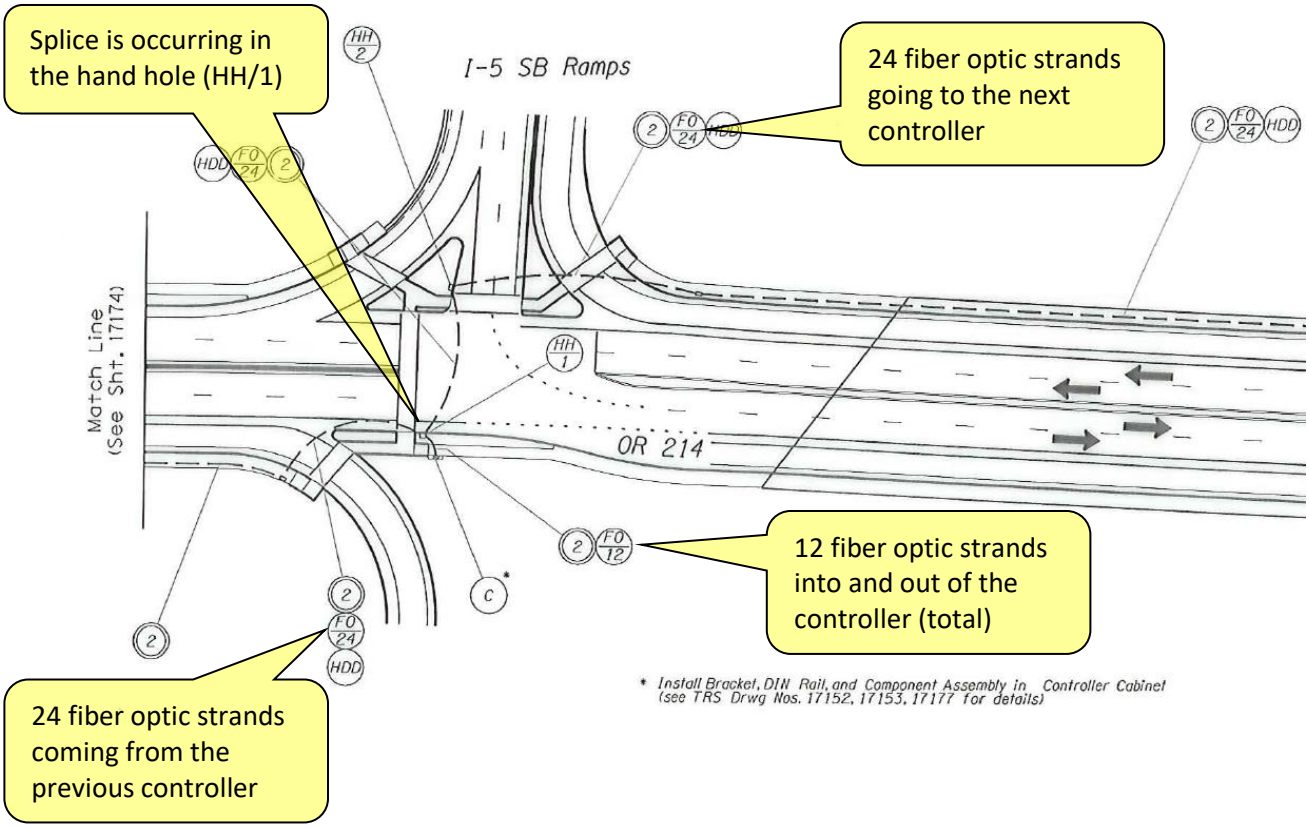
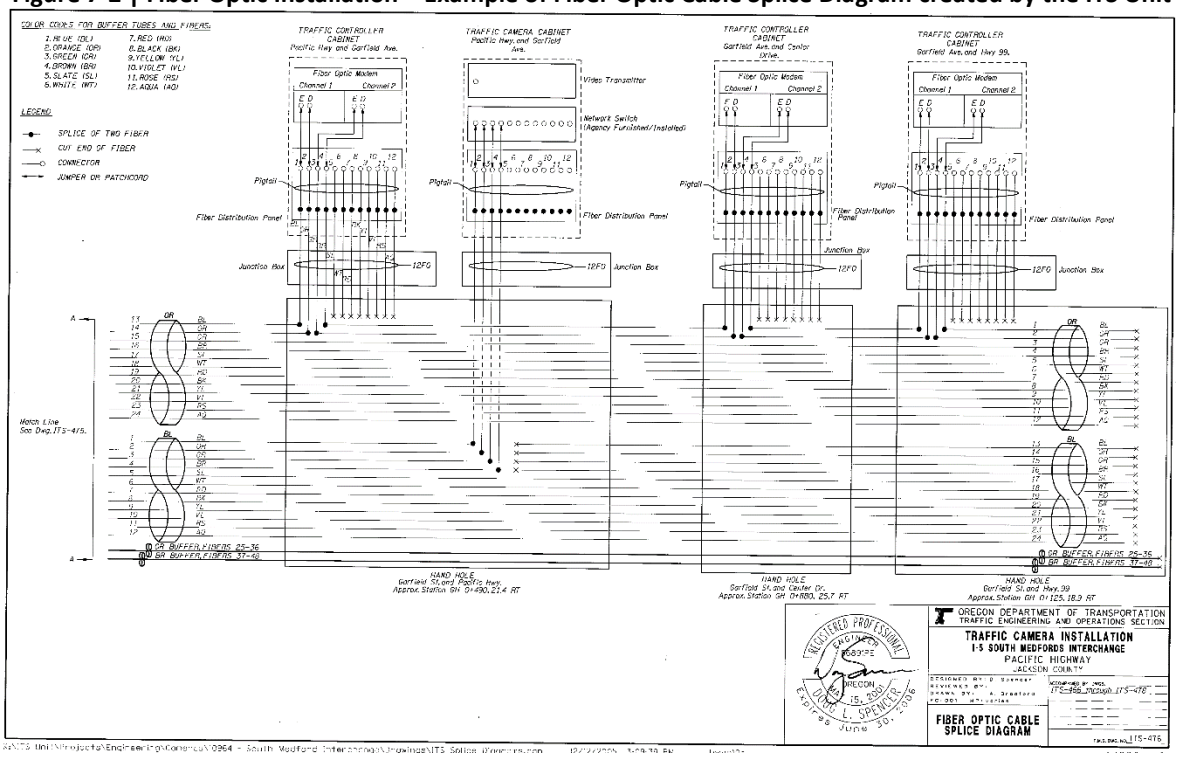


Figure 7-2 | Fiber Optic Installation – Example of Fiber Optic Cable Splice Diagram created by the ITS Unit



8 EXISTING UTILITIES PLAN

8.1 General

The existing utilities plan sheet became a requirement for signal design in the late 2000's at the request of a region that was experiencing utility conflict issues on signal projects. The inclusion of this plan sheet in the contract plans does NOT remove the requirement of the contractor to "call before you dig". Also, the signal designer is still responsible for working with the Region Utility Specialist to resolve all known utility conflicts prior to letting the project.

Utility conflicts should be identified early in the design process and resolved through the Region Utility Specialist PRIOR to letting the project!

8.2 When is this Plan Sheet Needed?

An existing utilities plans sheet is required for each intersection on the project if the work entails installing any poles, pedestals, cabinets, or conduit. These items can have a substantial impact to existing utilities due to their required foundation depth and/or height. In addition these items generally need to be installed in very specific locations with little room for placement tolerance, so addressing a utility conflict during construction can be very costly in either material costs and/or timelines.

An existing utilities plan sheet is recommended for each intersection for all other types of signal work if survey information for the utilities is available. It is not needed for signal work contained within existing signal appurtenances or the roadway (e.g. loop replacement).

8.3 What to Show on the Plan Sheet

The existing utilities plan sheet is generally shown at the scale of the detection plan sheet for each intersection, to show the location of utilities with respect to the major signal work. Due to the nature of interconnect/communication work (i.e. work spans a long distance and typically contains less critical design aspects with respect to utility conflicts), an existing utilities plan sheet is NOT required for interconnect/communication work located beyond the scale used to show the intersection.

The existing utility plan sheet should show the following features:

- All overhead and underground existing utility locations
- Right-of-way
- All new and existing signal appurtenances, except those located in the roadway such as loop detectors (e.g. poles, pedestals, mast arms, cabinets, junction boxes, conduit runs)
- The new roadway alignment and lane lines
- The existing edge of pavement if helpful for reference purposes
- North arrow
- Street name labels
- Stationing
- Lane use arrows

Use the survey provided line styles for the utilities. Do NOT label any signal appurtenances, just graphically show.

The following figures show typical examples of what is contained in an existing utility plan sheet.

Figure 8-1 | Existing Utility Plan Sheet Example 1

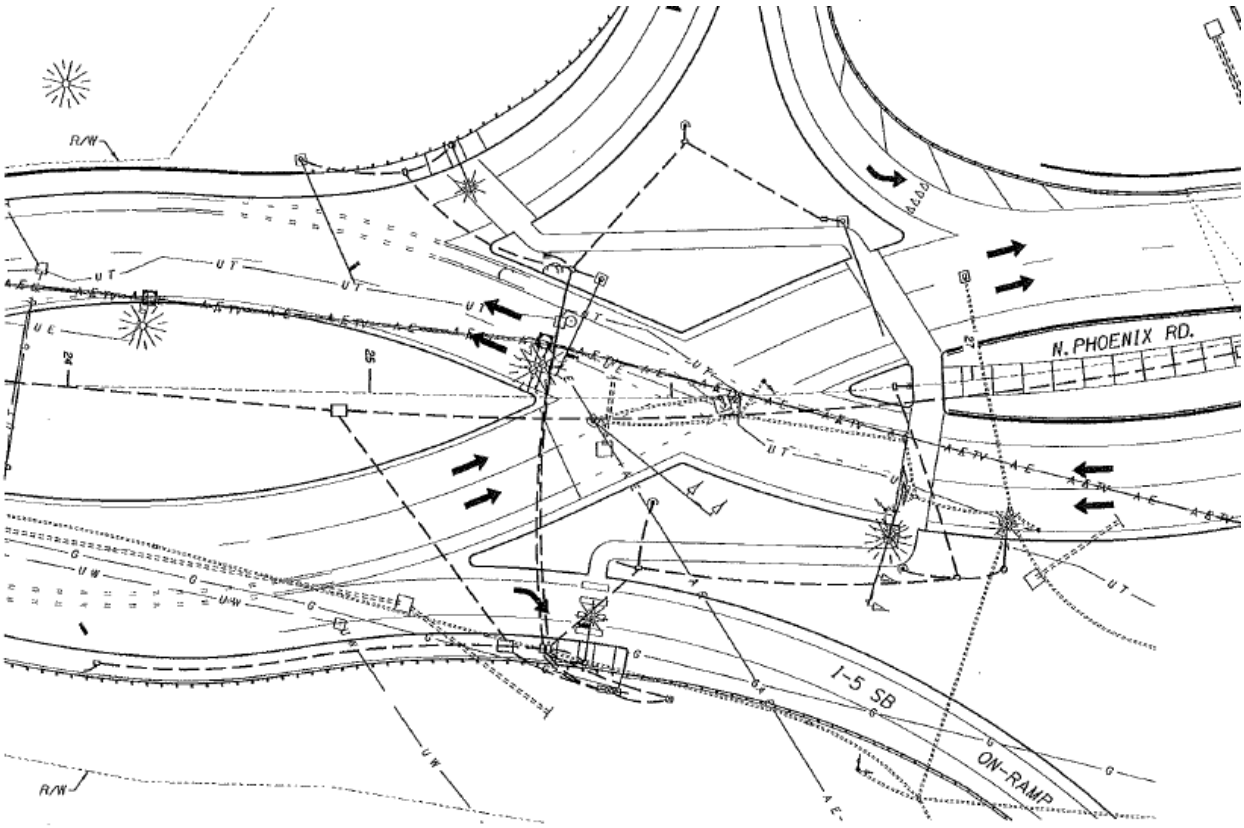
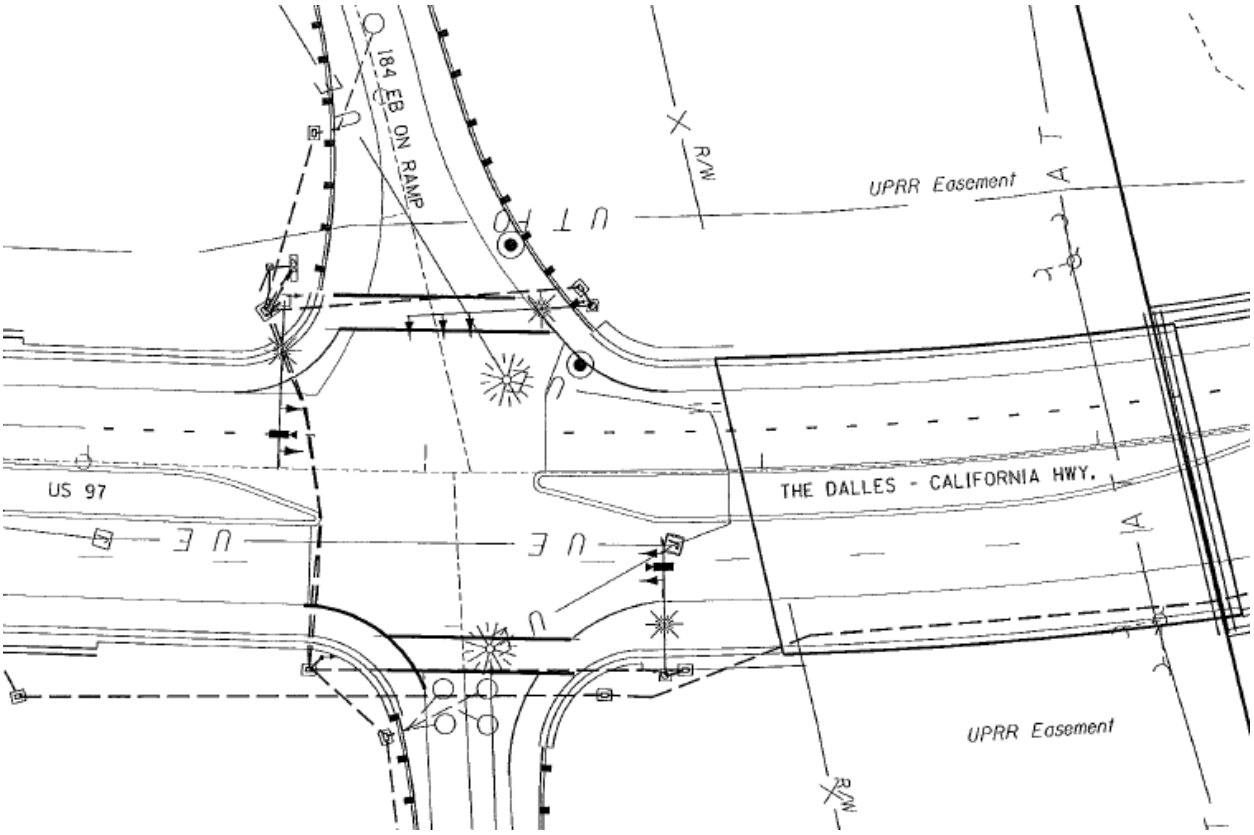


Figure 8-2 | Existing Utility Plan Sheet Example 2



9 DETAILS PLAN

9.1 General

The details plan sheet is used to show ANY design information that cannot be shown on the standard designated plan sheet. This is typically due to a drafting space issue; for example, the pole entrance chart is contained on a separate details plan sheet because there is not enough room on the signal plan sheet to show all the pertinent signal design information. Other common design information shown on detail sheets includes customized diagrams created from Standard Details.

This chapter will cover the two basic types of information routinely contained on the details plan sheet; the pole entrance chart and custom details created from standard details.

9.2 Pole Entrance Chart - General

The pole entrance chart lists the micro details related to the signal pole and all mounted signal equipment. Some of the information listed in the pole entrance chart is redundant (e.g. the mast arm length is listed on the signal plans AND in the pole entrance chart), but this chart aids in reviewing signal pole submittals and also serves as a quick glance summary for how many and what type of poles are needed for the project.

There are two default types of pole entrance charts; one for mast arms (See Section 9.3) and one for span wires (See Section 9.4).

9.2.1 When is a pole entrance chart needed?

A pole entrance chart is required for any work that involves installing a new push button post, pedestrian/vehicle pedestal, or signal pole.

A pole entrance chart is recommended for any work that modifies the equipment located on an existing mast arm, span wire, or signal pole. The exception to this recommendation is for minor modifications where all the necessary information (contained in the pole entrance chart) can be very clearly shown on the signal plan sheet.

If the project involves a combination of mast arms and span wires, both charts will need to be included.

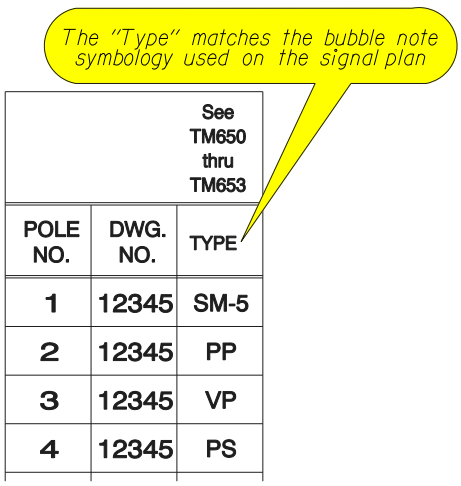
9.3 Pole Entrance Chart – Mast Arm

The following section discusses how to fill out the mast arm pole entrance chart properly. If any of the columns do not apply to the pole that is being detailed, leave those columns blank.

9.3.1 First 3 Columns

The first 3 columns list the basic pole identifiers: the unique pole number, the signal plan sheet the pole is located on, and the type of pole it is (signal pole type as per standard drawing TM650, pedestrian pedestal, vehicle pedestal or pedestrian push button post). See **Figure 9-1**.

Figure 9-1 | Basic Pole Information

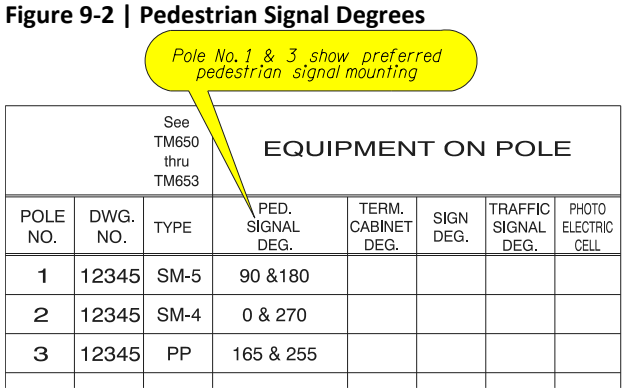


9.3.2 Equipment on the Pole

The next five columns detail all the equipment that is located on the pole itself. All equipment that is located on the pole itself is measured by degrees to ensure the correct orientation of the equipment. The degrees are measured to the nearest 5 degree increment.

The pedestrian signal degrees column shows the location of the clamshell mount for the pedestrian signal (which is 90 degrees from the face of the signal indication). If more than one pedestrian signal indication is mounted to a pole an "&" symbol is used between the two locations. See Figure 9-2.

Figure 9-2 | Pedestrian Signal Degrees



For a mast arm pole, the degrees are measured clockwise from the centerline of the mast arm. Pedestrian signals should be mounted at or near 90 degrees and 180 degrees on a mast arm pole (located on the "back-side" of the mast arm pole). See Figure 9-3. They may be mounted on the "front side" of the mast arm pole (at or near 0 degrees and 270 degrees) if that location provides better line of sight within the crosswalk, but keep in mind that pedestrian indications located on the front side of the pole are more vulnerable to being damaged by large trucks making a right turn at the intersection. See Figure 9-4. Note that the degrees for mast arm poles are measured differently than degrees for pedestals; pedestal degrees are measured from the north arrow. See Figure 9-5.

Figure 9-3 | Pedestrian Signal Degrees – Pole 1 Example

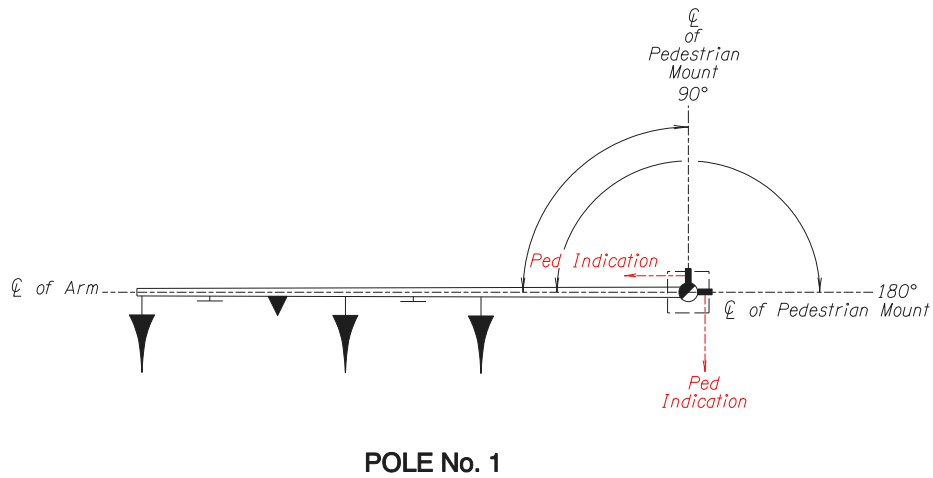


Figure 9-4 | Pedestrian Signal Degrees – Pole 2 Example

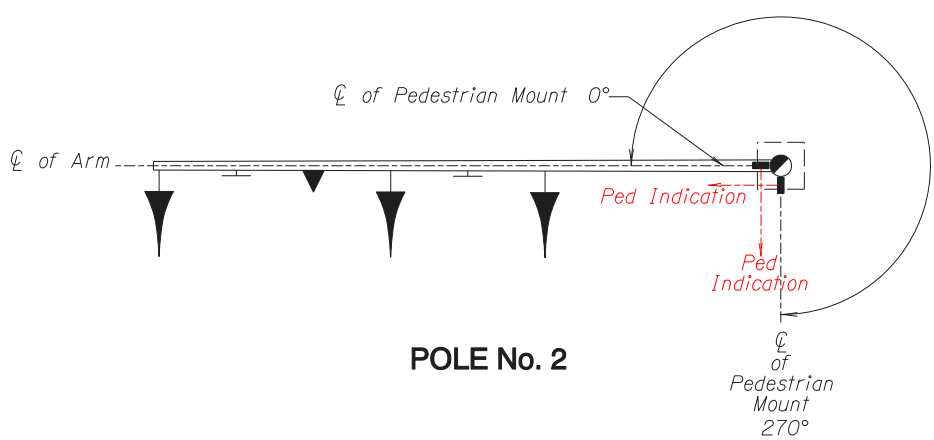
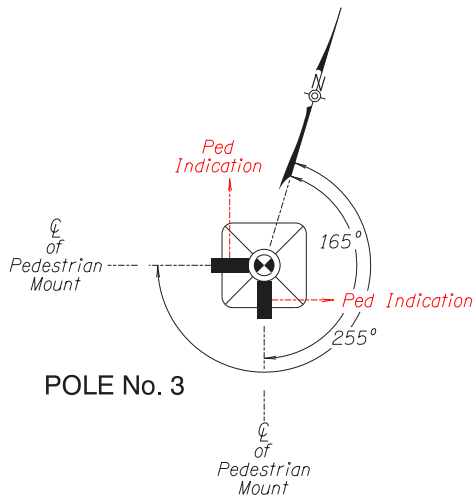


Figure 9-5 | Pedestrian Signal Degrees – Pole 3 Example

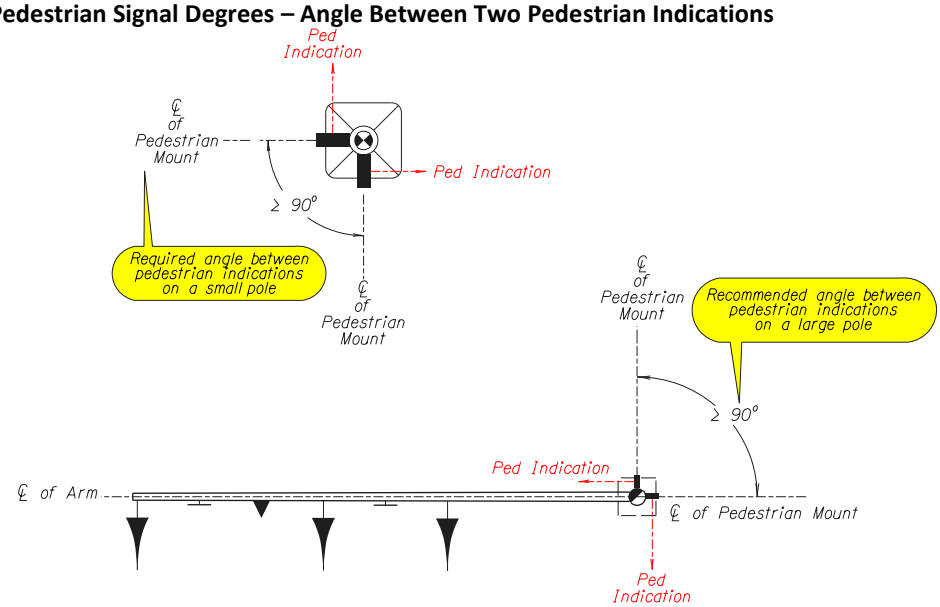


The origin for measuring degrees is NOT the same for mast arm poles (clockwise from arm) and pedestals (clockwise from the north arrow).

When two pedestrian indications are mounted to the same pole, the acute angle between the two pedestrian heads should be 90 degrees or greater on a large diameter pole (mast arm and strain poles) and shall be 90 degrees or greater on a small diameter pole (pedestals). See Figure 9-6. When the indications are placed closer than 90 degrees several things may occur:

- The indications can be occluded
- The clamshell mounting brackets cannot be installed (the hardware for each indication would overlap)
- It may be difficult to fully open the clamshell and/or the pedestrian indication for maintenance

Figure 9-6 | Pedestrian Signal Degrees – Angle Between Two Pedestrian Indications



The terminal cabinet degrees shows the location of the factory welded hub required to mount the terminal cabinet to the signal pole (see TM450 and TM488 for additional details). See Figure 9-7. Pedestals do NOT have a terminal cabinet. For mast arm poles, the terminal cabinet degrees should be located at 180 degrees unless there is some obstruction which would make accessing the terminal cabinet difficult at 180 degrees. See

Figure 9-8. The Region Electrical Crew will provide direction on the best location to mount the terminal cabinet in these situations.

Figure 9-7 | Terminal Cabinet Degrees

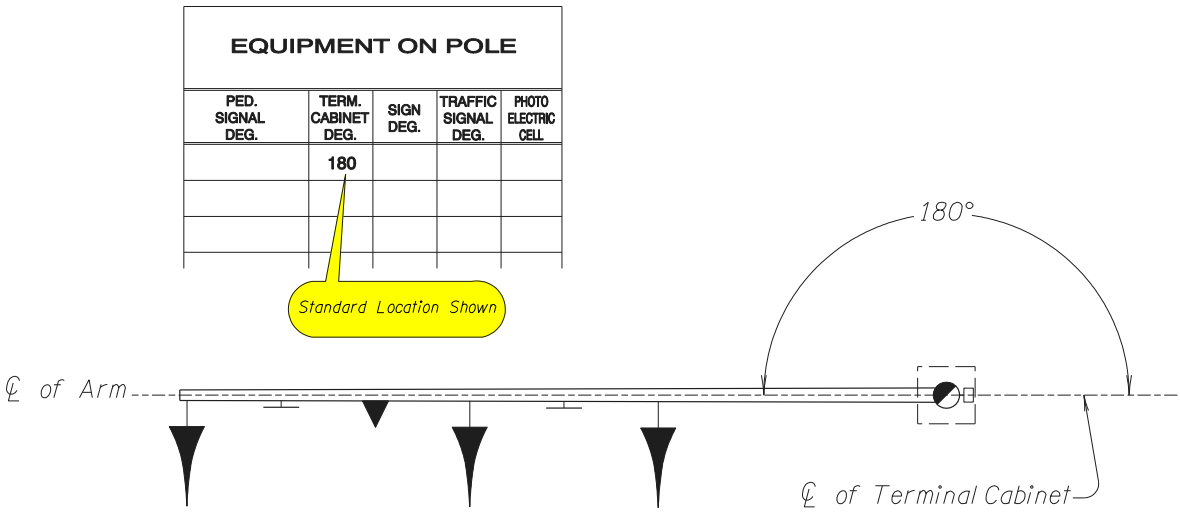
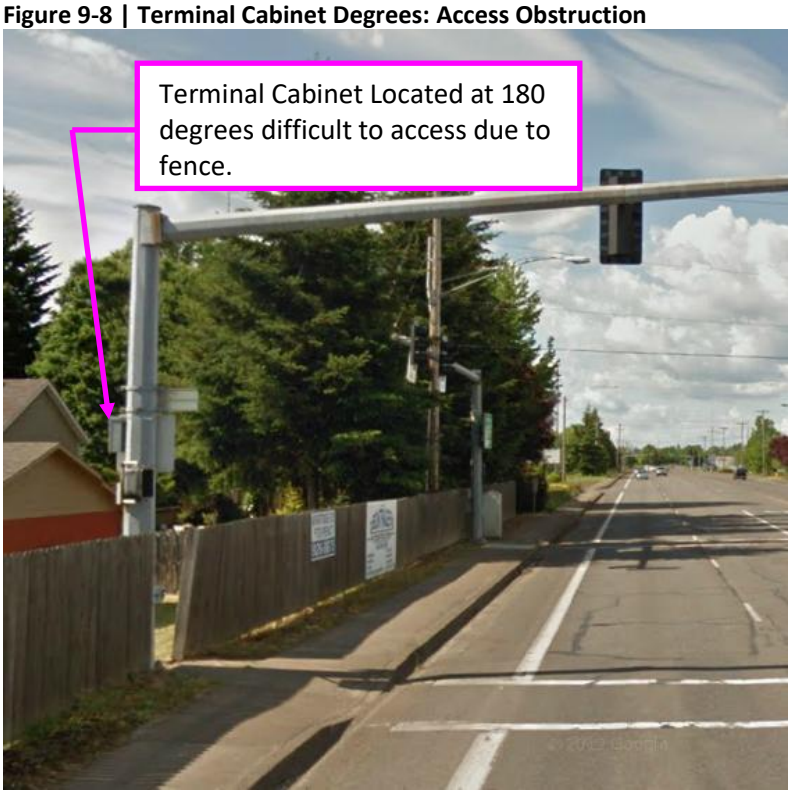


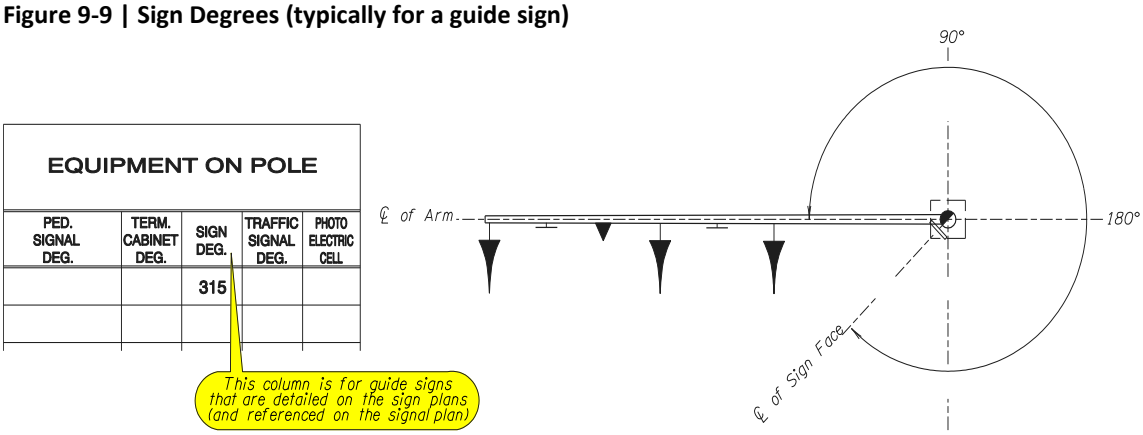
Figure 9-8 | Terminal Cabinet Degrees: Access Obstruction



The sign degree column shows the location of the face of the sign mounted on the signal pole, typically a guide sign. See Figure 9-9. The other details for the guide sign fabrication and mounting will be shown on the signing plans and will be paid for as a sign bid item (not under the lump sum traffic signal bid item). Guide signs mounted to signal poles must meet the requirements shown in standard drawings TM650 and TM680 (such as a maximum area of 60 square feet, maximum height of 7 feet and maximum width of 12 feet). If at all possible, the guide sign should be designed to fit within these parameters. If the sign cannot be meet these requirements and cannot be mounted in a different location, then a standard signal pole cannot be used and a custom designed pole must be used.

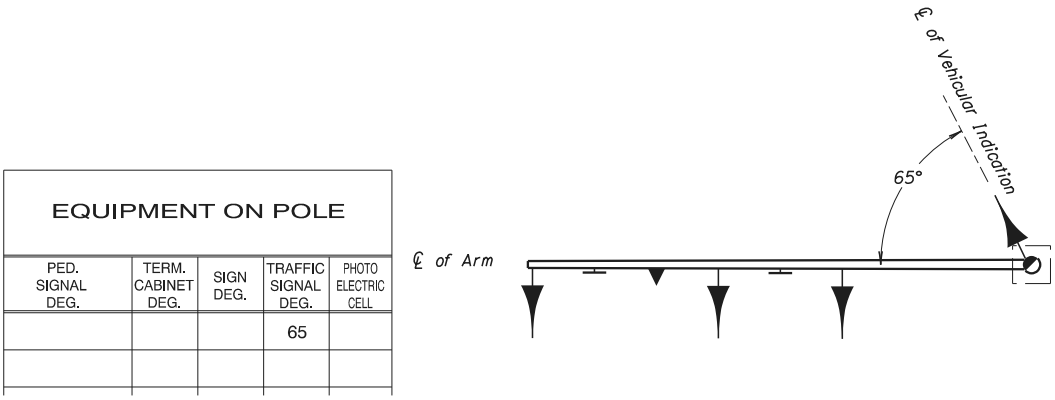
If a sign other than a guide sign is mounted to the pole (i.e. a NO TURN ON RED sign), this column can be used to detail the orientation. In the case where multiple signs are mounted to the same pole (i.e. guide sign AND a regulatory) it is recommended to add a column to the "equipment on pole" to distinguish between the two signs. See Figure 9-13. Multiple signs on the same pole must be evaluated to ensure that a standard pole will accommodate the loading as per TM660 and TM680.

Figure 9-9 | Sign Degrees (typically for a guide sign)



The traffic signal degree column shows the location of the face of the vehicular signal indication mounted on the pole. See Figure 9-10. Vehicular signal indications are not typically mounted to signal poles unless there is need for a near-side signal indication or the intersection geometry/phasing requires unique placement of the signal indication.

Figure 9-10 | Traffic Signal Degrees



The origin for measuring the degrees is NOT the same for mast arm poles and pedestals.

The photo-electric cell column shows the location of the mount used for the photo electric cell. See Figure 9-11. The photo-electric cell's sensor must be oriented to the north to operate most effectively, so when mounting the photo electric cell to the pole, ensure that photo cell's sensor will NOT be pointed directly at the signal pole. See Figure 9-12.

Figure 9-11 | Photo Electric Cell

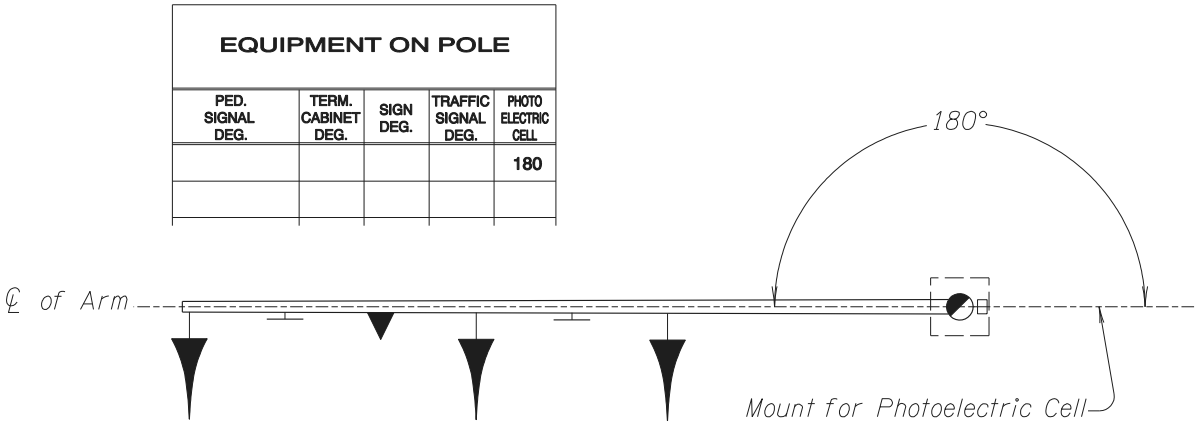
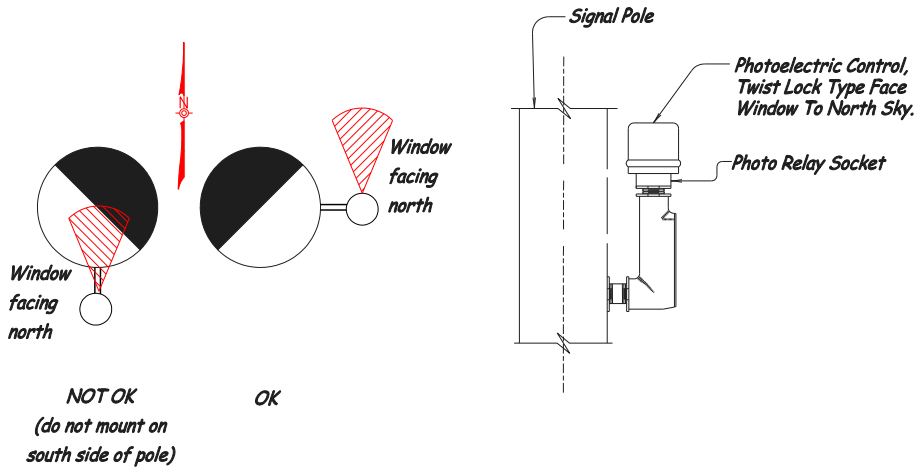
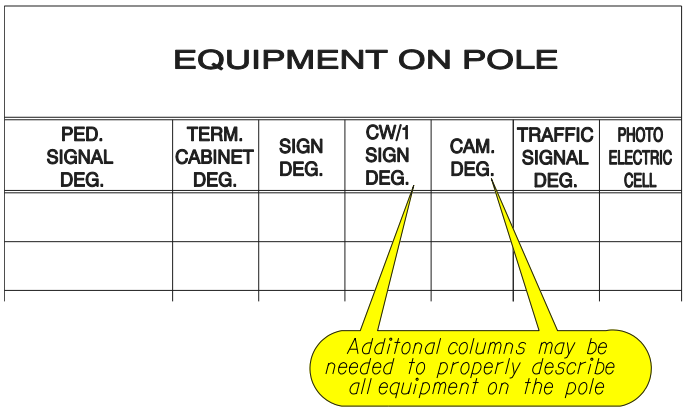


Figure 9-12 | Photo Electric Cell Orientation



There may be cases where additional columns may need to be added to the “equipment on pole” section. Typical examples include a column for the “crosswalk closed” sign if it needs to be mounted to the signal pole or a “Cam. Deg.” column if a video detector/ITS camera is mounted to the pole. See Figure 9-13. A column is NOT needed for pushbuttons as these are installed as per standard drawing TM467 and can only be installed in one orientation.

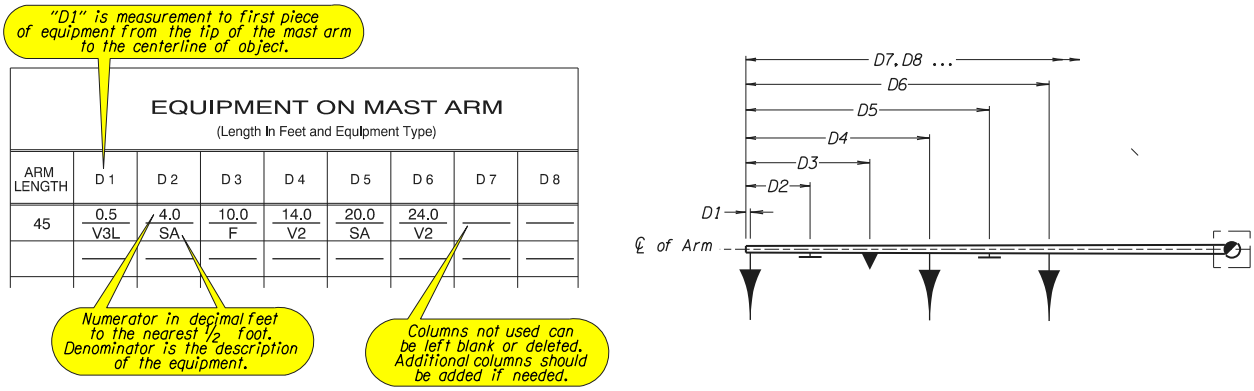
Figure 9-13 | Adding Columns



9.3.3 Equipment on the Mast Arm

The next columns show all the equipment located on the mast arm. See Figure 9-14. The first column shows the mast arm length. The following columns list each piece of equipment that is located on the mast arm, starting from the tip of the mast arm and going towards the signal pole. For each piece of equipment, the distance in feet from the tip of the mast arm (numerator) AND a description of the type of equipment (denominator) is included. The description is a standard abbreviation that is defined in a legend. The distance is shown in decimal format, with measurements rounded to the nearest half foot.

Figure 9-14 | Mast Arm Equipment



9.3.4 Foundation Information

The foundation information columns show the foundation number and the foundation depth for each signal pole. See Figure 9-15. The foundation number is specific to the type of mast arm/strain pole type used and is found on standard drawing TM653 in the "standard foundations" chart. The foundation depth is determined using site specific information documented in a geotechnical report according to the ODOT Traffic Structures Design Manual. This report is produced by the Geotechnical Engineer once the location of the signal poles has been determined. The foundation depth is shown in decimal format to the tenth of a foot. The geotech report is also referenced on the plan sheet just below the pole entrance chart with the name of the agency/firm that produced the report and the date of the report.

Do NOT include any foundation information for pedestrian pedestals, vehicle pedestals or pedestrian push button posts as these standard foundations do not have any variables and are installed according standard drawing TM457. Leave these columns blank.

Figure 9-15 | Foundation Information

		See TM650 thru TM653	FOUNDATION INFORMATION (See Std. Drg. TM653)	
POLE NO.	DWG. NO.	TYPE	FOUNDATION NUMBER	REQUIRED FOUNDATION DEPTH
1	12345	SM-5	5	12.0
2	12345	VP		
3	12345	PP		
3	12345	PS		

Leave foundation info blank for VP, PP & PS

This note to be placed at the bottom of pole entrance chart

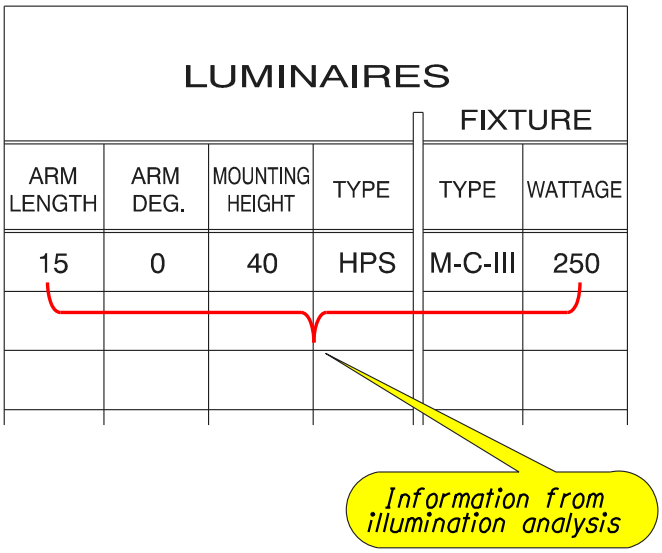
Foundation Depth as per (Agency Name who preformed report) Geotech Report Dated (XX-XX-XXXX)

9.3.5 Luminaires

The illumination columns show the details for the luminaires mounted on signal poles. See Figure 9-16. The information comes from the illumination analysis. The following are typical values for illumination:

- 15 foot arm length
- 0 arm degrees (i.e. “in-line” with the mast arm)
- 35 to 40 foot mounting height
- Standard luminaire type is LED
- Standard fixture type for LED is Type 3.
- Standard wattage is from 130 to 275, depending on design.

Figure 9-16 | Luminaire Information



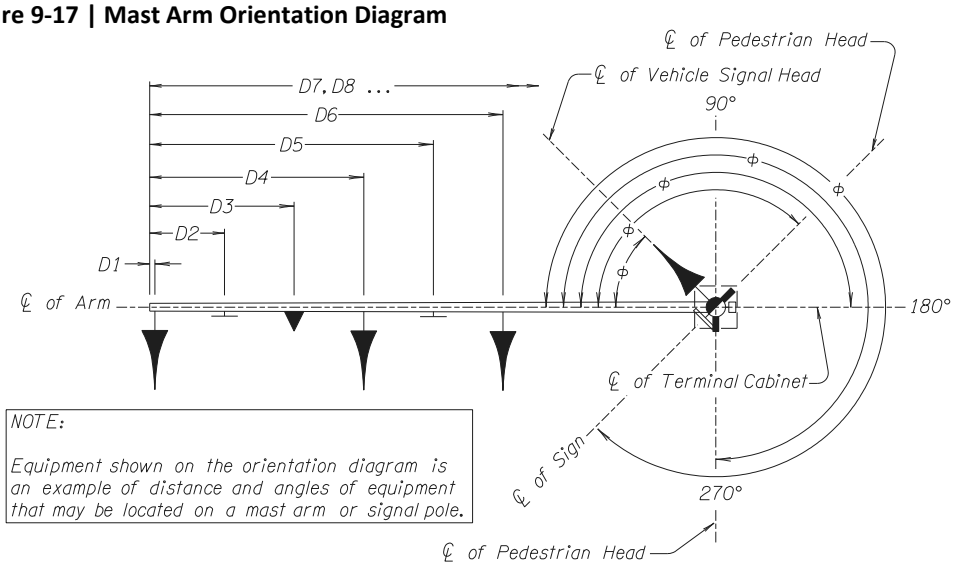
9.3.6 Orientation Diagrams

The orientation diagrams provide a legend for how to read the information provided by the pole entrance chart.

There are two standard orientation diagrams that are included with the pole entrance chart:

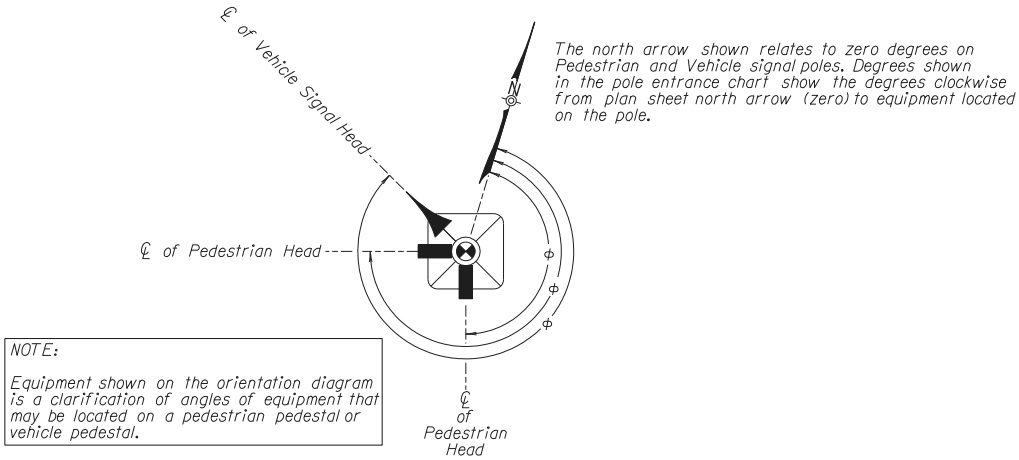
- The mast arm orientation diagram. See Figure 9-17.
- The pedestrian pedestal/vehicle pedestal orientation diagram (included only if this type of pole is used on the project). See Figure 9-18.

Figure 9-17 | Mast Arm Orientation Diagram



MAST ARM POLE ORIENTATION DIAGRAM

Figure 9-18 | Pedestrian Pedestal/Vehicle Pedestal Orientation Diagram



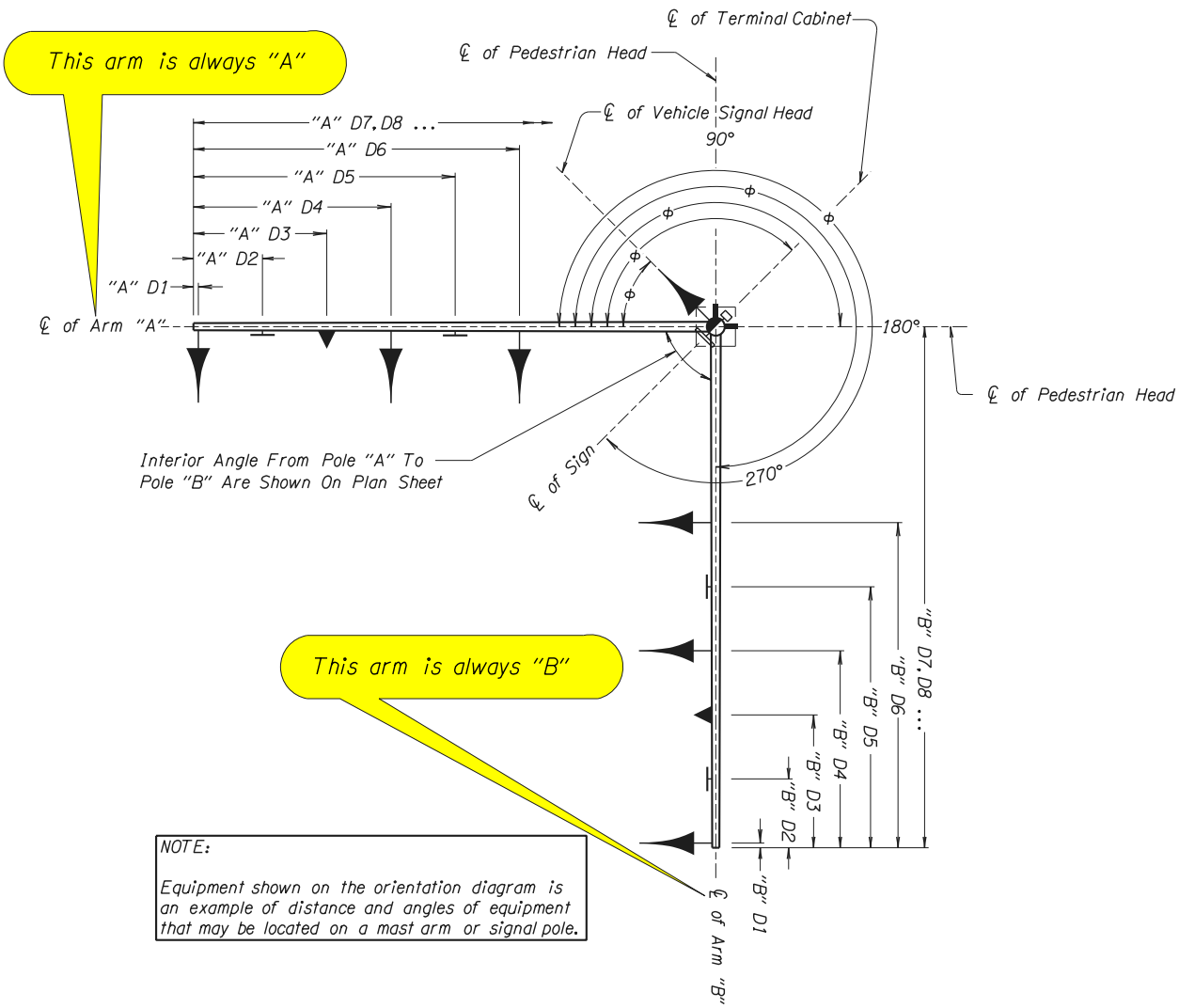
PEDESTRIAN PEDESTAL / VEHICLE PEDESTAL ORIENTATION DIAGRAM

9.3.7 Detailing Dual Mast Arm Pole in the Pole Entrance Chart

A dual mast arm pole is a custom designed pole and requires a few more pieces of information in the mast arm pole entrance chart (and signal plan sheet) than a standard mast arm pole. In addition, there is a specific pole orientation diagram that must be used for dual mast arm poles.

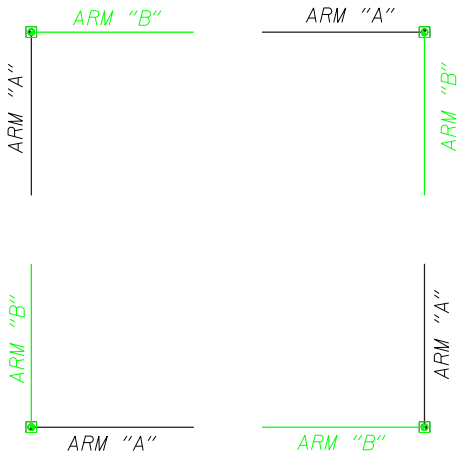
A dual mast arm pole has one mast arm labeled “A” and one labeled “B” as per the orientation diagram. This clearly designates which arm is being detailed in chart. See Figure 9-19. If possible (e.g. there is only one dual mast arm on the project or each dual mast is oriented in the same way), rotate the dual mast arm in the orientation diagram to match the orientation in the signal plan sheet. See Figure 9-20.

Figure 9-19 | Twin Mast Arm Pole Orientation Diagram



TWIN MAST ARM POLE ORIENTATION DIAGRAM

Figure 9-20 | Twin Mast Arm Pole Orientation Diagram – Rotated



The information presented in section 9.3.7 applies to dual mast arm poles, with the Figure 9-21 through Figure 9-25 showing the slight modifications necessary to properly detail a mast arm pole in the pole entrance chart.

Figure 9-21 | Twin Mast Arm Pole – Pole Entrance Chart

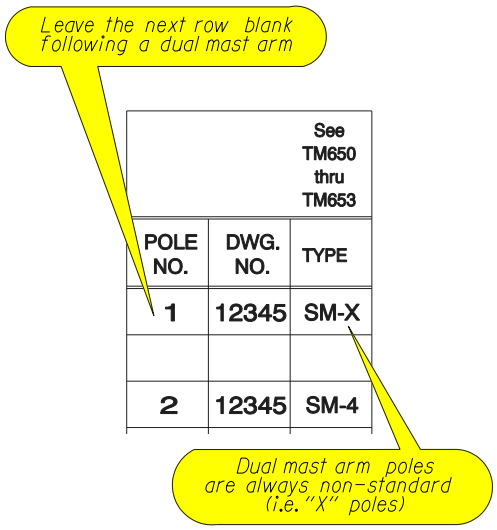


Figure 9-22 | Twin Mast Arm Pole – Equipment on Pole

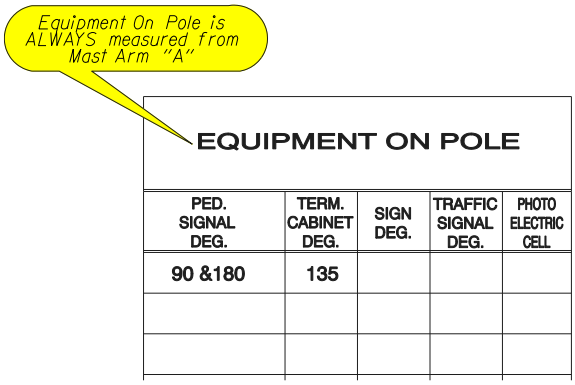


Figure 9-23 | Twin Mast Arm Pole – Equipment on Mast Arm

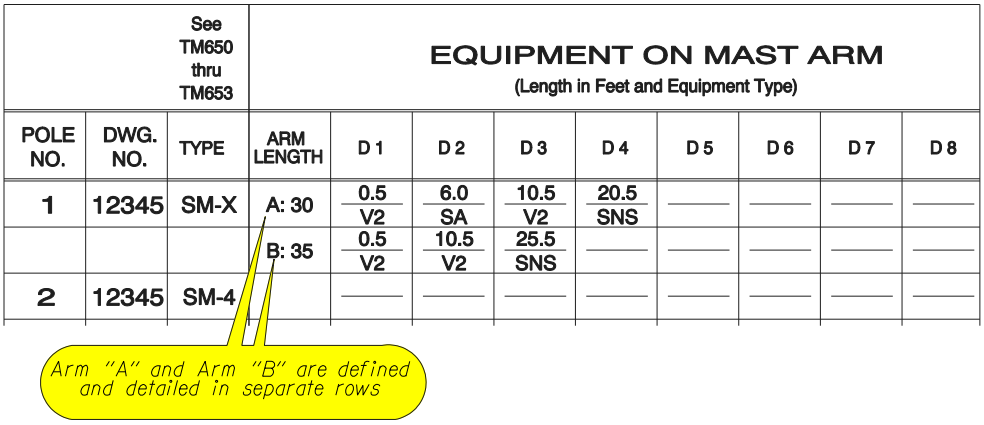


Figure 9-24 | Twin Mast Arm Pole – Foundation Information

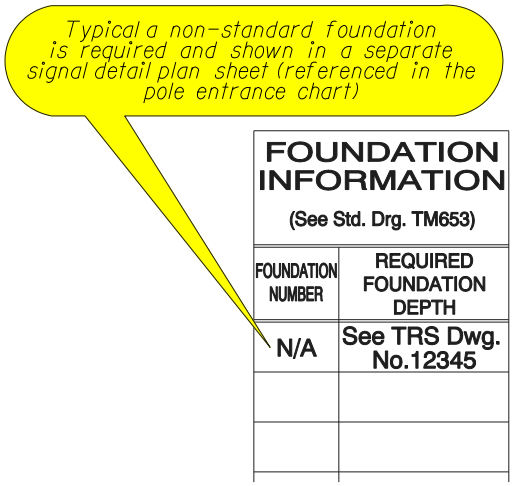
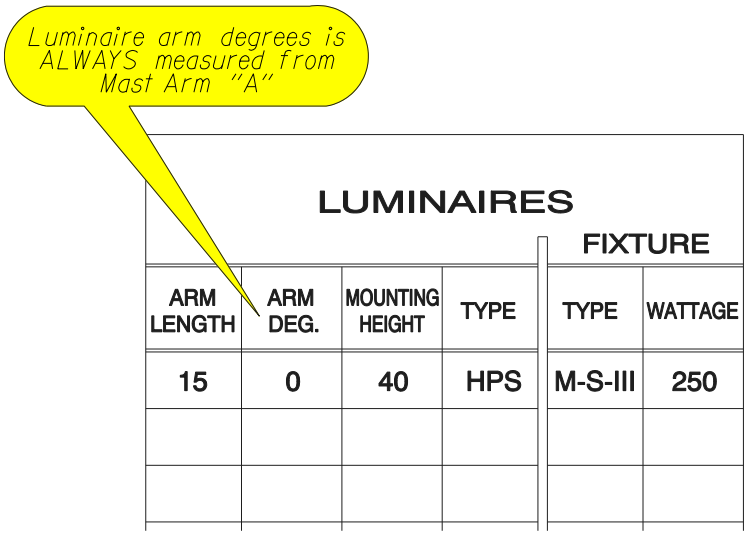


Figure 9-25 | Twin Mast Arm Pole – Luminaires



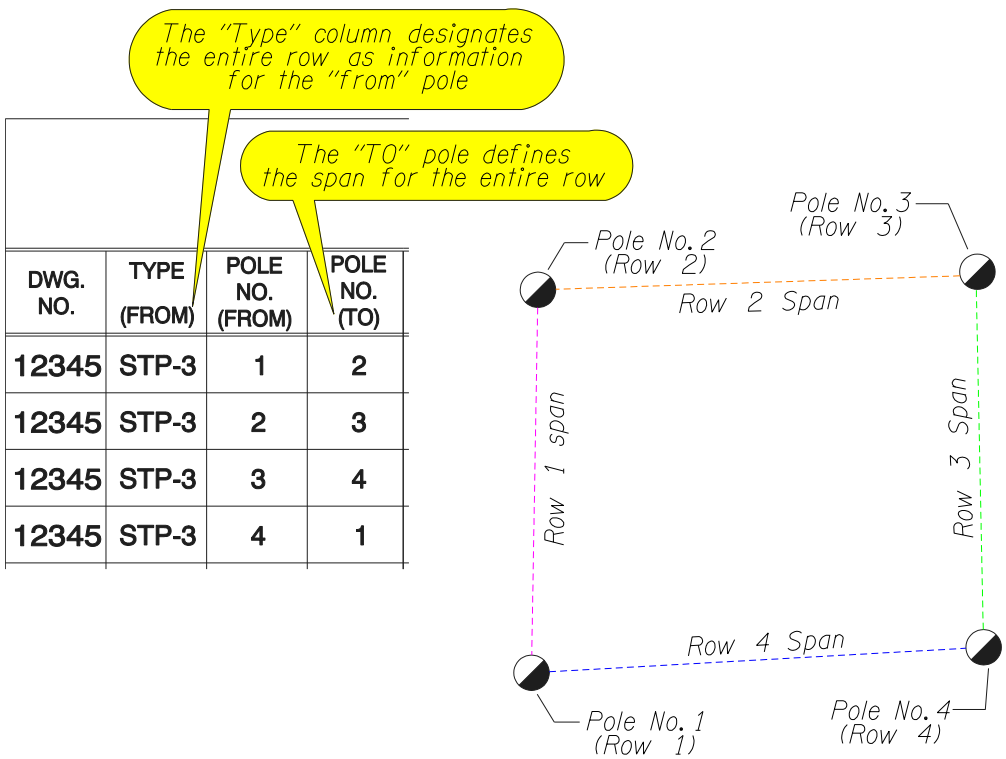
9.4 Pole Entrance Chart – Strain Pole

The following section discusses how to fill out the strain pole entrance chart properly. If any of the columns do not apply to the pole that is being detailed, leave those columns blank.

9.4.1 First 4 Columns

The first 4 columns list the basic pole and span identifiers: the signal plan sheet the pole is located on, the type of pole it is (signal pole type as per standard drawing TM661, the unique pole number (designated as the "FROM" pole), and the span (defined by the "TO" pole). See Figure 9-26. The type of strain pole is determined by the structural engineer performing the structural analysis based on the following information provided by the signal designer: pole location & span length, equipment & location of equipment on each span, and the Messenger Cable Attachment Height (MAH) for each pole.

Figure 9-26 | Basic Pole and Span Information



DWG. NO.	TYPE (FROM)	POLE NO. (FROM)	POLE NO. (TO)
12345	STP-3	1	2
12345	STP-3	2	3
12345	STP-3	3	4
12345	STP-3	4	1

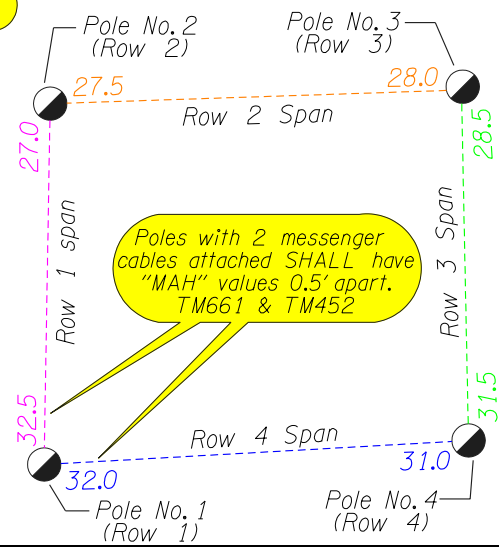
9.4.2 Messenger Cable Attachment Height (MAH)

The next 2 columns after basic pole information show the messenger cable attachment height (MAH) for each messenger cable attached to the pole. All values should be reported in increments of 0.5 feet. For poles with 2 messenger cables attached, the MAH values must be separated by 0.5' as per standard drawing TM661 and TM452. See Figure 9-27.

Figure 9-27 | Messenger Cable Attachment Height (MAH)

Round to the nearest 0.5'

					See TM660 and TM661
DWG. NO.	TYPE (FROM)	POLE NO. (FROM)	POLE NO. (TO)	CABLE "MAH" (FROM) POLE	CABLE "MAH" (TO) POLE
12345	STP-3	1	2	32.5	27.0
12345	STP-3	2	3	27.5	28.0
12345	STP-3	3	4	28.5	31.5
12345	STP-3	4	1	31.0	32.0



The MAH is defined as the distance from the baseplate of the signal pole (or ground line for temporary wood pole) to the point of attachment of the messenger cable. To determine the MAH, request a cross-section from the roadway designer for each span. To calculate the MAH, see Figure 9-28 which assumes the following:

- The MAH values for the span are at approximately equal elevations (typically within 1 foot of each other). If the elevations of the MAH for the span are different by more than 1 foot due to a super elevation or steep vertical grade, see Figure 9-29 for how to calculate the MAH.

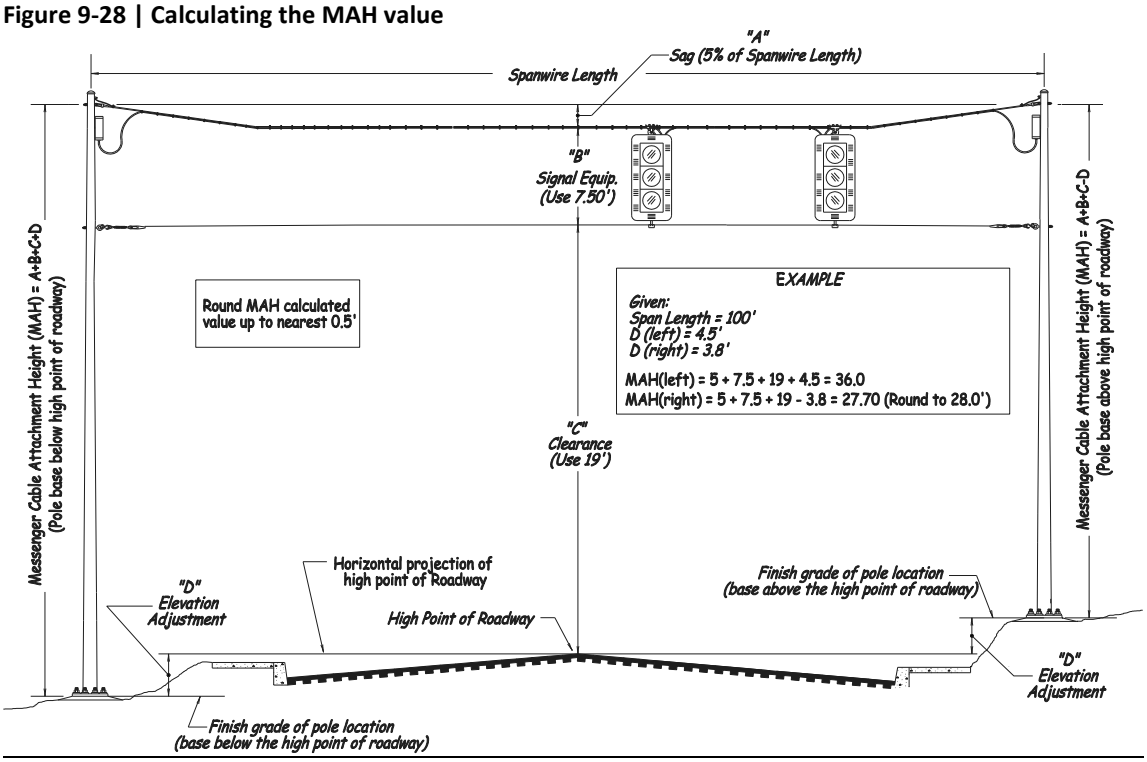
- 19' Maximum roadway clearance. The tolerance for the roadway clearance is 18' minimum to 19' maximum as per standard drawing TM450. Using the 19' maximum value for calculating the MAH results in a conservative MAH value (from the perspective of roadway clearance).

- A type 5 signal head is mounted at the lowest spot on the span which coincides with the highest spot on the roadway. This is a requirement of standard drawing TM660 which states that the strain pole supports, "Accommodate enough vertical space for a type 5 signal." The results in a conservative MAH value and allows for future revisions to the traffic signal. However, if the project

contains a span wire installation for either a flashing beacon or temporary signal, this assumption is no longer valid (flashing beacon span wire installations should NOT be converted into a traffic signal installation and temporary signals by their nature do not need to accommodate unplanned future revisions). In these two cases, the largest piece of signal equipment to be installed on the span should be used in the calculation in lieu of the Type 5 signal head.

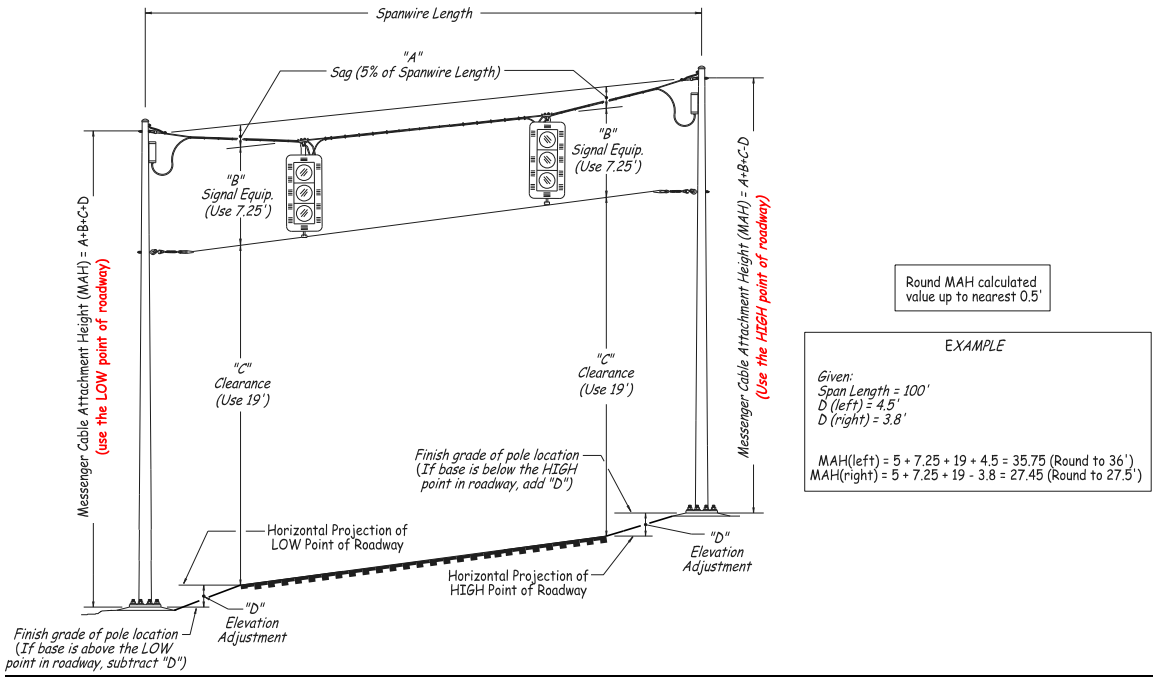
- The vertical distance from the finish grade of the pole location to the pole base plate is negligible.

Figure 9-28 | Calculating the MAH value



There are rare cases where the roadway cross-section will result in unequal MAH elevations for the span (e.g. when there is a steep grade or super elevation). In these cases both the high point of the roadway AND the low point of the roadway is used to determine the MAH for each pole as per Figure 9-29. Using the method shown in Figure 9-29 is oversimplified and results in a conservative estimate for roadway clearance, as the low point in the catenary span will not actually occur at the locations shown when the MAH elevations are not equal.

Figure 9-29 | Calculating the MAH value – spans with MAH elevations differing by more than a foot

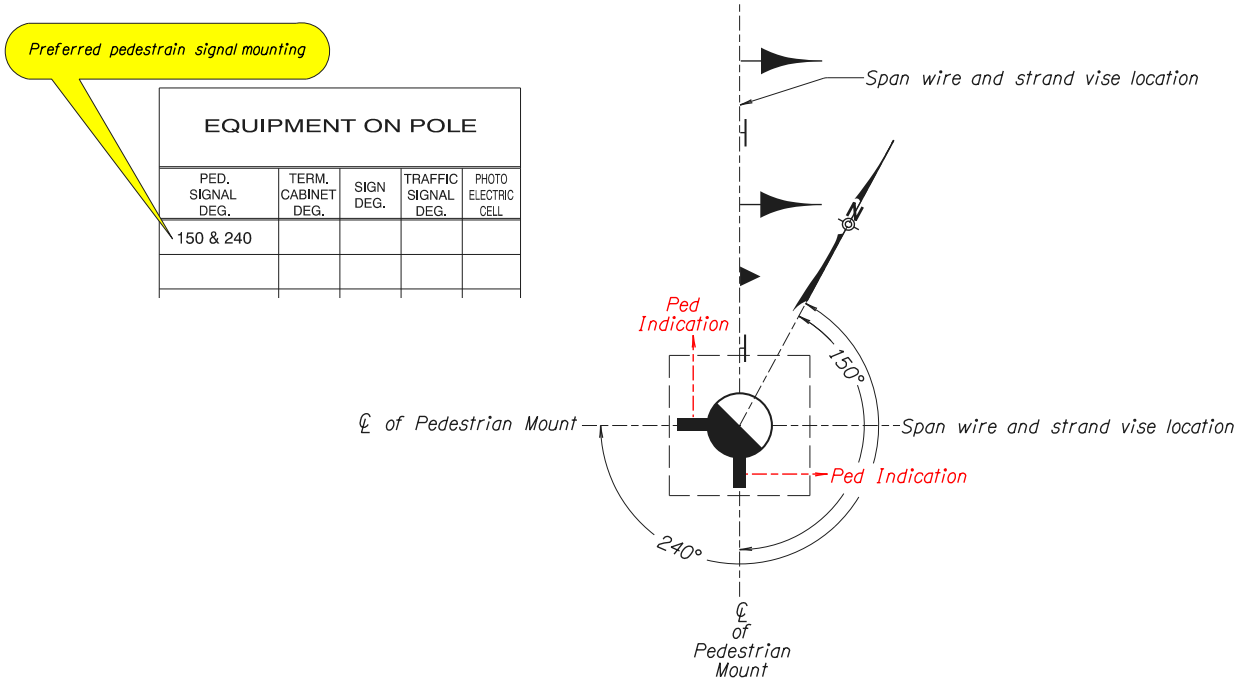


9.4.3 Equipment on Pole

The next five columns detail all the equipment that is located on the pole itself. All equipment that is located on the pole itself is measured by degrees to ensure the correct orientation of the equipment. The degrees are measured to the nearest 5 degree increment.

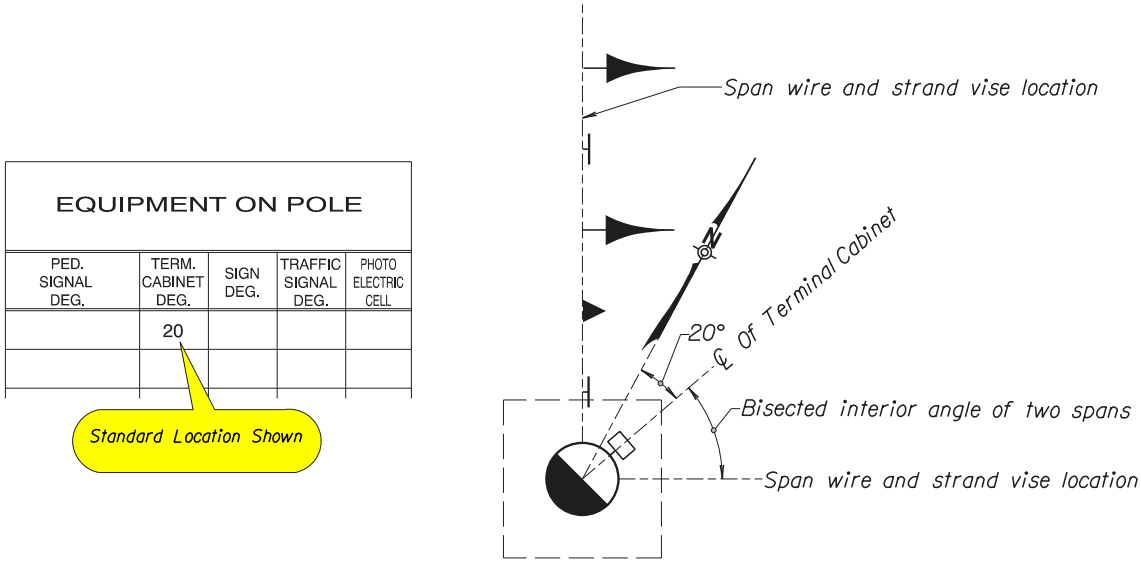
The pedestrian signal degrees column shows the location of the clamshell mount for the pedestrian signal (which is 90 degrees from the face of the signal indication). If more than one pedestrian signal indication is mounted to a pole an "&" symbol is used between the two locations. The degrees for a strain pole are measured clockwise from the north arrow. The preferred mounting on the "back side" of the strain pole is shown in Figure 9-30.

Figure 9-30 | Pedestrian Signal Equipment



The terminal cabinet degrees shows the location of the factory welded hub required to mount the terminal cabinet to the signal pole (See TM452 & TM488 for additional details). For strain poles, the terminal cabinet should be located on the bisected interior angle formed by the two span wires for ease of maintenance. See Figure 9-31.

Figure 9-31 | Terminal Cabinet on Strain Pole



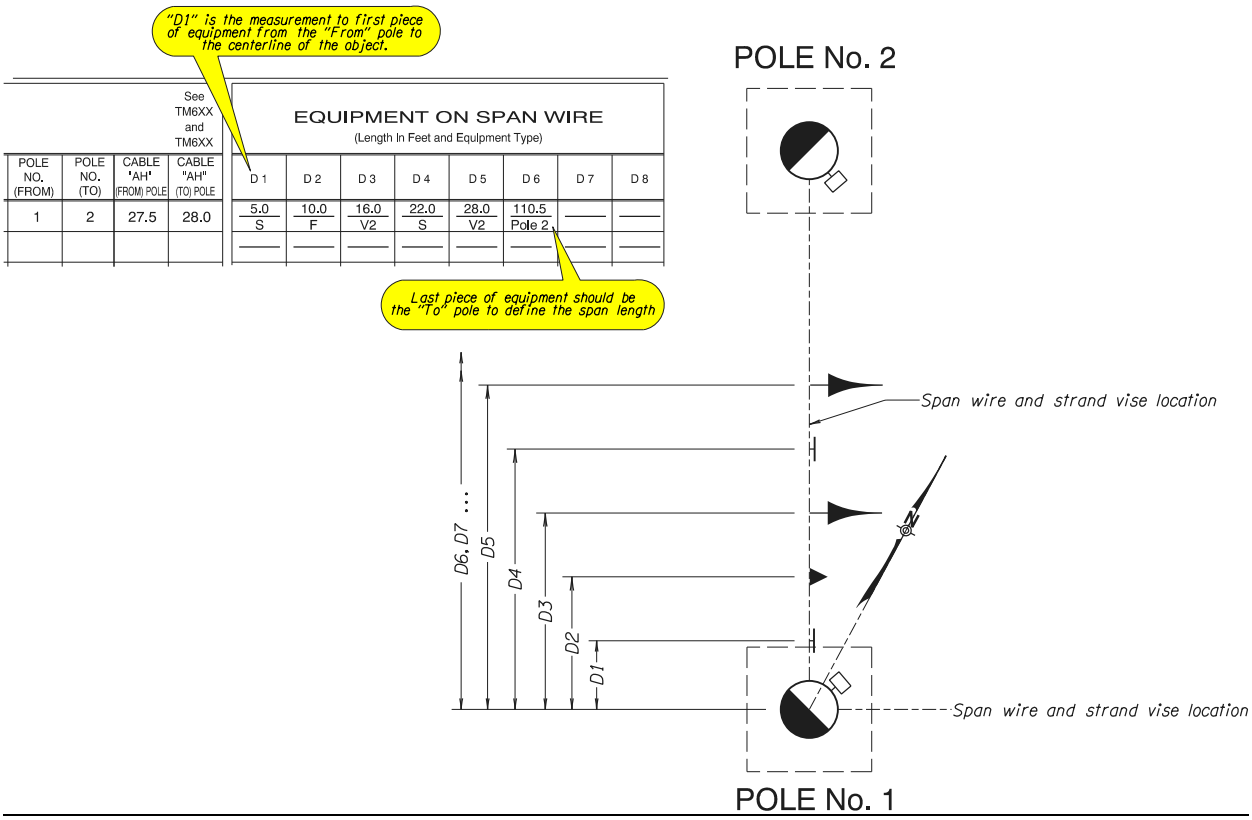
The last 3 columns in the Equipment on Pole (sign deg., traffic signal deg., and photo electric cell) are detailed the same as for a mast arm pole, with the only exception being the origin of degree measurement (strain poles always measure degrees based off of the north arrow). See Section 9.3.2.

9.4.4 Equipment on Span Wire

The equipment on located on the span wire is detailed the same as the equipment located on the mast arm (see Section 9.3.3) with the two following exceptions (see Figure 9-32):

- The origin of measurement is based on the “From” pole
- The “To” pole is listed as the last piece of equipment to define the length of the span

Figure 9-32 | Equipment on Span Wire



9.4.5 Foundation Information

The same information presented for mast arm pole orientation diagram applies to strain poles (See Section 9.3.4).

9.4.6 Luminaires

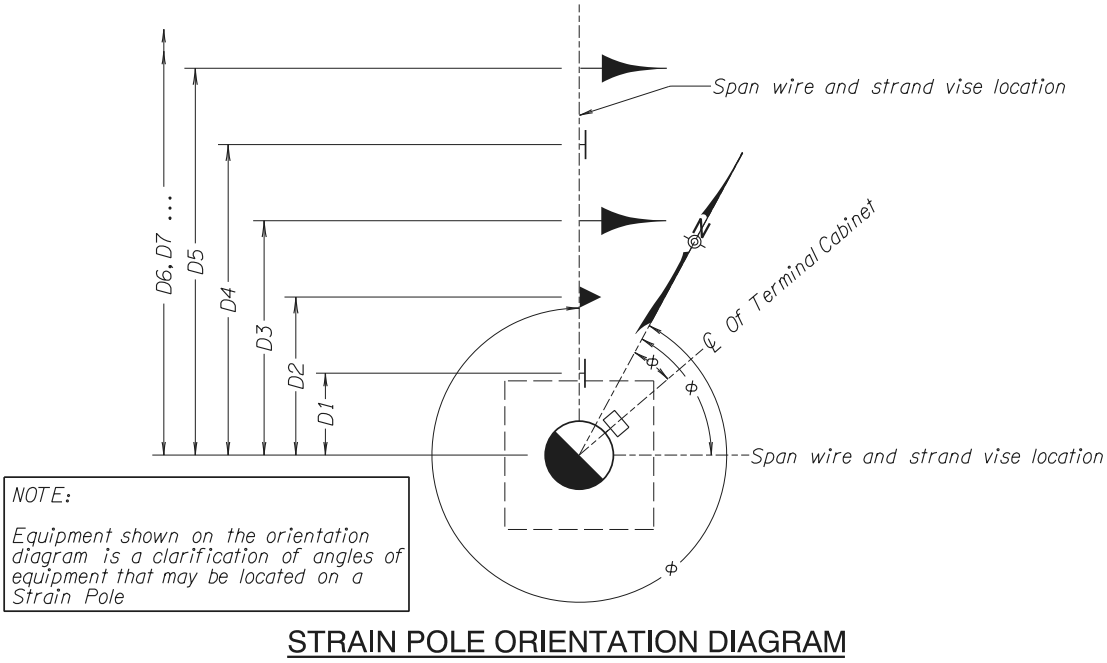
The same information presented in the mast arm pole orientation diagram applies to strain poles (See Section 9.3.5).

9.4.7 Orientation Diagrams

The orientation diagram provides a legend for how to read the information provided by the pole entrance chart.

The orientation diagram that is included with the pole entrance chart for a span wire is shown in Figure 9-33.

Figure 9-33 | Strain Pole Orientation Diagram



9.5 Custom Details Created From Standard Details

Most custom details that will be shown on a details plan sheet will be created from a Standard Detail (See Chapter 17 for more info on Standard Details). A custom detail is needed anytime the standard drawings need to be modified to be applicable to the project or a standard drawing addressing the necessary micro details of installation doesn't exist.

9.5.1 ITS Equipment

If the project has ITS equipment such as, fiber optics or communication gear, there will most likely be a need for a detail plan sheet that shows micro details for these installations (splicing, equipment mounting in the controller cabinet, etc.). See Figure 9-34 through Figure 9-36 for examples of ITS details. Typically, the ITS Designer is responsible for the ITS detail sheets.

Detail sheets that contain ITS information should have dual sheet numbers assigned, a TRS Dwg. Number from the Traffic Standards Section and an ITS Dwg. Number from the ITS Unit.

Figure 9-34 | ITS Fiber Splice Detail Example

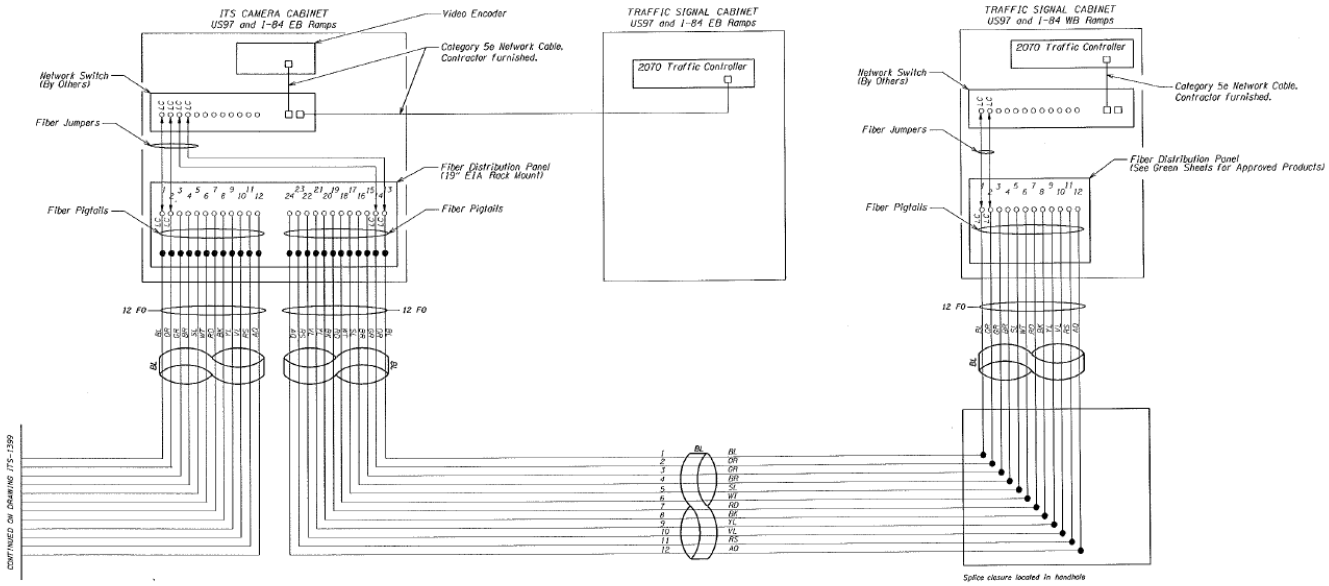


Figure 9-35 | Communication Rack Detail Example

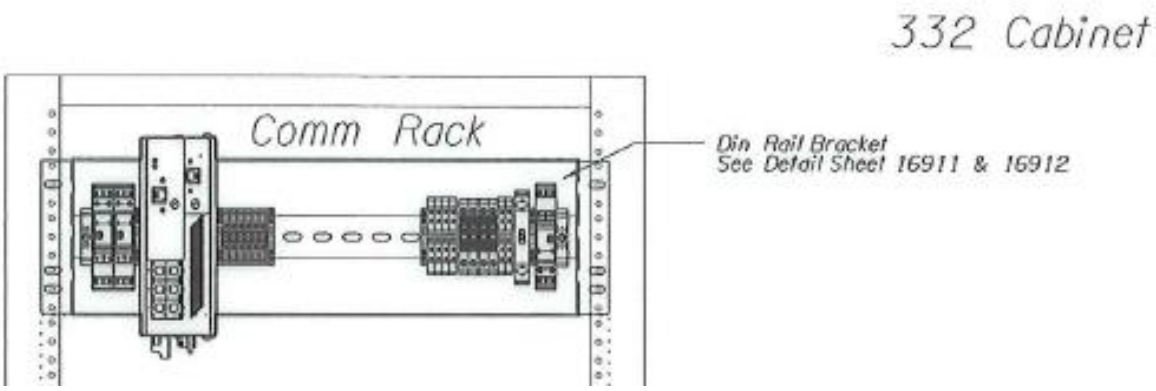
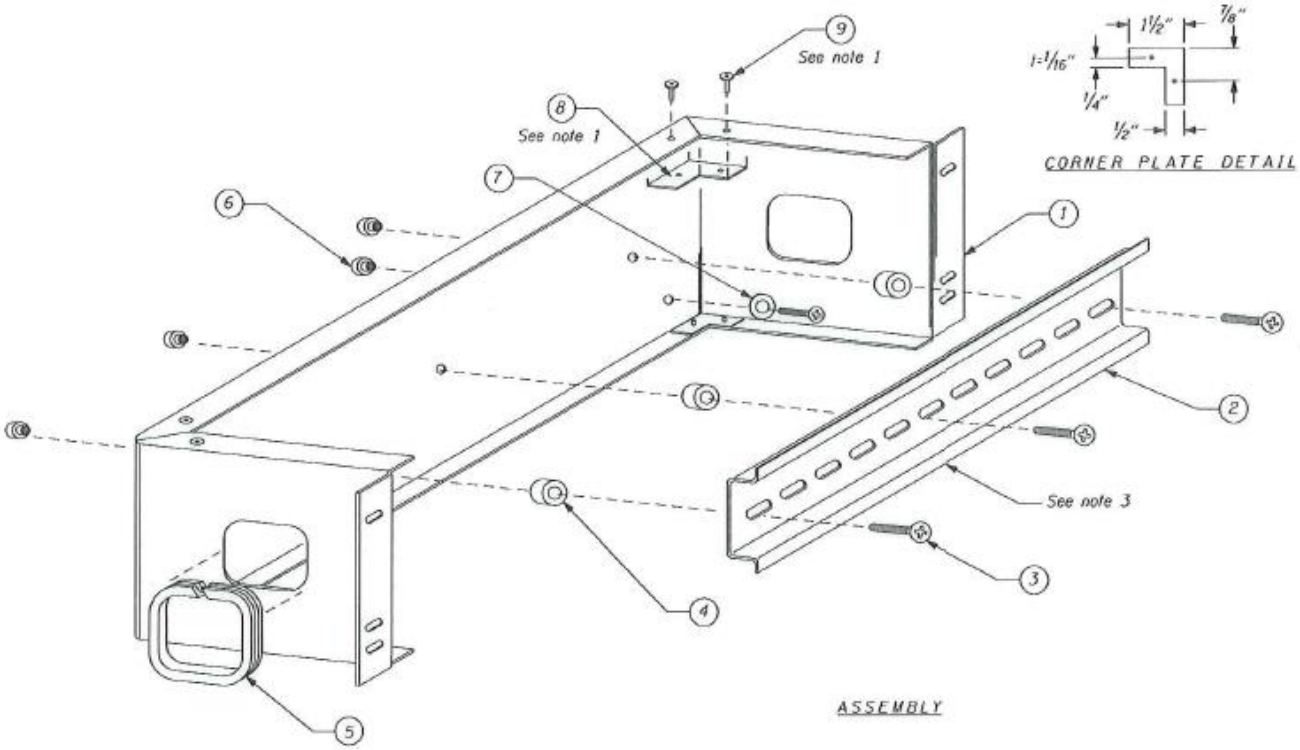


Figure 9-36 | Din Rail Bracket Detail Example



10 REMOVAL PLAN

This chapter will discuss when a removal plan sheet is needed and all the elements that should be shown the plan sheet.

10.1 When is a removal plan sheet needed?

A removal plan sheet is necessary for the following types of work:

- A complete re-build of an existing traffic signal (where all existing equipment is to be replaced by new equipment)
- Replacing an intersection flashing beacon with a traffic signal (where all existing equipment must be removed)
- Removal of any signal poles

A removal plan is recommend for any other type of removal work that **cannot clearly** be shown on the primary plan sheet or within the special provisions section 00950.02.

A removal plan is NOT required for temporary signal plans; standard specification 00225.45(a)(1) directs the contract how and when to remove the temporary signal, as well as what equipment is property of the contractor.

10.2 Equipment Salvaging and Stockpiling

Unless otherwise specified, all equipment/material that is removed becomes property of the contractor at the place of origin by standard specification. The contractor can then reuse, recycle, or dispose of the equipment/material. However, certain signal equipment may be desirable for the owner of the existing traffic signal to salvage. Typical salvaged equipment includes:

- the signal controller cabinet (includes all components within)
- signal heads and signal poles (which can be reused for future maintenance if they are in decent condition)
- Any special equipment, such as external communication gear, video detection cameras, etc.

The Region Electrical Crew will provide direction on the which removed appurtenances, if any, should be salvaged, the location to stockpile, and their contact information. This information is contained within the special provisions section 00950.42 (removal of the item is shown on the plan sheet, salvage information related to the item is shown in the special provisions). In addition, when salvaging materials, a “public interest finding letter” must be on file.

10.3 Abandoning Equipment

The removal plan should show any equipment that is to be abandoned. Abandoning equipment should only be considered if both of the following conditions are met:

- The process of removal would require extensive repair or replacement of nearby facilities that would otherwise be unharmed (e.g. removal of loop wires from the pavement would require repair of the pavement).
- The equipment can be abandoned without causing confusion or problems in the future (e.g. the deep signal pole foundation is abandoned 2' below grade which makes it clear it is no longer in use with the likelihood of encountering a problem on a future project or during a maintenance activity being low).

There are only a few signal appurtenances that meet these requirements:

- Conduit located underground (However, if extensive earth/roadway work will be done in the locations of the conduit to be abandoned, the conduit should be removed instead)
- loop detectors
- Foundations may be abandoned (below grade), but removal is preferred

All other signal equipment should always be removed, NEVER abandoned (e.g. Junction boxes, wiring, cabinets, etc.).

10.4 Removing Equipment

Depending on the type of work being done on the project, certain appurtenances should always be removed (not abandoned).

- Wiring in conduit
- Junction boxes
- Cabinets

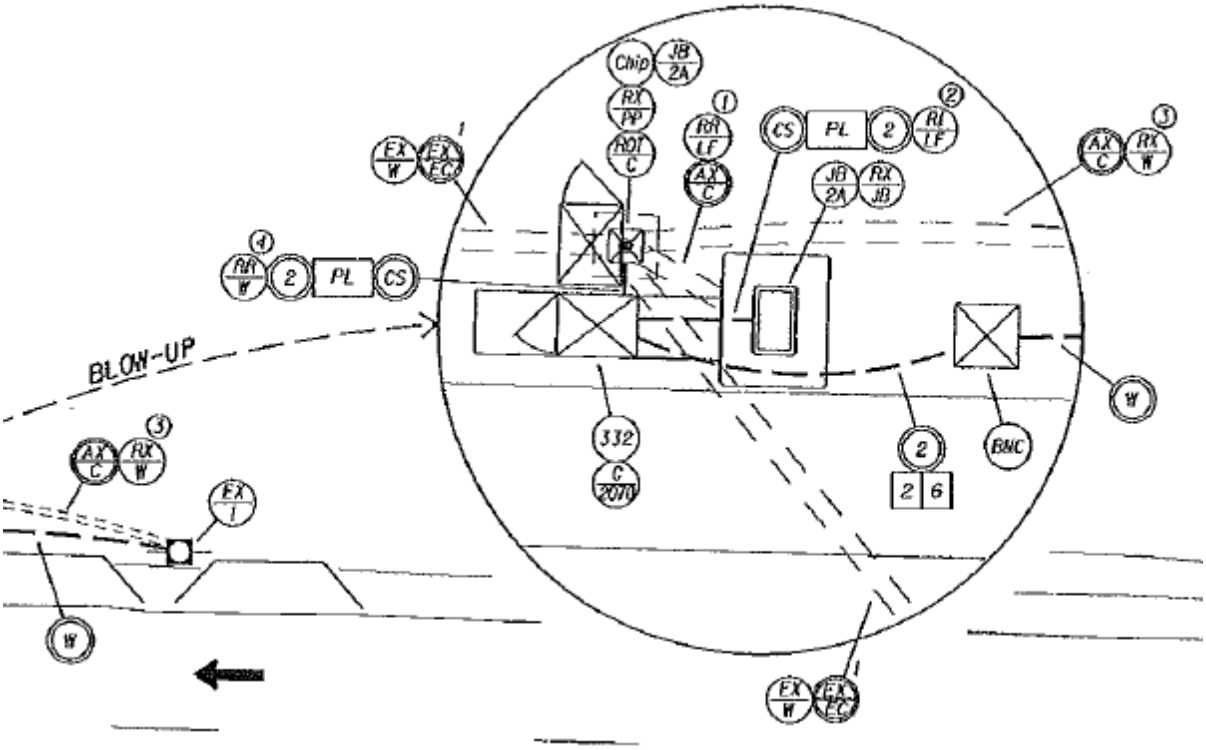
10.5 Removing and Relocating Equipment

The Region Electrical Crew should provide direction on which signal appurtenances may be relocated, as they have the most up-to-date information on the condition and remaining time-of-service of the equipment. Only equipment that is good condition and meets current standards should be considered for relocation. When in doubt, always remove and install new.

The removal plan should show any equipment that is to be removed and relocated. The removal plan should NOT show where the equipment is to be reinstalled; this information should be shown on the primary signal plan sheet. In some cases it will be obvious where the removed item will be relocated just using the standard bubble note designations. In other cases it might not be so clear. For example, a lot of the same type of items are to be removed and re-installed (vehicle signal heads) with some to be reinstalled at other intersection or only certain wiring is to be removed and relocated up to a certain JB and reinstalled into another

conduit. In these cases, adding some custom general notes that correspond to the appropriate remove & relocate and reinstall bubble notes is advised.

Figure 10-1 | Remove and Relocate Equipment with Custom General Notes



GENERAL NOTES

Construction notes shown as ① or ② pertain to this sheet only.

① Pull out existing loop feeder cables from existing controller to junction box.

② Reinstall loop feeder cables to new controller.

③ Coordinate with Power Company for wire removal.

④ Remove existing wiring from existing controller and reinstall wiring to new controller.

10.6 When a Removal Plan Sheet is Required

The following examples show extensive removal and thus require as separate removal plan sheet to clearly show the work to be done.

Figure 10-2 | Removal Plan Sheet Example 1

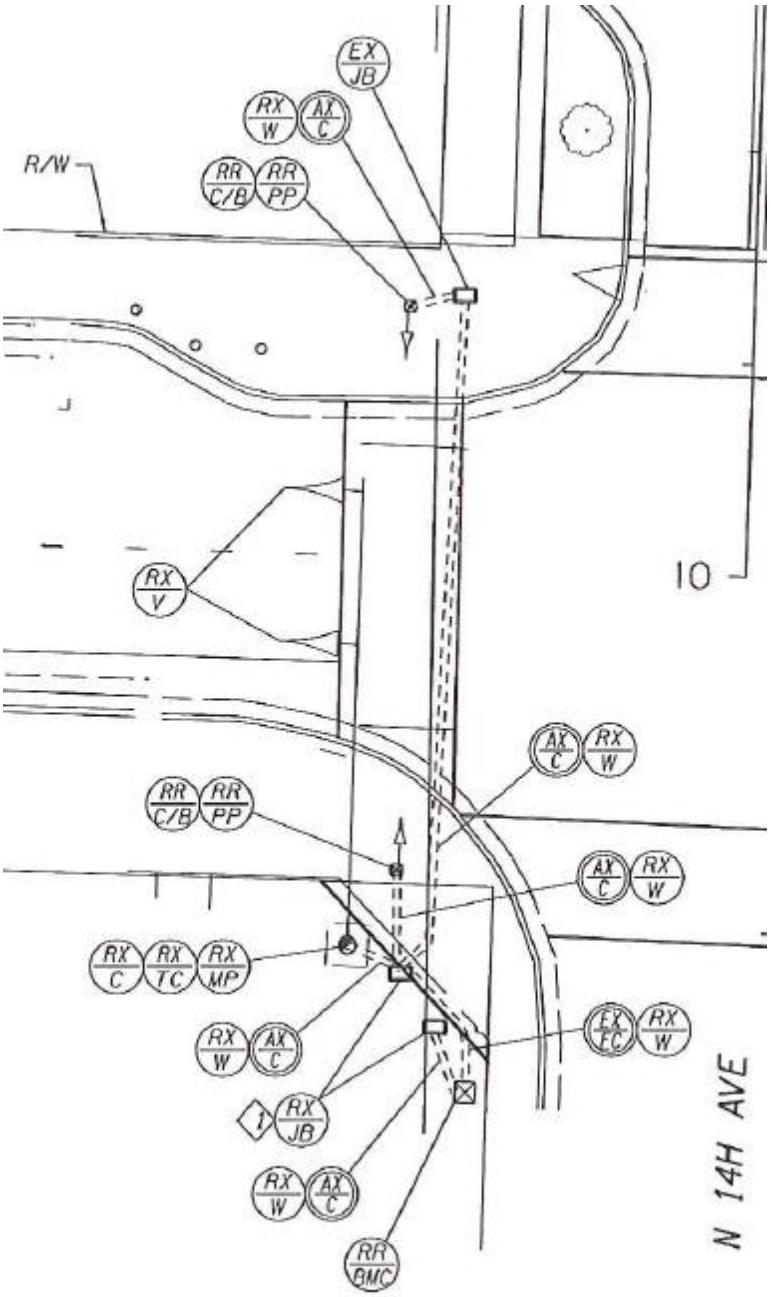
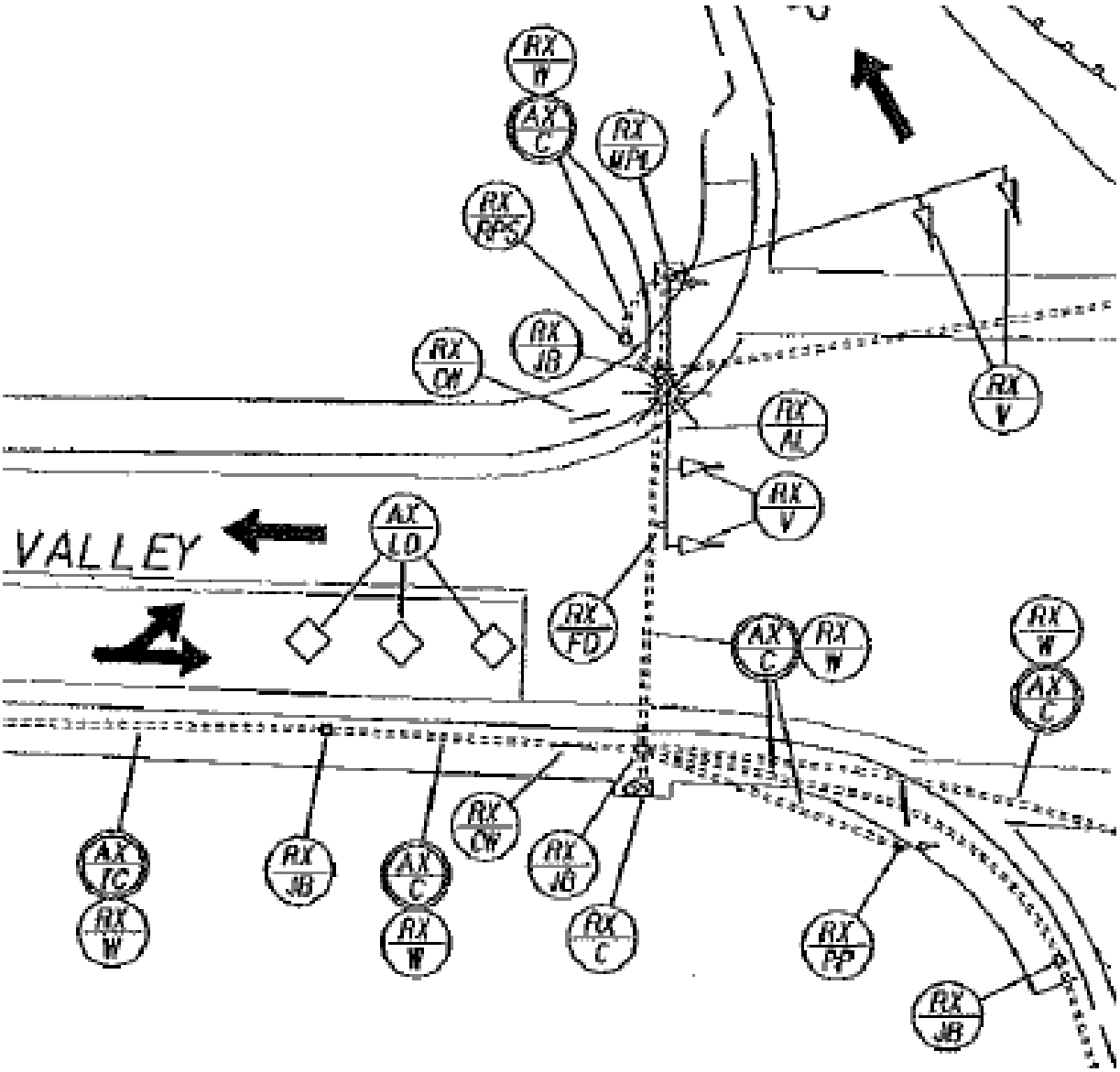


Figure 10-3 | Removal Plan Sheet Example 2



10.7 When a Removal Plan Sheet is NOT Required

In some cases removal of items can clearly and easily be shown on the primary signal plans sheet (e.g. signal plan sheet, detector plan sheet, interconnect plan sheet, etc.). If this is the case, a separate removal plan sheet is not recommended.

Figure 10-4 | Removal Notes Shown on a Primary Signal Plan Sheet Example 1

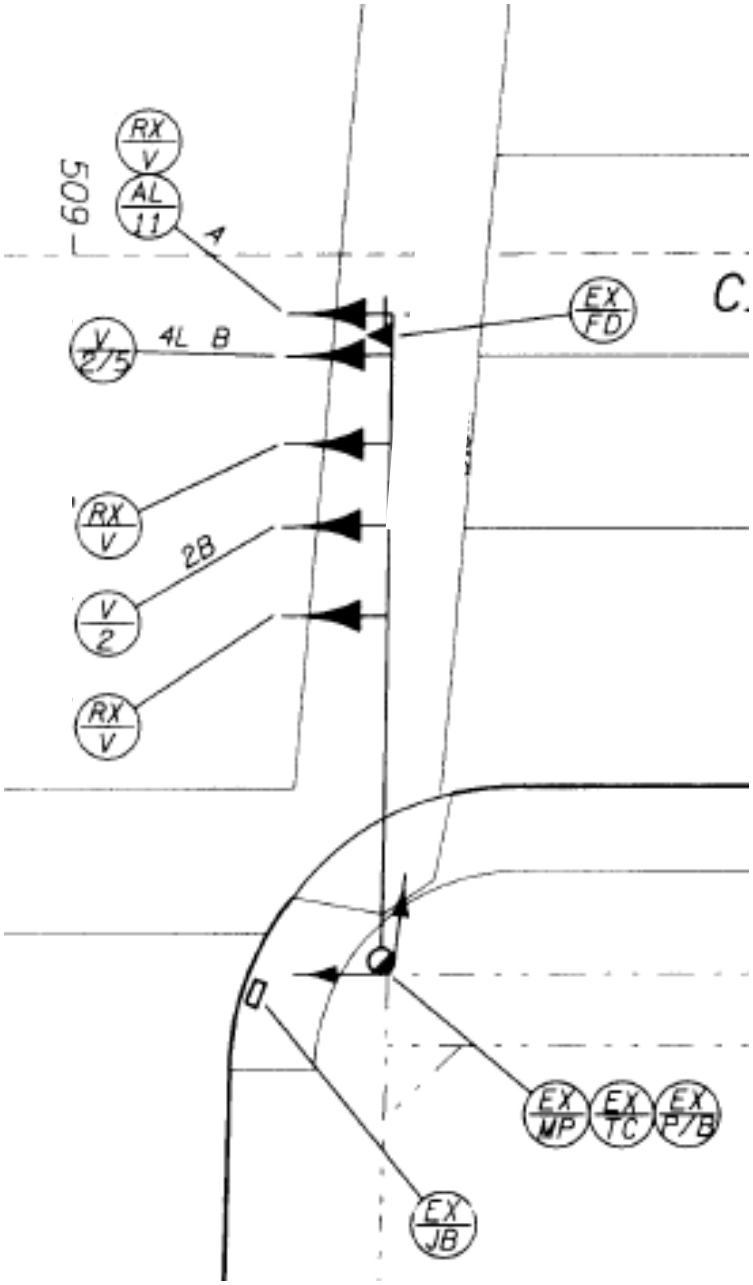


Figure 10-5 | Removal Notes Shown on a Primary Signal Plan Sheet Example 2

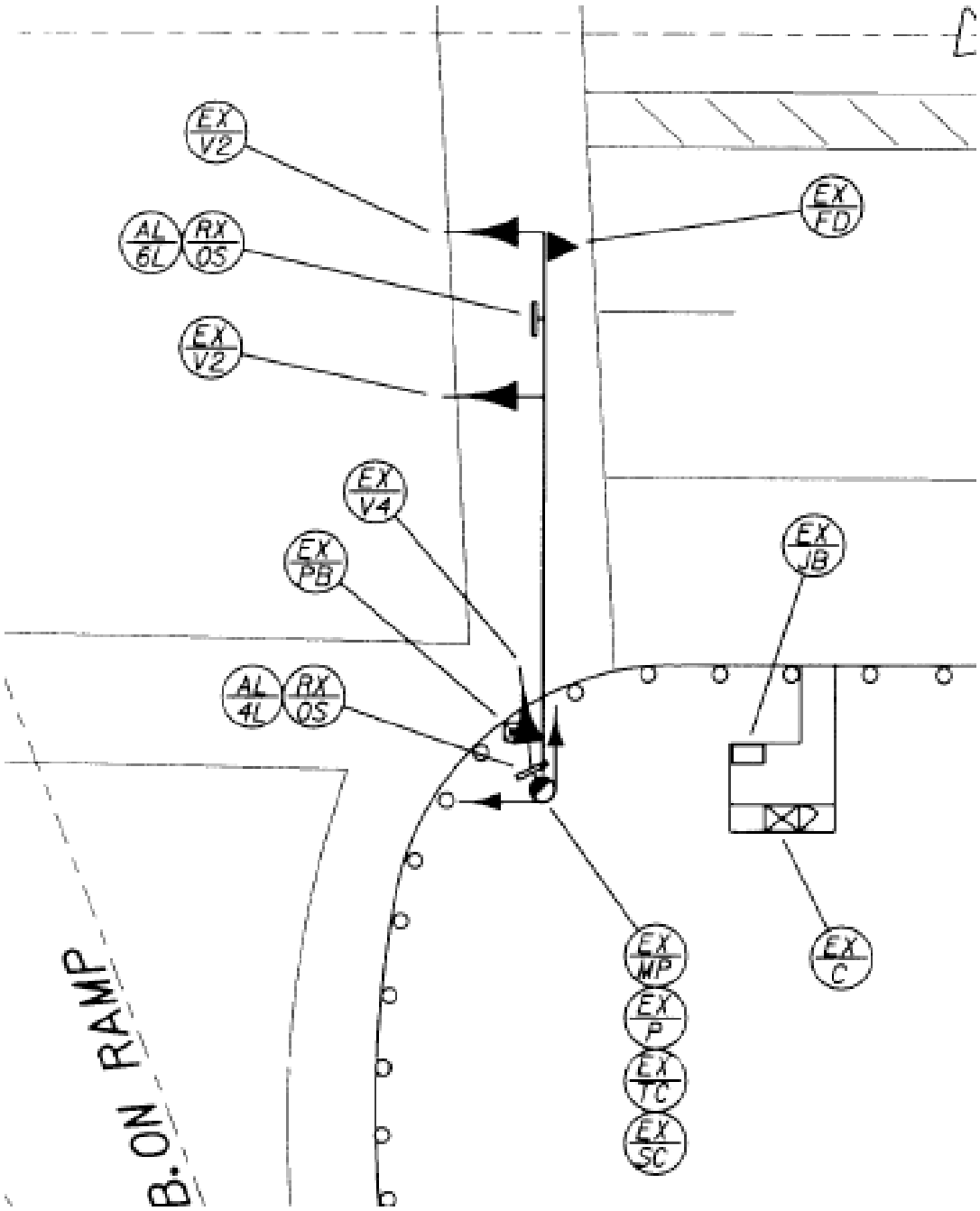
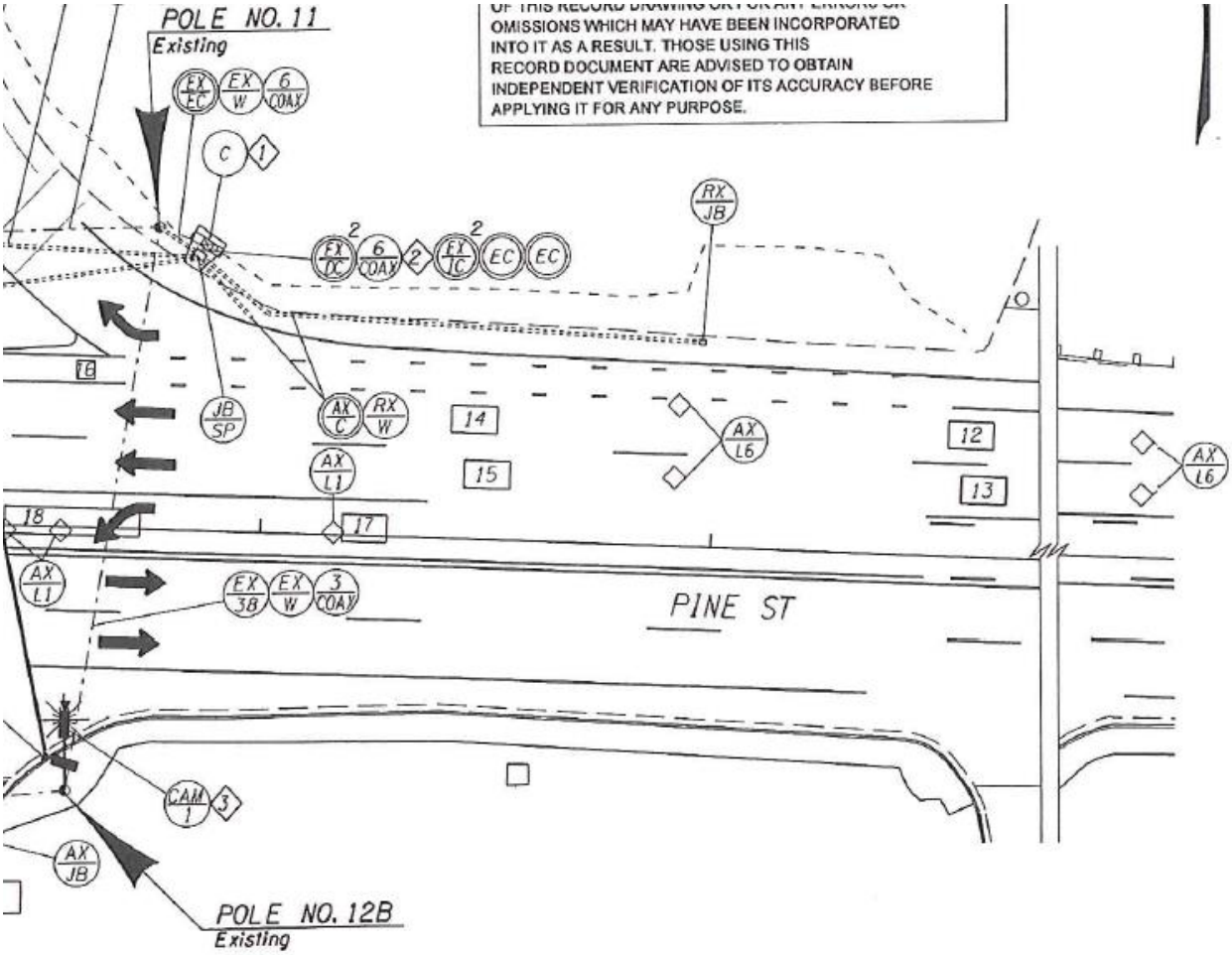


Figure 10-6 | Removal Notes Shown on a Primary Signal Plan Sheet Example 3



11 TEMPORARY SIGNAL PLAN

11.1 General

Temporary signals are intended to be used for long-term stationary temporary traffic control zones, yet their appearance, design and operation are held to the same standards as permanent signals. Motorists expect the same meaning and security from temporary traffic signals as they do from permanent traffic signals, so the signal design and operation shall meet all applicable MUTCD and ODOT standards. The design procedure for a temporary signal shall follow the same standards and guidelines that would be used for a permanent signal.

The ODOT Traffic Control Plans Design Manual, Section 2.6 should be consulted for additional information on the use of temporary traffic signals.

11.2 When is a Temporary Signal Needed?

There are two typical design categories that most temporary signals will fit into; temporary bridge signals and temporary signals for modification or replacement of an existing signal.

Temporary signals are required in the following circumstances:

- For construction staging that requires one-lane, two-way traffic AND where use of 24/7 flagging would be cost prohibitive. Either a standard Temporary Bridge Signal or a Portable Temporary Traffic Signal could be used for this application.

- When the new signal can't be built without impacting the existing signal.

- When re-building an existing signal that requires staged construction (where lane use and/or signal phasing will be modified based on each stage)

- When the temporary re-alignment or modification of the signal heads at an existing signal is needed to accommodate traffic during construction of a project in the vicinity of the traffic signal.

- When adjustment to the existing pushbutton locations is required to accommodate Temporary Pedestrian Accessibility Routing (TPAR)

In some cases, re-building an existing signal can be accomplished without a temporary signal if the existing intersection geometry doesn't change (or changes very little) and placement of the new signal equipment is carefully considered. If possible, place the new poles behind the existing poles so that construction of the new mast arm does not block the existing signal heads. See Figure 11-1 for examples of signal heads being obstructed during construction. If a new signal pole must be placed in front of an existing signal pole, there is an opportunity to save the expense of a temporary signal by requiring that the new mast arm be installed on the day of the signal turn-on. However, to allow for an efficient and successful signal turn-on, only one signal mast arm per intersection may be allowed to be installed at the day of turn on. See Figure 11-2.

Figure 11-1 | Obstructing Signal Heads During Construction

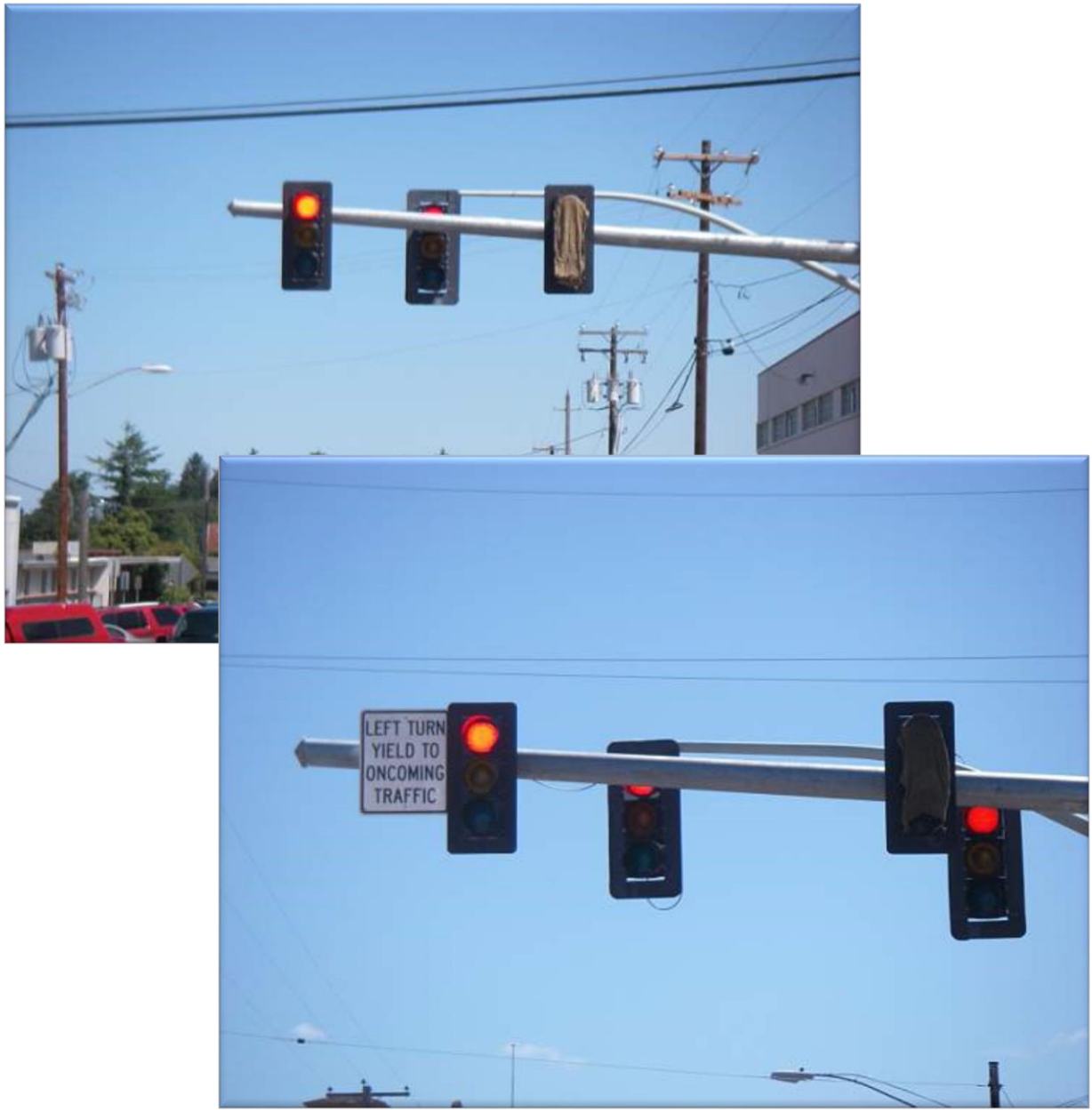
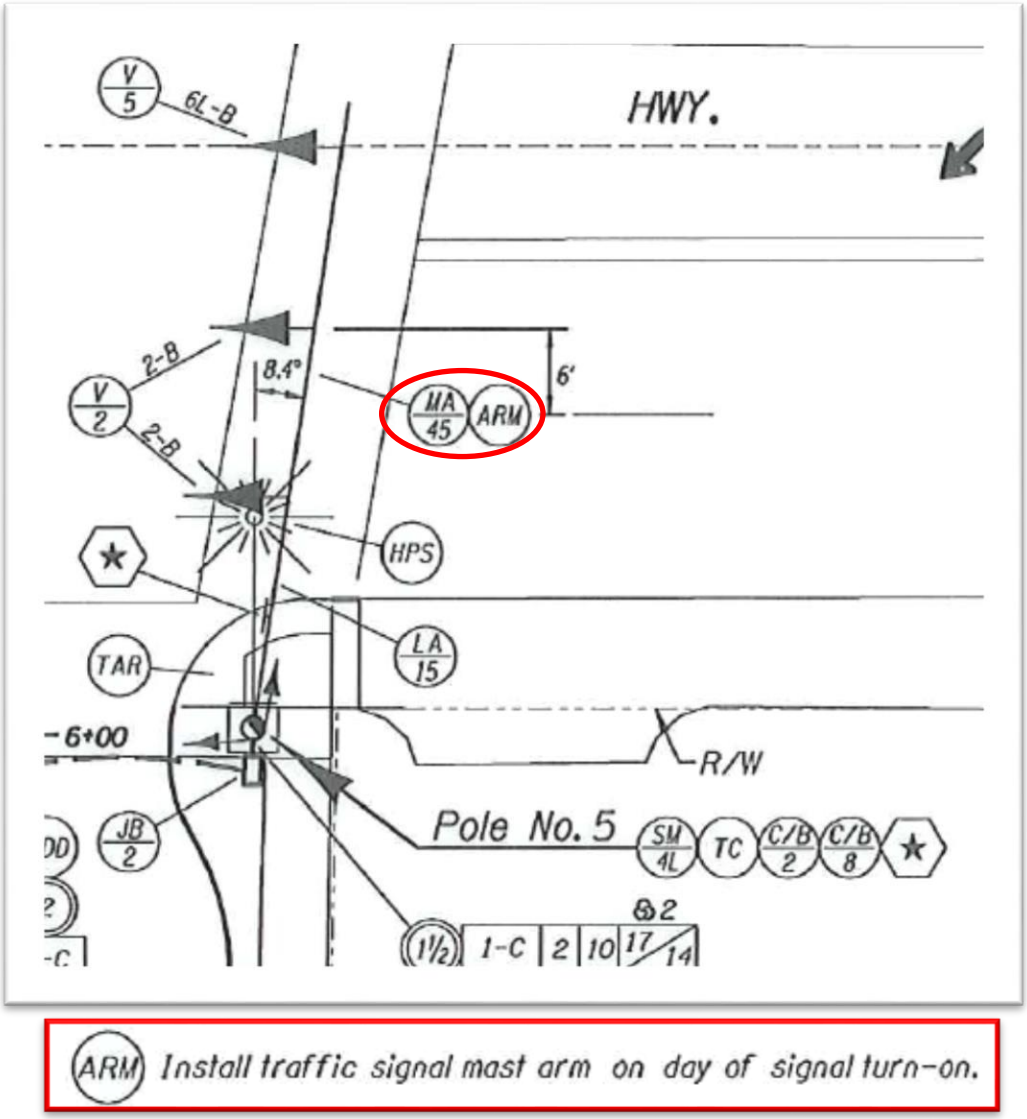


Figure 11-2 | Installing Mast Arm the Day of Signal Turn-On



11.3 Operational Approval of Temporary Signals

The following temporary traffic signal applications require STRE Operational Approval (see Chapter 3 for more information on Operational Approval):

- Temporary Portable Signals
- Temporary Bridge Signals (i.e. one-lane, two-way operation)
- Temporary signals located at intersections that are not currently under signalized control (e.g. detours that require re-routing large volumes of traffic to existing un-signalized intersections)
- Temporary closure of crosswalks at signalized intersections

Temporary signals installed at the same location with the same operations that mimic an existing signal or mimic the proposed STRE approved new signal do NOT require STRE or RTE approval.

The following temporary traffic signal application requires RTE Operational Approval (see Chapter 3 for more information on Operational Approval):

- Stage construction that is <u>significantly</u> different (geometry, lane use, and/or operation) than the existing traffic signal or the approved new traffic signal.

The one grey area concerning operational approvals for temporary traffic signals is determining if the geometry and operation is significantly different from the existing or approved signal operations. The main reasons for requiring an operational approval for a temporary signal needed for stage construction is to determine if the operation is safe, meets driver expectation, and will not be detrimental to maintaining traffic flow.

If the temporary signal operational/geometric changes are minor and incrementally made over the course of construction, additional operational analysis beyond what is required for the permanent signal is typically not needed to ensure the temporary signal staging is appropriate. See Figure 11-3. This case study shows a project going from existing conditions to the permanent signal installation and the temporary traffic signals (for each stage) do NOT require an operational approval.

However, significantly different operations or geometry (especially if the signal will be operating in a coordinated system) typically require a more in-depth analysis to ensure that temporary signal will operate appropriately. See Figure 11-4. This case study shows a project going from existing conditions to permanent signal installation where three of the temporary traffic control stages result in significant lane use and/or operational changes that do require

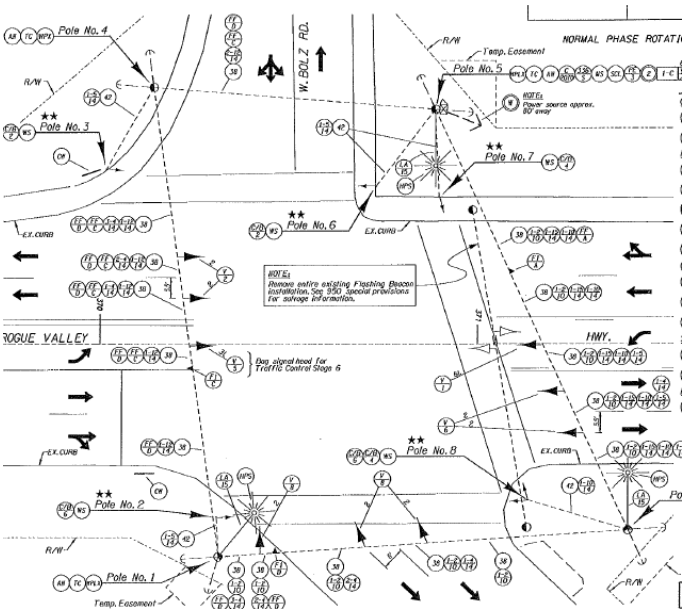
additional operational approval(s) for the temporary staging. The types of changes shown require an RTE Operational Approval.

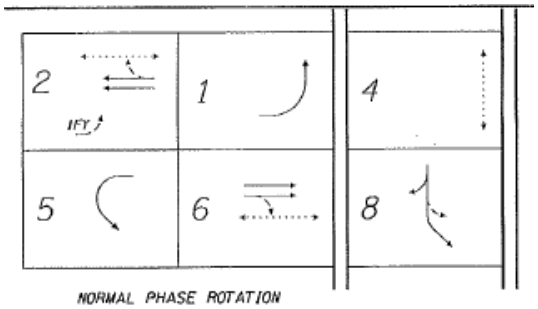
If there is a question as to whether a temporary traffic signal requires an operational approval, contact the ODOT Traffic Signal Operations Engineer. When in doubt, err on the side of caution and request an STRE Operational Approval.

Figure 11-3 | Case Study 1 – Operational Approval NOT Required for Temporary Signal Staging

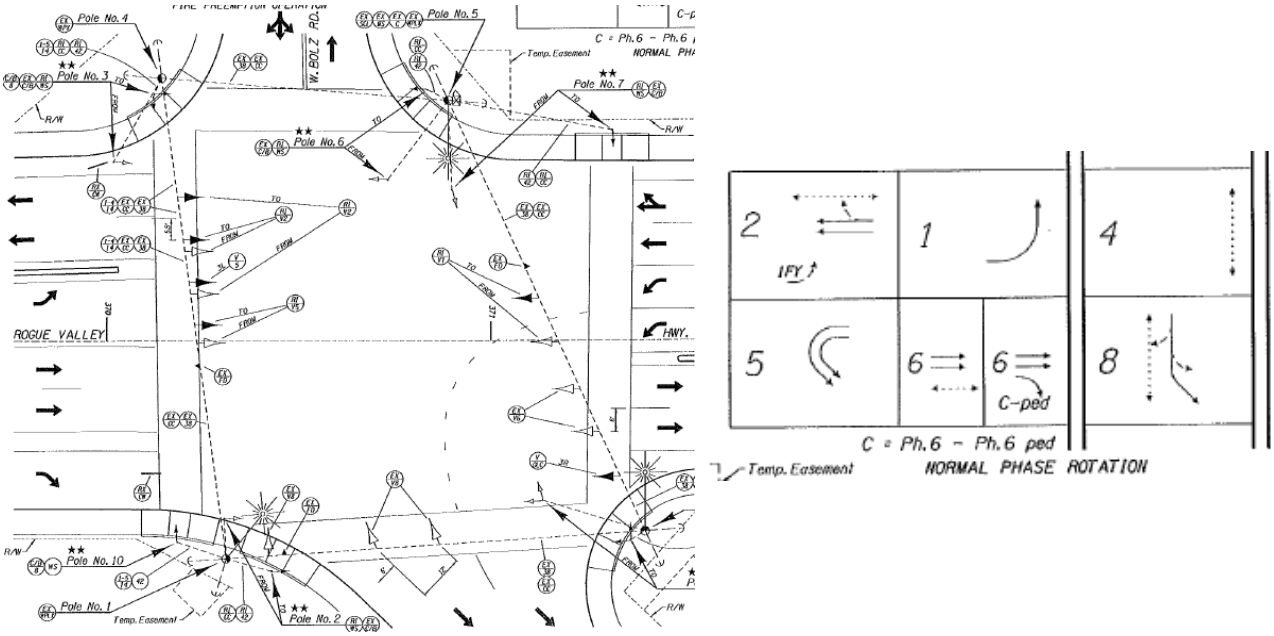
Existing conditions: The existing lane use is a 5-lane section on the main-line, with a right turn only from the top approach and one-way on the bottom approach. Three crosswalks are currently marked. The existing intersection operates as stop control on the side-street and free-flow on the mainline. This intersection has an STRE Operational Approval for a new, permanent traffic signal.

Stage 3: The existing lane use on the top approach has changed from a right turn only to a right-thru-left turn lane, matching the STRE approved permanent lane configuration for that approach. The existing marked crosswalks remain the same. The existing intersection operation has changed from stop control to signalized, with the signal phasing very closely matching the STRE approved operation.





Stage 7: The lane use from stage 3 has changed from a thru-right lane to the addition of right turn only lane on the left approach and from a single left turn lane to a dual left turn lane on the right approach, matching the STRE approved permanent lane configuration. All four crosswalks are now open. The operation from stage 3 has changed to allow a not-ped overlap phase for the new right turn only lane, matching the STRE approved permanent signal operation.



Permanent Traffic Signal: STRE approved permanent signal design and operation.

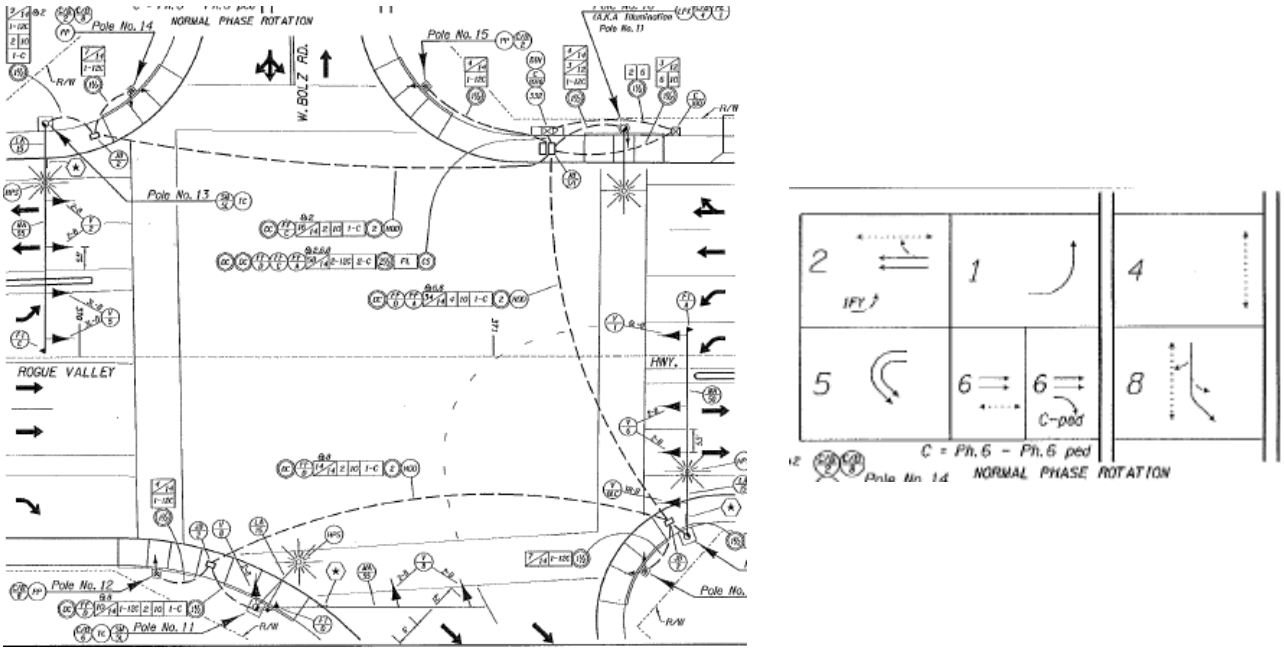
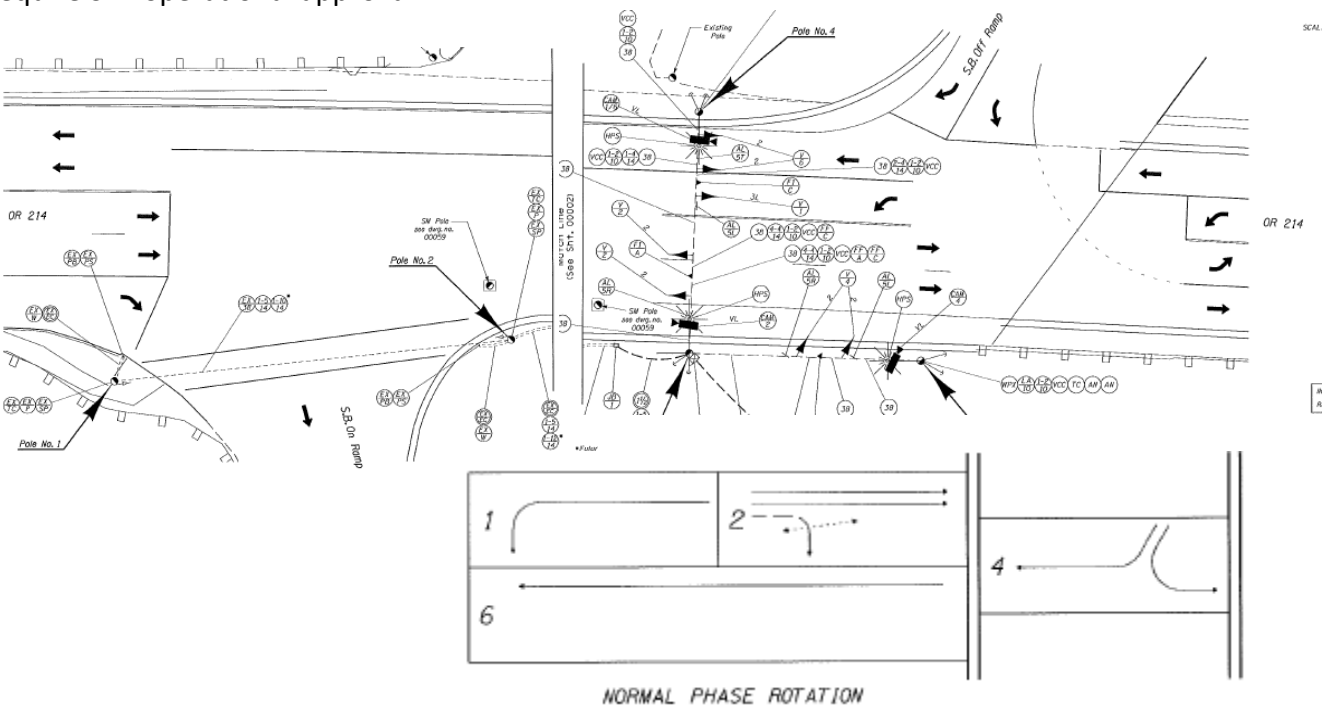


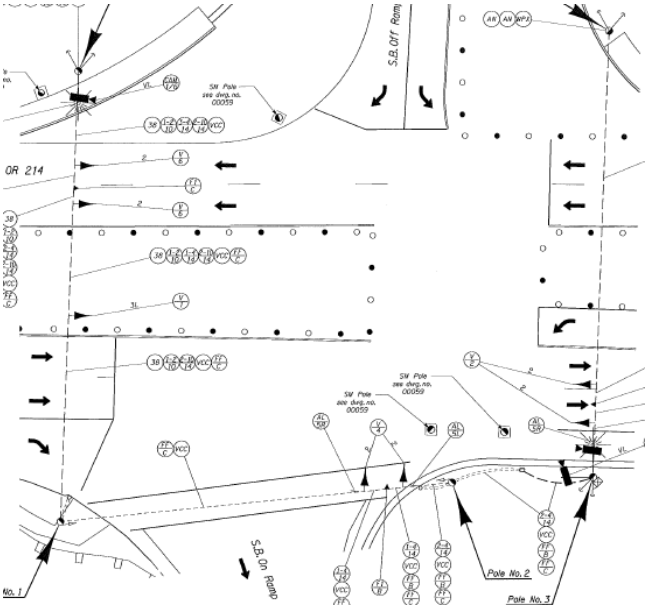
Figure 11-4 | Case Study 2 – Operational Approval Required for Temporary Signal Staging

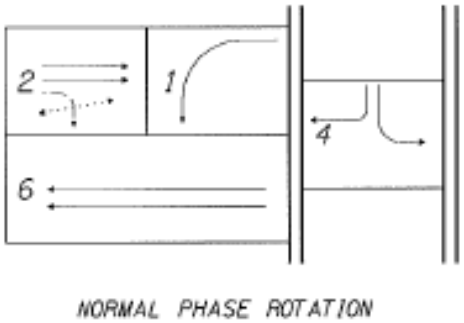
Existing conditions: The existing lane use is a 4-lane section on the main-line. The top approach is a freeway off-ramp and the bottom approach is a freeway on-ramp. Three crosswalks are currently marked. The existing intersection operates with PPLT phasing on the highway. This intersection has an STRE Operational Approval for a new, permanent traffic signal.

Stage 1, Phase 2 (RTE Operational Approval Required): The existing intersection geometry has significantly changed, with the top approach moving towards the right almost creating two separate intersections. Two of the existing crosswalks are now closed. This new geometry will require more red clearance time to clear vehicles. Because the geometry and operation of this intersection is significantly different from the existing and STRE approved permanent traffic geometry, this stage requires RTE approval. Note that the temporary crosswalk closures require STE operational approval.

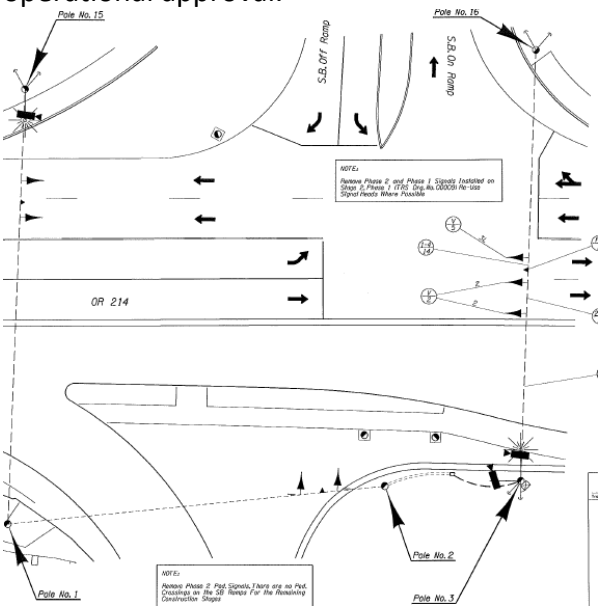


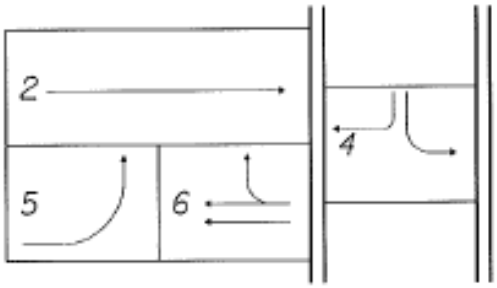
<u>Stage 2, Phase 1 (RTE Operational Approval NOT required):</u> The lane use from Stage 1, Phase 1 has shifted the top approach alignment back much closer to the original existing location. The crosswalk closures remain the same. Operation changes from the previous stage are minimal. This stage does NOT require RTE approval due to similarities of the existing conditions and previous stage RTE approval.





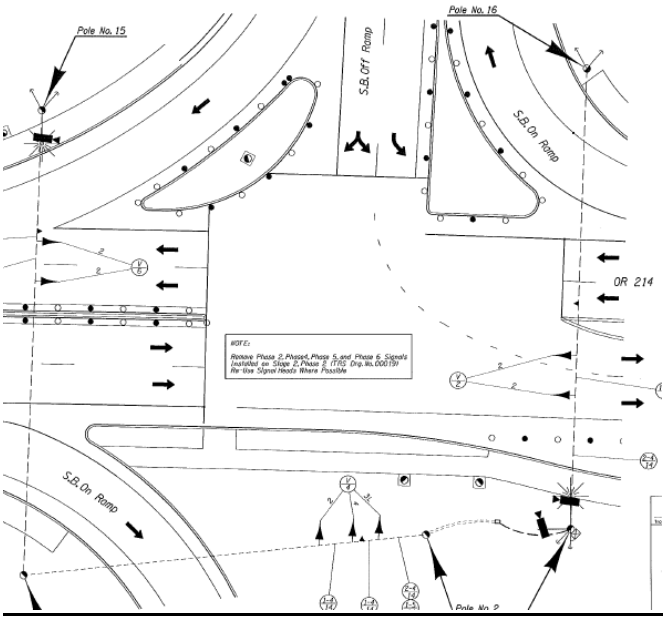
<u>Stage 2, Phase 2 (RTE Operational Approval Required):</u> The lane use from Stage 2, Phase 1 has changed significantly, with the top approach now containing the on-ramp for the freeway. All four crosswalks are now closed. Operation changes from the previous stage are significantly different and do not match the STRE approved permanent traffic geometry/operations. This stage requires RTE approval. Note that the temporary crosswalk closure here requires STE operational approval.

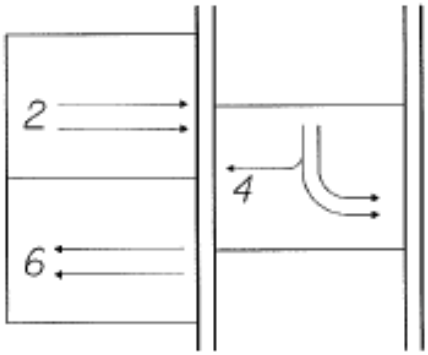




Stage 3, phase 1 (RTE Operational Approval Required)

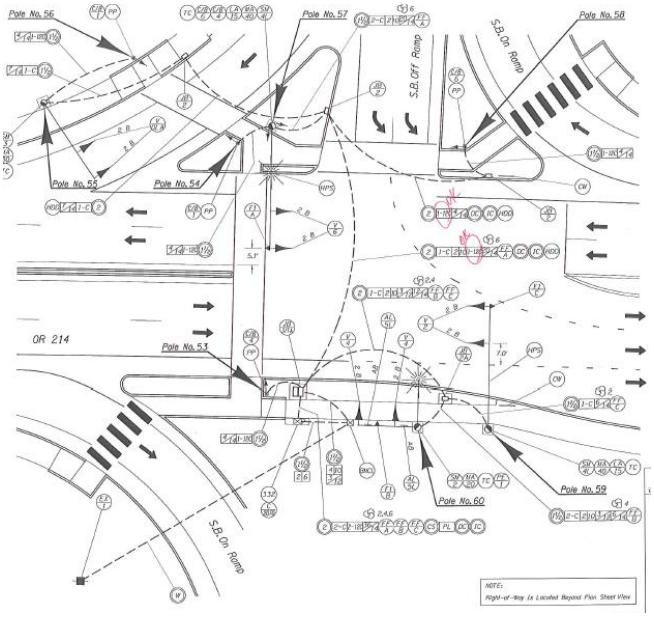
The lane use from Stage 2, Phase 2 has now changed to closely match the STRE approved permanent geometry. However, the unusual lane use for the top approach (where the right turn movement is divided – one is free flow and one is controlled by the signal in a left-right lane) warrants documentation. All four crosswalks remain closed. Operation changes from previous stage are significantly different and now closely match the STRE approved permanent operations (minus the top approach right turn overlap and pedestrian phases). This stage requires RTE approval.

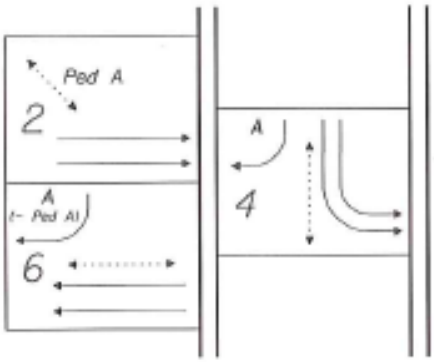




NORMAL PHASE ROTATION

Permanent Signal: STRE approved permanent signal design and operation.





NORMAL PHASE ROTATION

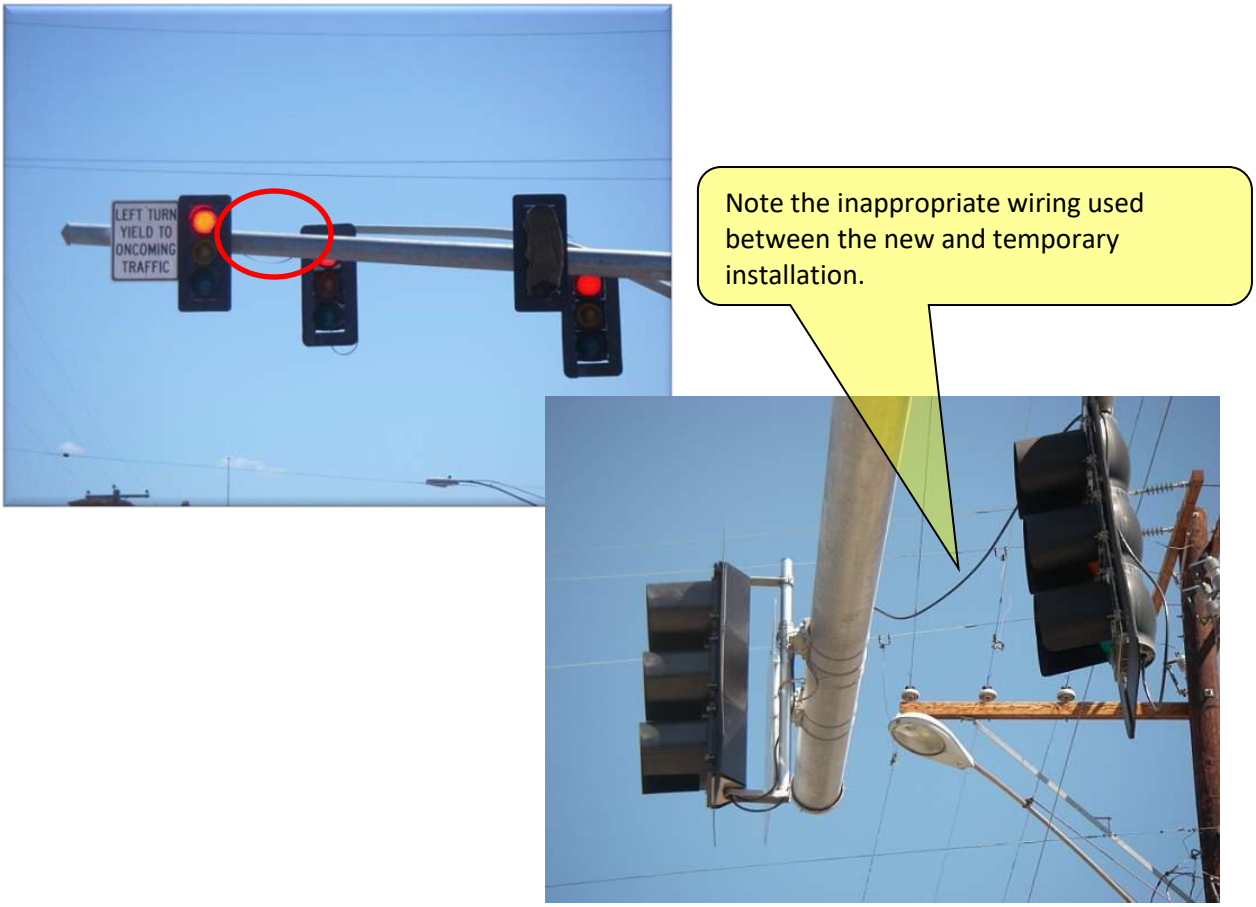
11.4 Design Approval of Temporary Signals

All temporary traffic signals, **except** Temporary Portable Signals, require Design Approval (See Chapter 2 for more information on Design Approval).

11.5 Using Existing or New Signal Equipment as Part of the Temp. Installation

The practice of using existing or new signal equipment as part of a temporary signal is not allowed, as it complicates the contract administration of project (payment issues), the responsible party for maintaining/power costs of the equipment becomes confusing (per specifications, maintenance of temporary installations is the responsibility of the contractor, maintenance of the permanent signal after turn-on is the responsibility of the agency), and equipment most likely will have to modified or wired in a non-standard way to incorporate the permanent or existing equipment into the temporary installation. There is also more potential for damage to the new equipment. See Figure 11-5 showing an example of improper use of new equipment for a temporary installation.

Figure 11-5 | Improper use of new equipment for a temporary installation



Do NOT mix existing or new signal equipment with temporary signal installations (including conduit, junction boxes, and wiring).

11.6 Temporary Signal Design

Temporary signal design should follow the same design guidelines that are contained in the permanent signal design chapters of this manual. This section discusses design information specific to temporary signals including deviations from permanent design (e.g. use of different materials/equipment).

11.6.1 Poles

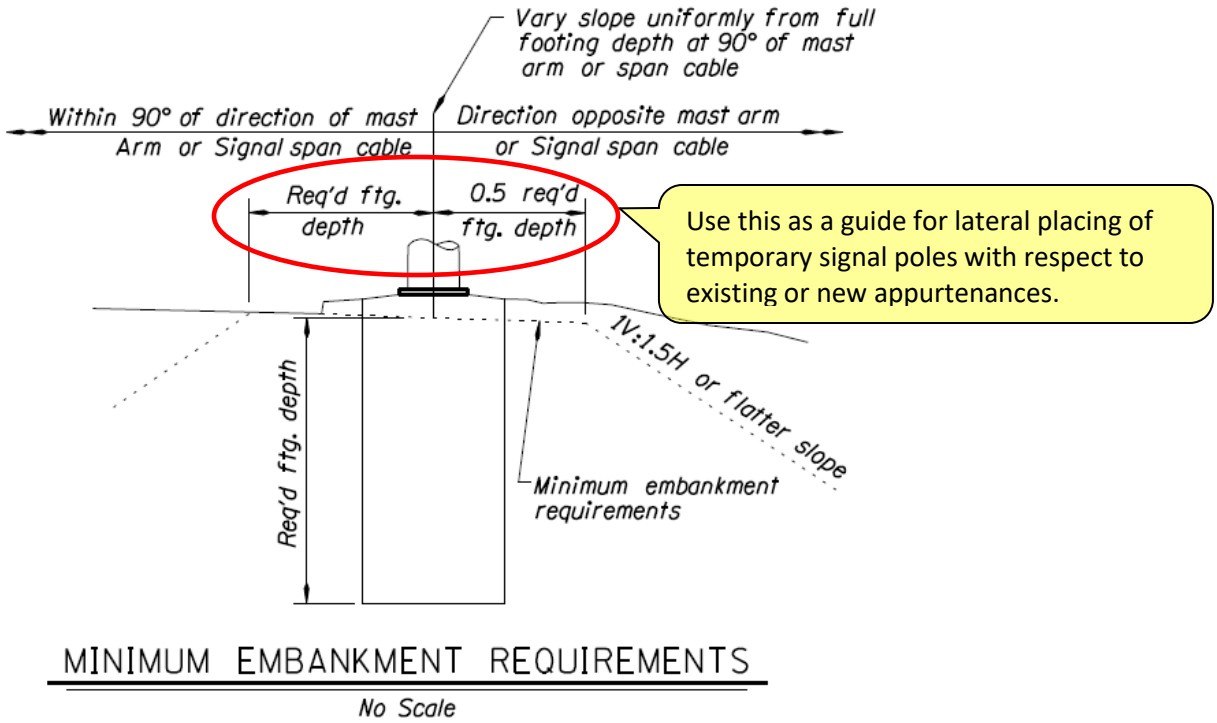
Wood poles with span wire are used for all temporary installations as per standard specification section 00225.15. Wood poles are considered non-standard (otherwise known as "X" poles, due to the drafting bubble note nomenclature used to define a non-standard pole). It is the contractor's responsibility to submit the wood pole certifications to ODOT's Traffic Structures Engineer for review before construction begins.

A span wire pole entrance chart is required to detail all temporary signal poles. See Chapter 9 for more information on the pole entrance chart. The only column in the pole entrance chart that doesn't apply to wood poles is the "Foundation Information" column (this column can be deleted or left blank). All other columns should be filled out as applicable to temporary signal design.

Temporary signals will require modeling of the signal pole, span wires and signal heads that are proposed to pass over the roadway cross section to determine the messenger cable attachment height (MAH) value. See Chapter 9 for how to calculate the MAH, with the following exception: temporary poles only need to consider the tallest piece of equipment that will be used on the span wire (as opposed to the standard Type 5 signal head that is to be used in permanent span wire calculations). Cross sections shall be cut and used to design all temporary signal installations. Particular attention shall be given to all cross section areas that have poles and signal heads in the adjacent area. The bottom of the signal heads must not be below 18 feet or above 19 feet during any phase or stage of construction.

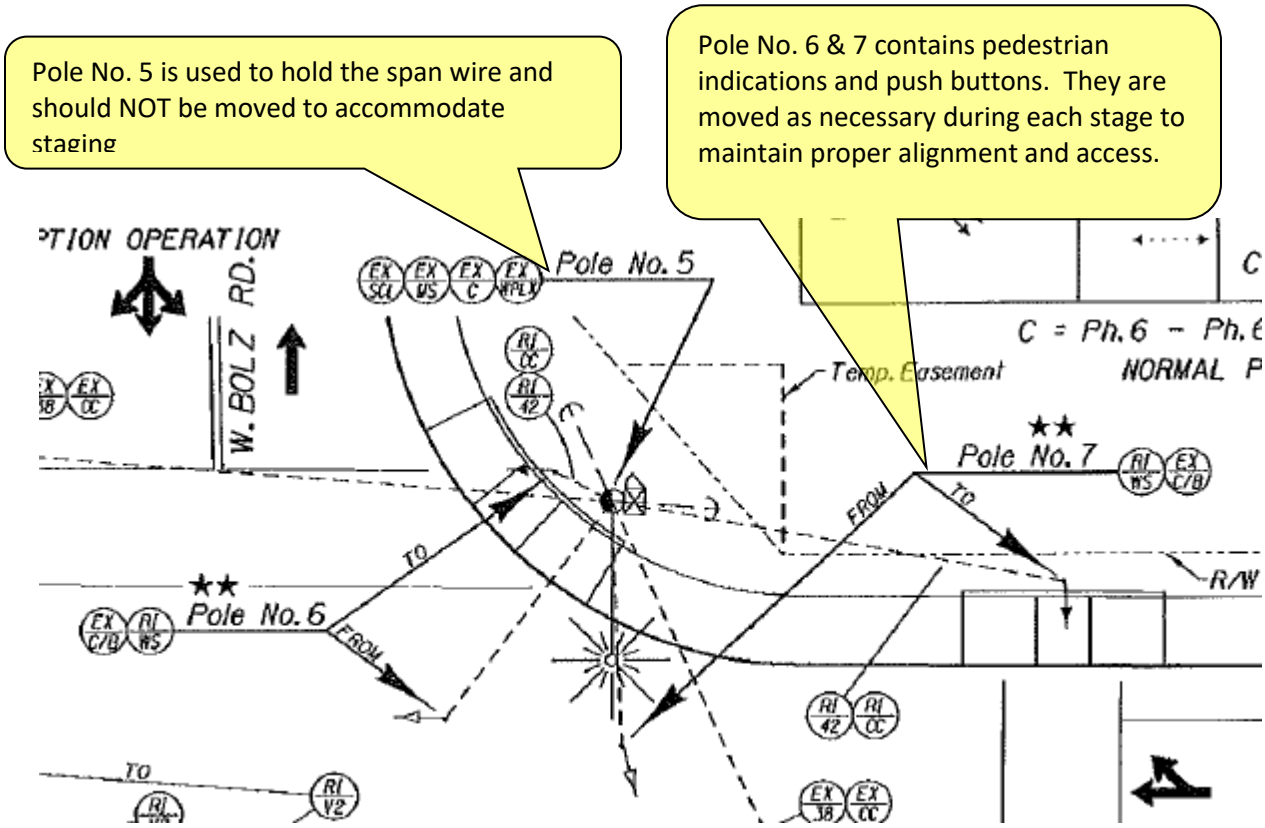
The lateral placement of temporary signal poles next to new or existing appurtenances (e.g. existing/new signal poles, cabinets, etc.) should follow the requirements in Standard Drawing TM653 that are established for embankments. See Figure 11-6. If a temporary pole is placed closer to an object than as shown in the minimum embankment requirements, contact the Traffic Structures Engineer for further analysis.

Figure 11-6 | TM653 Minimum Embankment Requirements



Large poles (those used for span wires) should be set to accommodate all construction staging. Small poles (for pedestrian indications and push buttons) can and should be moved as needed during each stage/phase. See Figure 11-7.

Figure 11-7 | Moving Poles During Staging



11.6.2 Controller Cabinet

The 332S controller cabinet mounted on a temporary, precast foundation is the standard for all temporary installations. Use Standard Detail DET4415 for the temporary foundation.

11.6.3 Service Cabinet and Meter Base

The service and meter base are pole mounted in the same quadrant that controller cabinet is located in. The service cabinet and meter base for temporary installation is shown in Standard Drawing TM455 (which references TM485 for wiring details).

The connection from the power source to the service cabinet/meter base is typically aerial (as opposed to underground for a permanent signal).

11.6.4 Junction Boxes

Junction boxes used for temporary applications do not require a concrete apron if located in non-paved areas.

11.6.5 Use of Detection (Vehicle, Bicycle, Pedestrian Push Buttons, and Fire Preemption Detectors)

Equipment such as vehicle detection, pedestrian pushbuttons, and fire preemption detectors should be evaluated according to their need, and should not automatically be included in the design. Several factors should be considered when determining whether detection is needed or not:

ALL DETECTION

- Duration of temporary signal – Detection becomes more beneficial and cost effective the longer it is expected to be in service.
- Construction staging changes – Providing detection can be labor and cost intensive if there are a lot of staging changes. Non-invasive detection systems (video, microwave, etc.) can provide more flexibility in these situations.

VEHICLE DETECTION

- Speed of the mainline – Detection becomes more beneficial if the mainline of the temporary signal is high speed (greater than 35 mph), due to the increased protection of the dilemma zone.
- Traffic Volumes – Detection becomes more beneficial if the traffic characteristics of the intersection are highly variable (i.e. heavy directional movements only during the AM and PM peak) or if the intersection operates below capacity the majority of the time. When an intersection is operating at or above capacity for all movements, the detection system is less critical because signal will just be "maxing out" all the green time, which is similar to the operation of a "fixed time" cycle. However, if the intersection is operating at or above capacity for only a few of the movements, using detection for those under capacity movements can improve the flow and queuing of traffic for the movements that are at or above capacity.
- Temporary signal operating in system vs. isolated – Signals operating exclusively in coordinated systems do not use any detection for the coordinated phases.

BICYCLE DETECTION

- Bicycle Lanes & Location – Bicycle detection may only be considered if there is a separate Bicycle lane. Detection is more beneficial on approaches with phases that are not recalled (i.e. side streets).

PEDESTRIAN PUSH BUTTONS

- Accessibility of pedestrian push buttons during construction – Pushbutton detection should NOT be used if the construction work will make accessibility (according to Section 5.4) a concern. If this is the case, recalling the pedestrian phase, closing the pedestrian crossing or use of non-invasive pedestrian detection (video, etc.) may be considered. Often temporary signal poles used for the span wire installation must be placed far away from the intersection in order to accommodate the construction work. In these cases, a separate temporary wood pole that is used just for the push buttons would be required so that the push buttons can be placed close enough to the intended crossing to meet the requirements stated in Section 5.4. The "Typical Pedestrian Installation on Wood Post" detail contained on standard drawing TM455 would be used.
- Feasibility of recalling pedestrian phases – Detection is less beneficial if the green time of vehicle phase that is compatible with the pedestrian phase is typically always longer than the pedestrian crossing clearance time.
- Pedestrian volumes – Detection is less beneficial if there is a heavy pedestrian volume (i.e. pedestrian phase is serviced every cycle).

Figure 11-8 | Pedestrian Push Button Access – Example 1

Figure 11-9 | Pedestrian Push Button Access – Example 2

EMERGENCY PREEMPTION DETECTION

- Does the existing signal or permanent new signal have emergency preemption detection? – Typically if an existing signal has preemption detection, the temporary signal will also require preemption detection. If the existing signal does not have emergency preemption but the permanent signal will, the temporary signal will NOT require preemption detection.

- Needs of emergency vehicle service providers – The need for temporary emergency vehicle preemption should be discussed with all interested parties. Understanding the main routes that emergency vehicles use can determine if preemption detection is needed primarily for only one or two approaches vs. each approach.

- Use of recalled pedestrian phases - The need for emergency vehicle preemption becomes less beneficial if pedestrian phases must be recalled. This is due to the requirements of the MUTCD which do not allow emergency preemption to shorten a conflicting “Flashing Don’t Walk” pedestrian phase.

11.6.6 Vehicle Detection

If vehicle detection is deemed necessary, video or radar detection are the preferred detection method to use for temporary traffic signals due to the non-invasive nature and ability for the vehicle detection zones to be easily reconfigured to accommodate various stages of construction. Loop detection should be avoided if possible.

The video or radar detection equipment should be mounted on a temporary signal pole or on a temporary illumination arm. Span wire mounting is not allowed.

11.6.7 Wiring

Wiring for the temporary signal follows the same basic guidelines contained in Chapter 5 for the permanent span wire signal design with the following exceptions:

- Underground (conduit) is not used to wire the phases (from the controller to the terminal cabinet). Wiring for the phase is routed overhead on along the messenger cable for ease of installation and removal.
- The connection from the power source to the service cabinet is typically aerial (as opposed to underground for a permanent signal).
- The wiring from the terminal cabinet to the signal heads may come from either terminal cabinet. If staging requires moving the signal heads, it is best to wire the signal heads from the terminal cabinet that they will be moving TOWARDS. That way there is enough extra wire to accommodate the change in head location. This allows for the most efficient stage change.

Figure 11-10 | Span Wire Wiring – Example 1

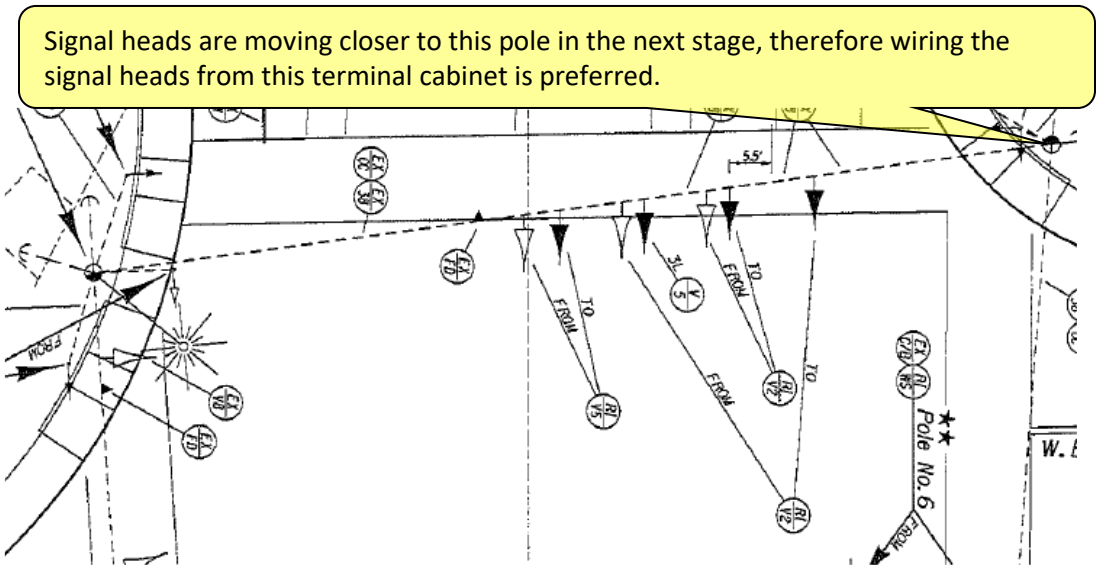
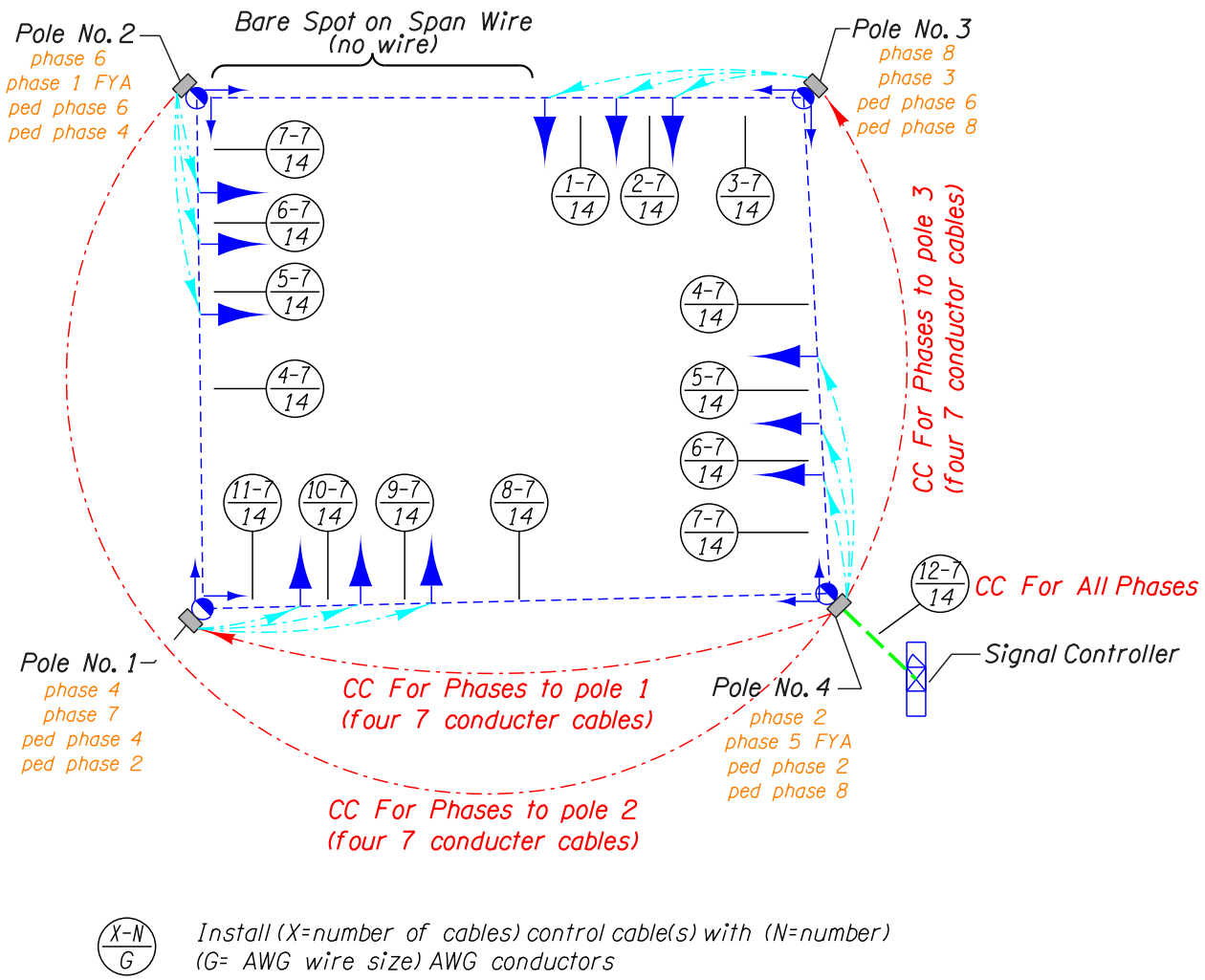


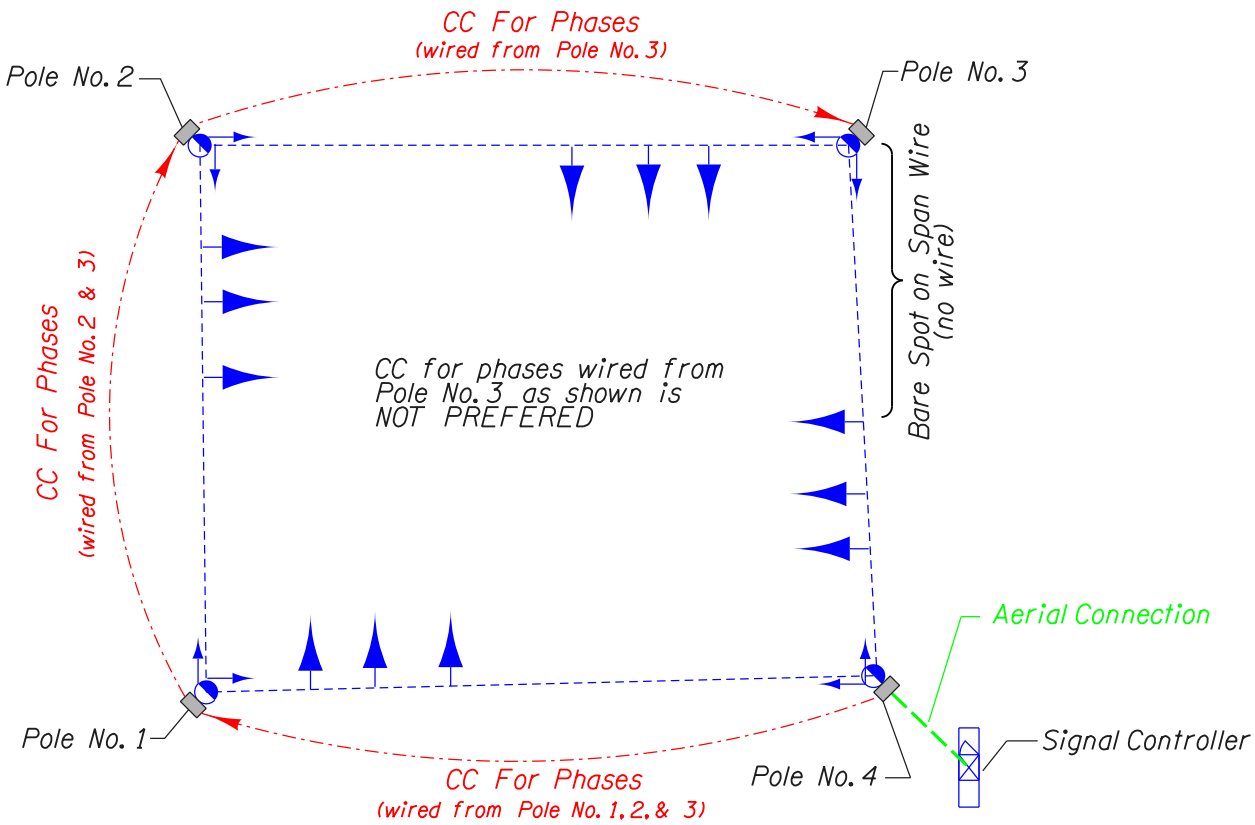
Figure 11-11 illustrates the preferred method for wiring signal phases on a temporary span wire. The control cable for the phases (drawn in red) goes to each pole and a bare spot will always occur on a portion of the span wire (no wire, only the messenger cable). To determine the number of control cable needed, count the number of phases powered from each pole and the number of signal heads. Each phase and each signal head requires one 7 conductor control cable. For example in Figure 11-11, pole No. 2 will power two pedestrian phases, one thru phase, and one PPLT left turn phase. Therefore, four 7 conductor control cable is needed to power each phase. These four 7 conductor control cables will start from the controller cabinet and go directly to the Pole No. 2 terminal cabinet (all four 7 conductor control cables will bypass the terminal cabinets on Pole No. 4 and 1). The wiring is shown after each piece of signal equipment.

Figure 11-11 | Preferred Method for Wiring Signal Phases on a Span Wire



There are many ways to wire a traffic signal that work, but to achieve uniformity (which has many benefits for maintenance and construction), we strive to wire traffic signals in a consistent manner. The following Figure 11-12 shows a possible way to wire the signal phases, but this is not a preferred method for more reasons than uniformity alone; the wiring as shown in Figure 11-12 is not very economical (the wiring for pole No. 3 phases is much longer than as shown in Figure 11-11) and the terminal cabinet located on pole No. 1 may not have enough area to accommodate the increased number of control cables that must now come in and out of the bottom of the terminal cabinet.

Figure 11-12 | NON-Preferred Method for Wiring Signal Phases on a Span Wire



11.6.8 Staging

When designing any temporary signal, keep in mind you may need to adjust the signal heads and detection for various stages of construction. Signal designers should coordinate their work early in the process with the traffic control designer assigned to the project and Region Traffic (or the Operations Unit). This will assure correct operation of the temporary signal and safe traffic control during the construction phase.

Depending on the complexity of the project, the temporary traffic control plans may detail specific stages and phases for construction (e.g. Stage I, phase 1; Stage I, phase 2; Stage II, phase 1, etc.). If specific stages and phases have been produced for the project that will impact a signalized intersection, the signal designer needs to produce a temporary signal plan sheet for each stage and phase that details the following components at a bare minimum:

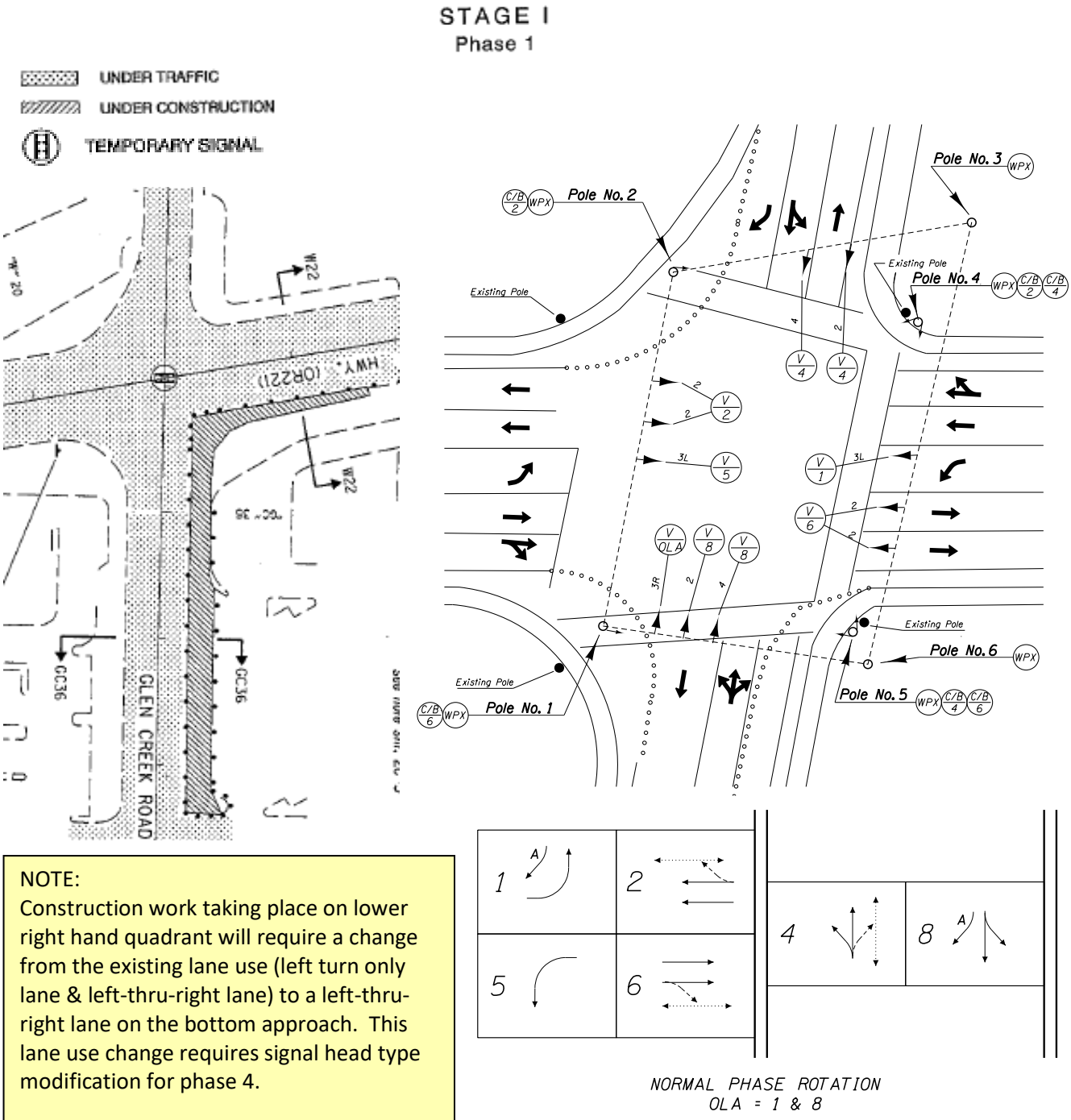
- Lane use at the intersection
- Signal and pedestrian head configuration and type
- Lane use signing and other regulatory signing mounted on the signal equipment as necessary
- Signal phasing
- Detection as necessary (push buttons, loops, etc.)
- Reference existing and/or proposed signal poles or curb lines (helps establish the location of the temporary features in relation to existing and proposed conditions)

Keep in mind that the construction staging that is produced for the contract plans is only showing one way to complete the required construction work, and therefore, there is a strong possibility that the contractor will elect to modify the staging/phasing shown in the plans. There is also the possibility that the contractor will propose an entirely different staging plan. This is allowed per standard specification 00225.05 which states the contractor is responsible for submitting a written traffic control plan (detailing any modifications to traffic control plan as contained in the contract plans) to the Engineer for approval.

Figure 11-13 through Figure 11-22 show each stage and phase of an example project with the traffic control plans (TCP) shown on the left side (produced by the traffic control plans designer) and the corresponding temporary traffic signal plans shown in the right side (produced by the signal designer). This example project was a modernization project to add capacity (lanes) at the intersection.

The temporary signal plans must correspond with and match the traffic control plans.

Figure 11-13 | Staged Construction Example – Stage I, Phase 1



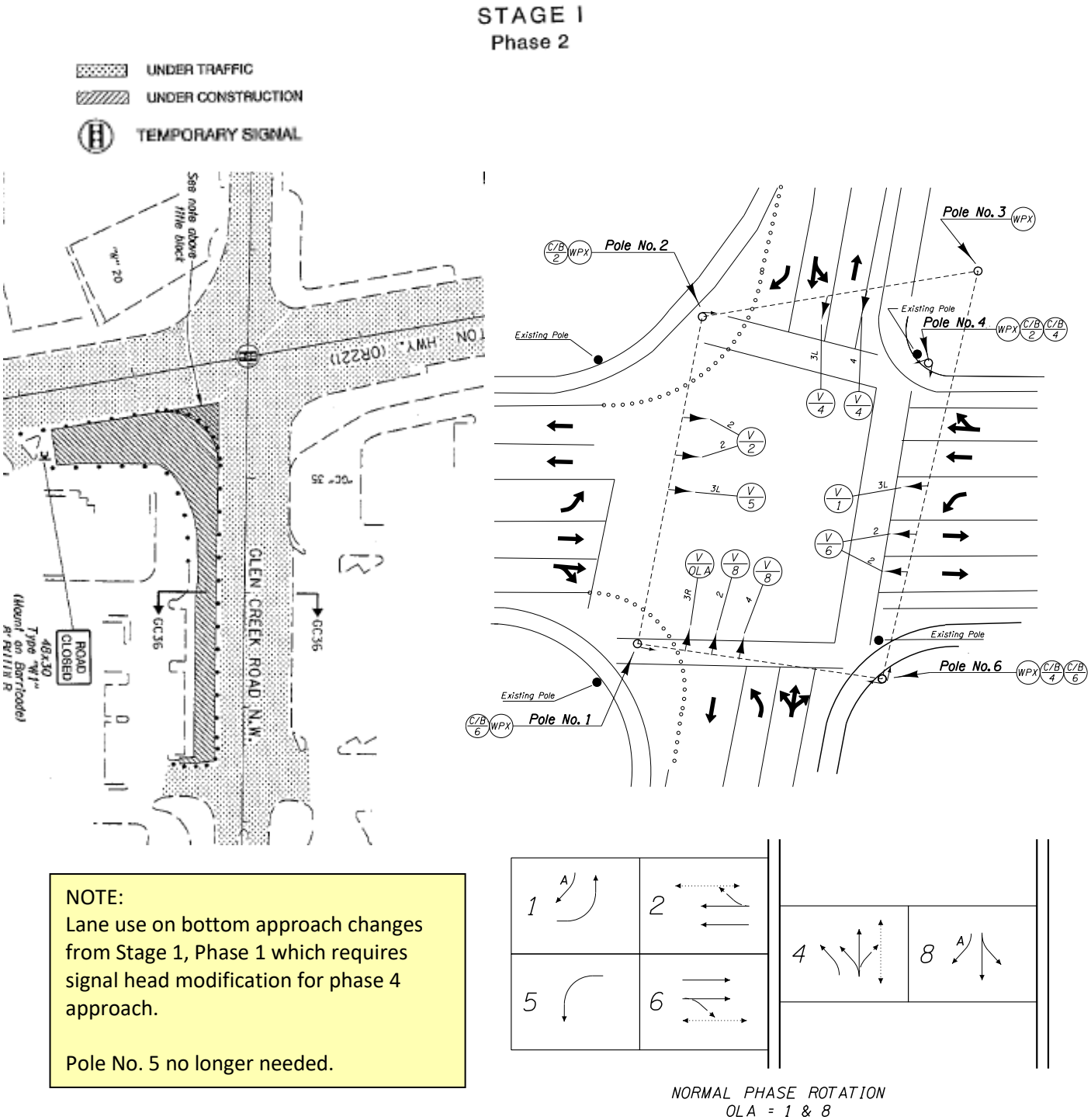
NOTE:
Construction work taking place on lower right hand quadrant will require a change from the existing lane use (left turn only lane & left-thru-right lane) to a left-thru-right lane on the bottom approach. This lane use change requires signal head type modification for phase 4.

Placement of temporary signal pole nos. 1 and 2 will require modification to the radii. Poles 1, 2, 3 & 6 (major poles) will stay in same location for entire temp staging.

TCP Plans

Temporary Signal Plans

Figure 11-14 | Staged Construction Example – Stage I, Phase 2



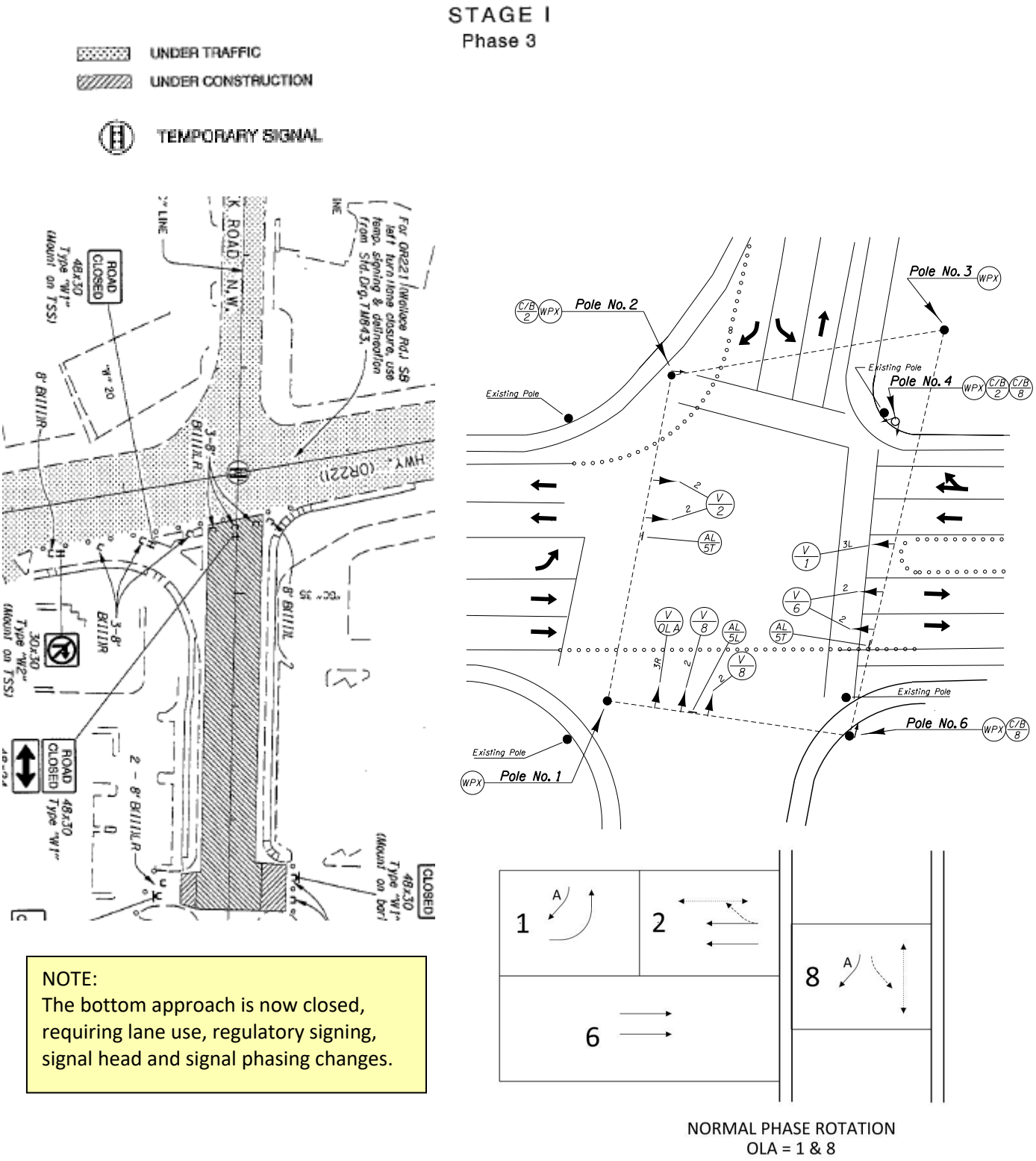
NOTE:
Lane use on bottom approach changes from Stage 1, Phase 1 which requires signal head modification for phase 4 approach.

Pole No. 5 no longer needed.

TCP Plans

Temporary Signal Plans

Figure 11-15 | Staged Construction Example – Stage I, Phase 3



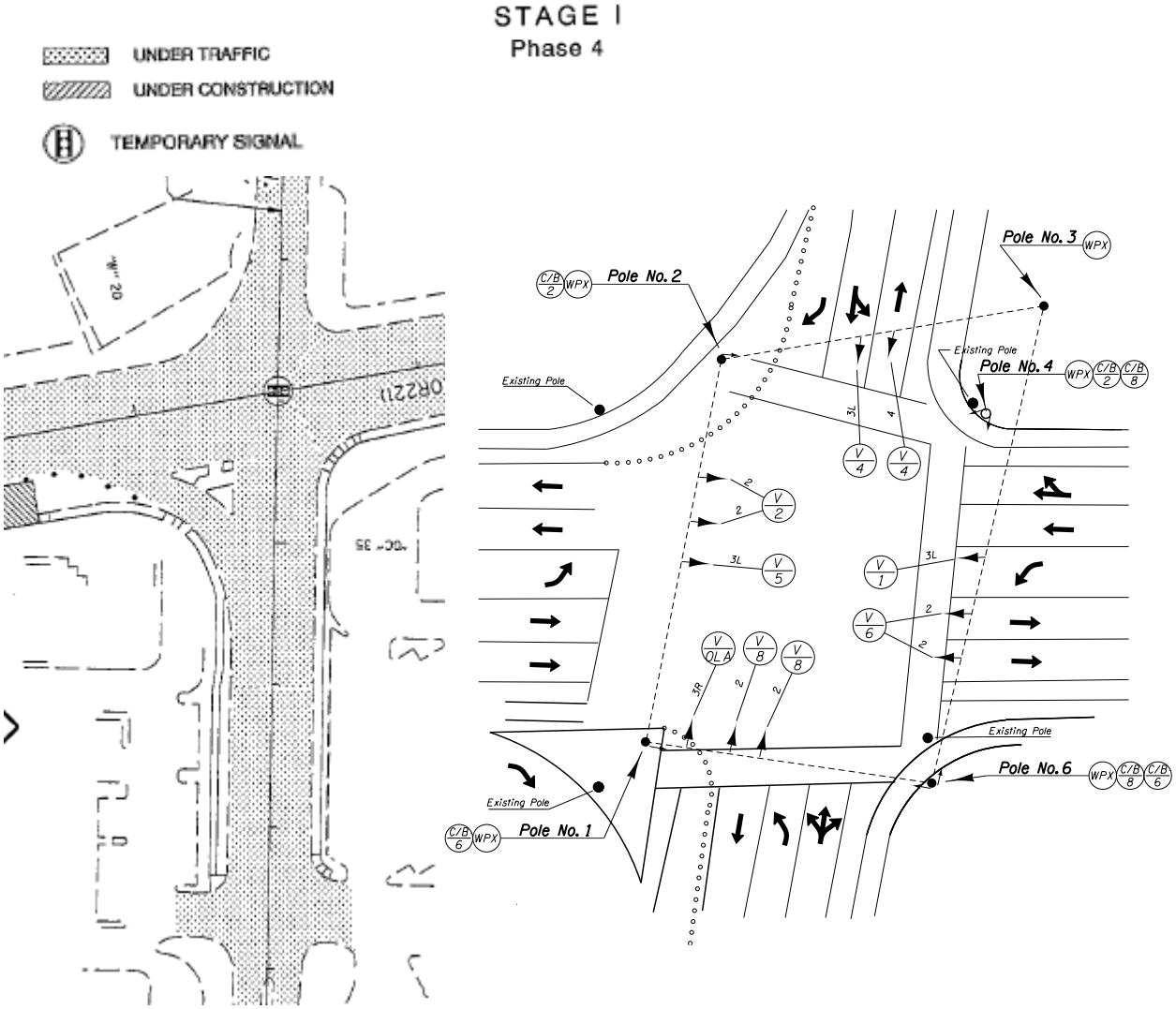
NOTE:
The bottom approach is now closed, requiring lane use, regulatory signing, signal head and signal phasing changes.

NORMAL PHASE ROTATION
OLA = 1 & 8

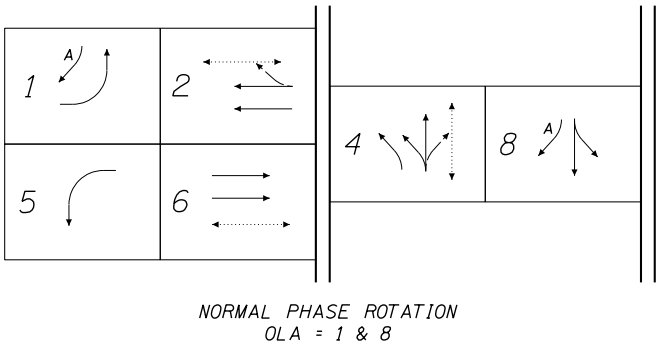
TCP Plans

Temporary Signal Plans

Figure 11-16 | Staged Construction Example – Stage I, Phase 4



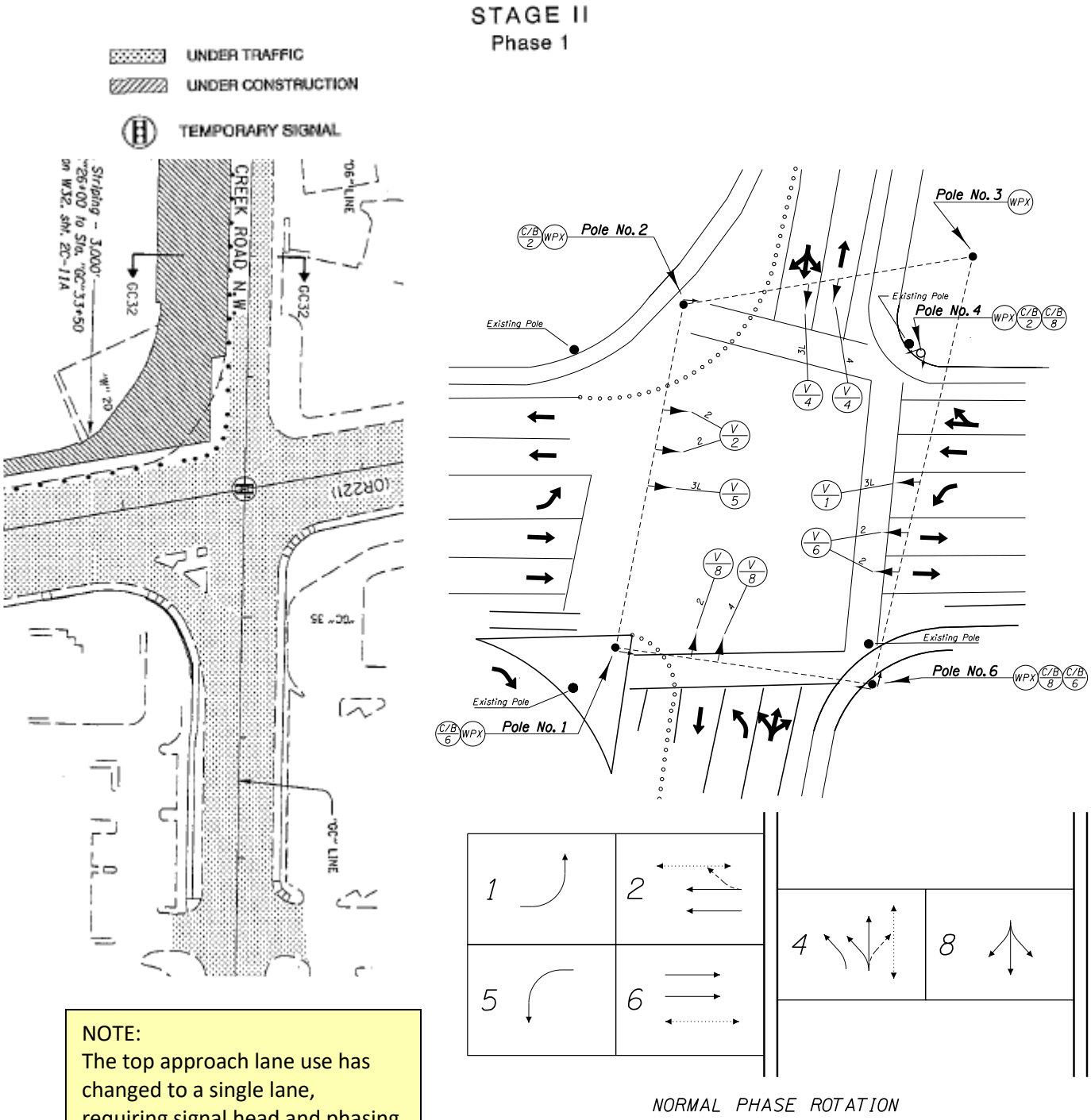
NOTE:
The bottom approach final lane configuration is complete; however, the final lane configuration for the bottom approach cannot be used yet due to the severe lane off-set for the vehicle going straight thru the intersection from the top approach.



TCP Plans

Temporary Signal Plans

Figure 11-17 | Staged Construction Example – Stage II, Phase 1

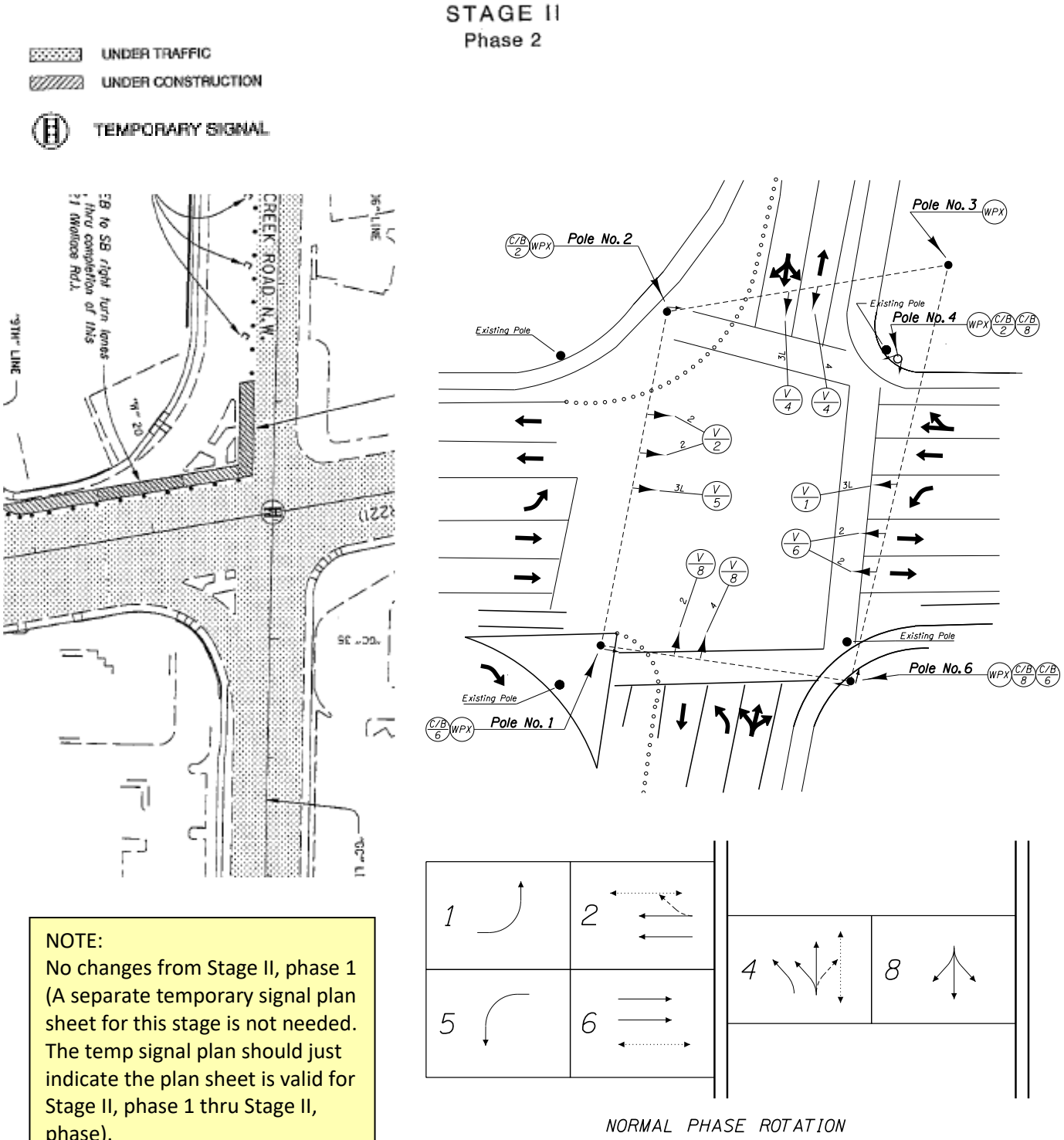


NOTE:
The top approach lane use has changed to a single lane, requiring signal head and phasing changes (overlap A has been removed for this stage).

TCP Plans

Temporary Signal Plans

Figure 11-18 | Staged Construction Example – Stage II, Phase 2

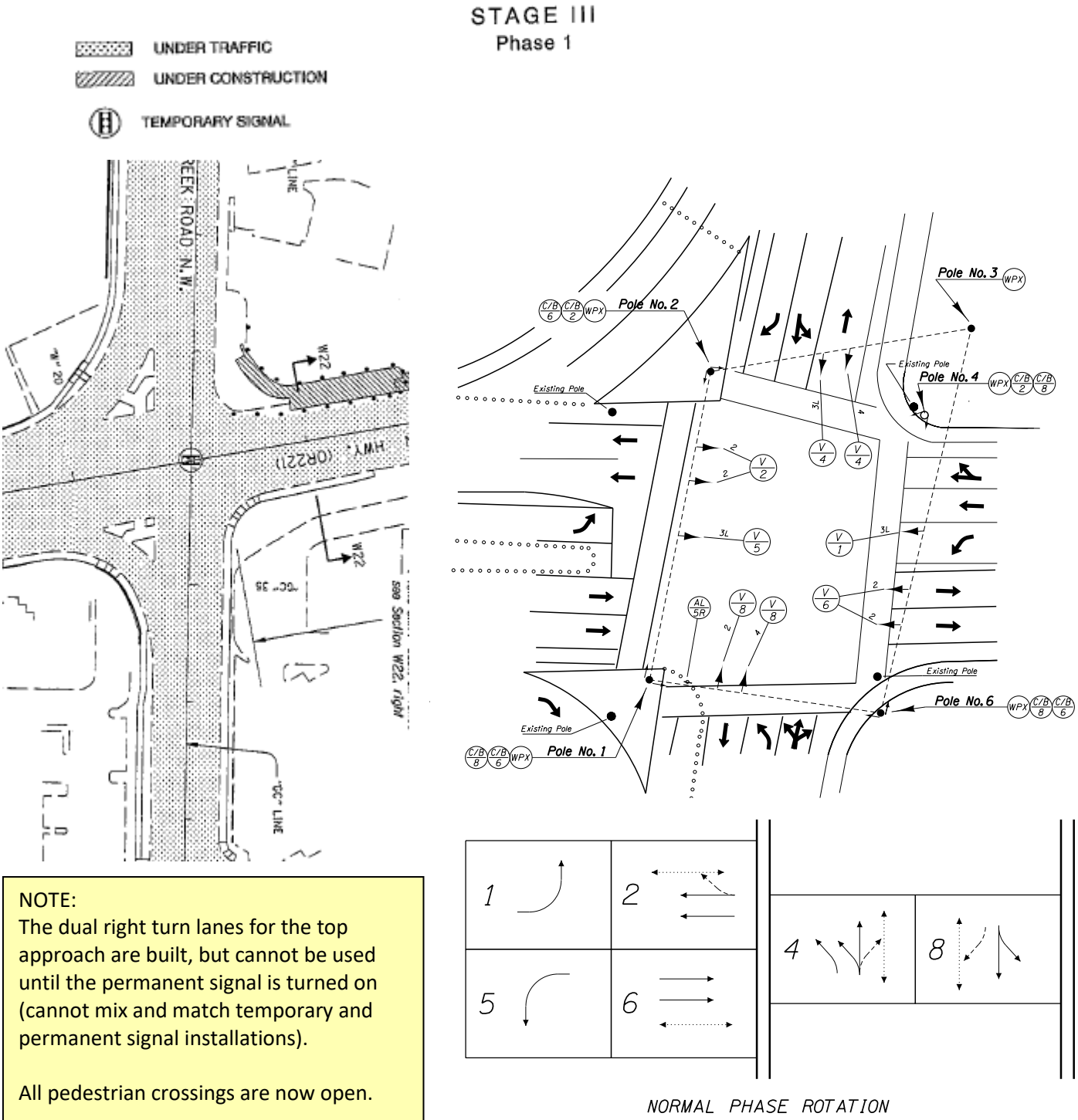


NOTE:
No changes from Stage II, phase 1 (A separate temporary signal plan sheet for this stage is not needed. The temp signal plan should just indicate the plan sheet is valid for Stage II, phase 1 thru Stage II, phase).

TCP Plans

Temporary Signal Plans

Figure 11-19 | Staged Construction Example – Stage III, Phase 1



NOTE:
The dual right turn lanes for the top approach are built, but cannot be used until the permanent signal is turned on (cannot mix and match temporary and permanent signal installations).

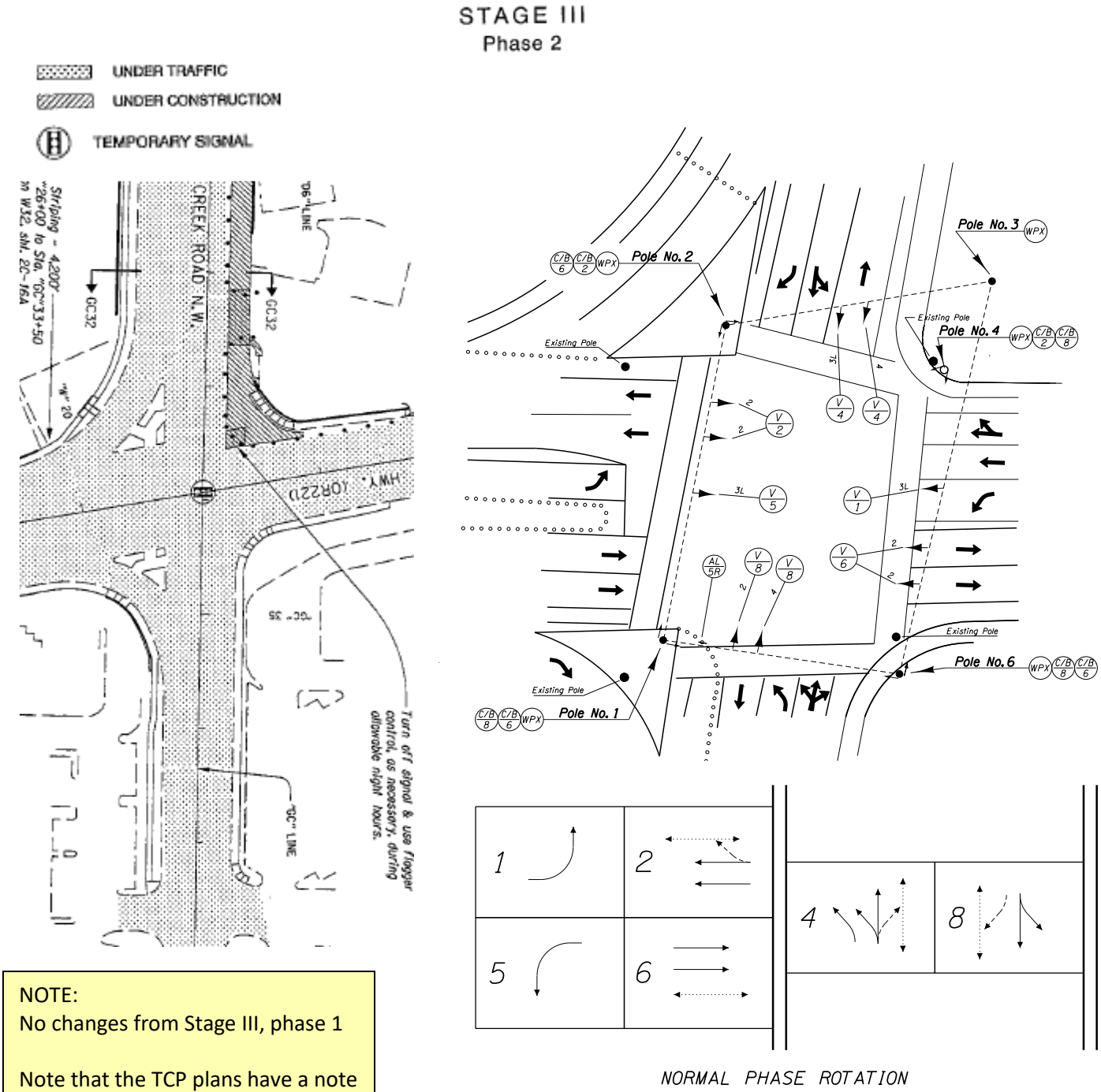
All pedestrian crossings are now open.

Left approach dual left turn lane cannot be opened yet (receiving lanes not yet built).

TCP Plans

Temporary Signal Plans

Figure 11-20 | Staged Construction Example – Stage III, Phase 2



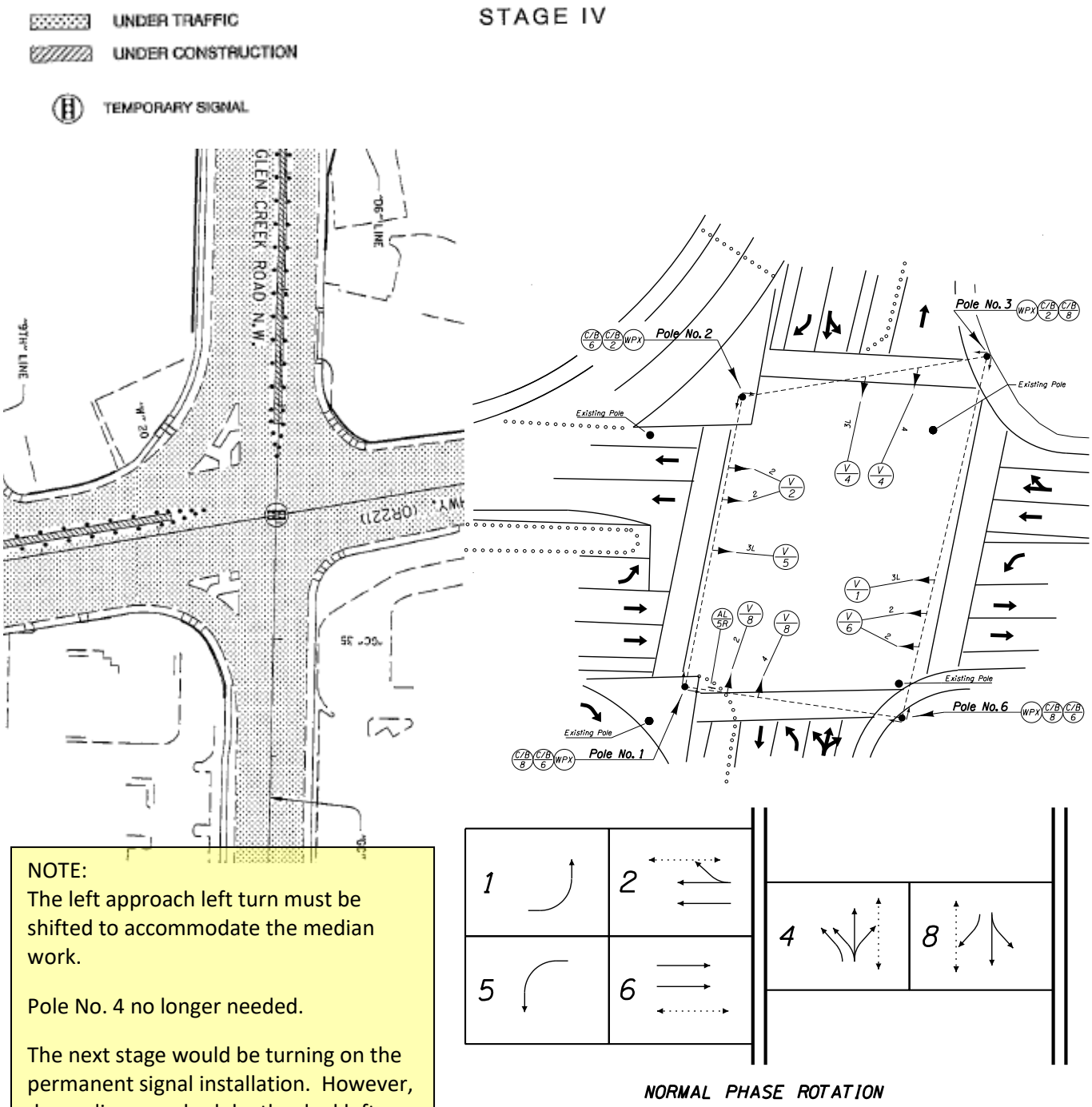
NOTE:
No changes from Stage III, phase 1

Note that the TCP plans have a note for the contractor about turning off the signal and flagging for the small amount of work to be done in the upper right hand quadrant.

TCP Plans

Temporary Signal Plans

Figure 11-21 | Staged Construction Example – Stage IV



NOTE:
The left approach left turn must be shifted to accommodate the median work.

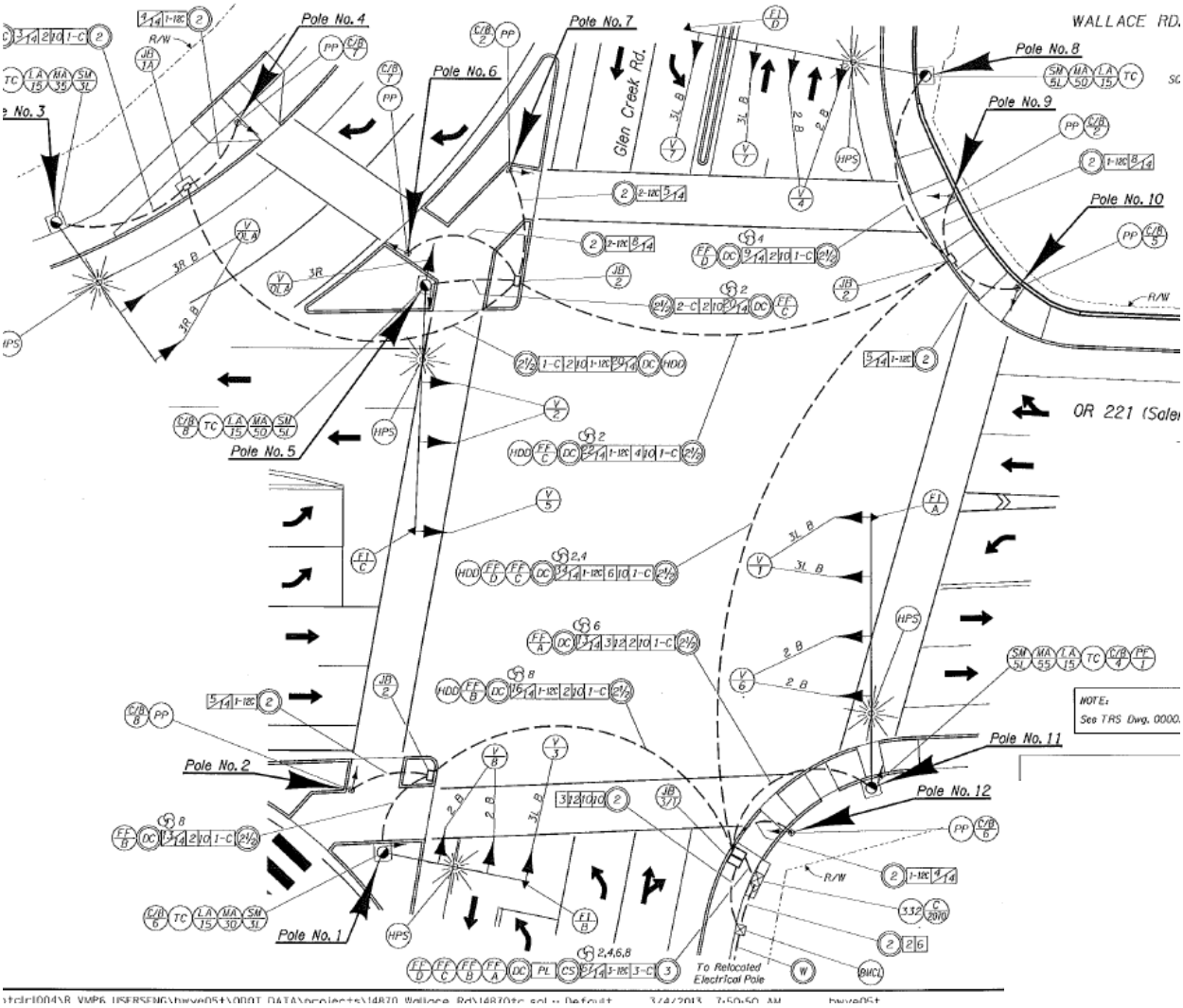
Pole No. 4 no longer needed.

The next stage would be turning on the permanent signal installation. However, depending on schedule, the dual left turn on the left hand approach could be opened <u>after</u> the median work and <u>prior</u> to turning on the permanent signal.

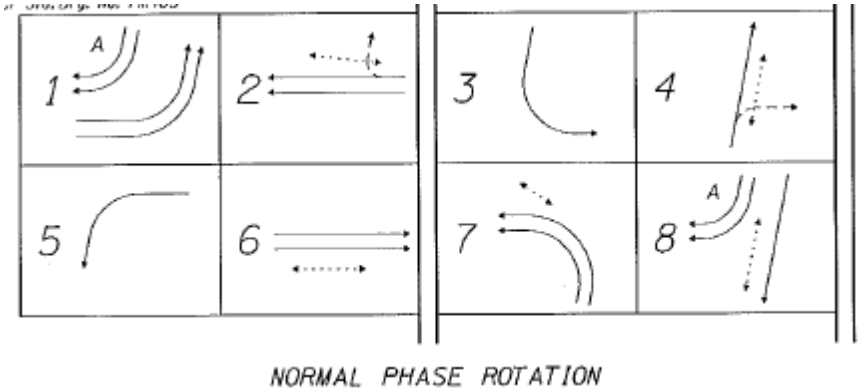
TCP Plans

Temporary Signal Plans

Figure 11-22 | Staged Construction Example – Permanent Signal



NOTE:
Final Configuration



11.7 Temporary Bridge Signal Design

This type of temporary signal alternates traffic across the bridge one direction at a time in a single lane. Note that this type of operation may occur at other locations besides a bridge, but bridge work comprises the majority, hence the designation of "temporary bridge signal". Considerations to include when beginning the design are the location of the bridge in relation to oncoming traffic and any other accesses within the intersection. All accesses within the "intersection" must be signalized.

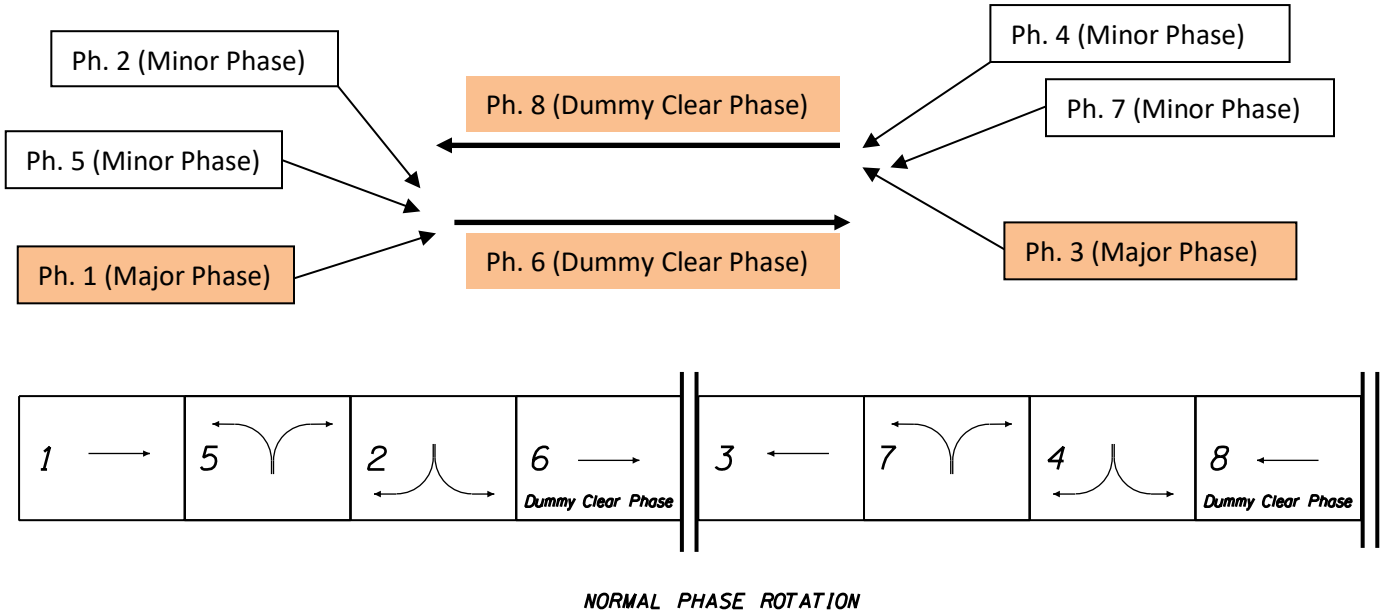
11.7.1 Phasing

One lane, two-way signal operations require exclusive phasing with long all red clearance intervals to clear the "intersection". This is usually accomplished by the use of dummy phases.

The standard phasing for this type of operation is shown in Figure 11-23, which allows for up to 4 separate accesses on each end of the single lane to be signalized. Accesses located in the middle of the single lane are not allowed and must be closed.

Pedestrian phases are typically not used given the typical location where this type of signal operation is used (i.e. rural bridge location).

Figure 11-23 | Standard Temporary Bridge Signal Phasing



11.7.2 Sight Distance

It is critical to maintain a good line of sight from stop line to stop line at each end of the single lane to ensure safe and efficient traffic operation in the event that the signal goes into flashing operation. If sight distance is not good and signal goes into flash, a motorist who cannot see opposing traffic will proceed ahead (after stopping) and may encounter an opposing vehicle in the single lane section, resulting in a crash or jockeying/reversing to make it thru the single lane section. These scenarios are not acceptable. If sight distance between the two stop line locations cannot be met (e.g. the single lane section is very long, the roadway geometry curves, vegetation or a cut slope is blocking the view) other means of traffic control shall be used (e.g. 24/7 flagging or pilot cars).

Figure 11-24 | Sight Distance Condition of Signal Turn-on Example

Note:

Prior to signal operation, remove trees and vegetation south of the straight line identified in the roadway plans, to establish a clear line-of-sight between temporary signal STOP lines.

11.7.3 Stop Line Location

Standard Drawing TM870 shows the typical layout for signing and pavement markings that are used for a temporary bridge signal. The stop line is shown as 60 feet (typical) from the signal heads, which is slightly more than the minimum 45 foot value to provide a more comfortable viewing angle for the driver. This value should work well for the majority of applications. However, if it is determined the stop line needs to be placed closer or farther than 60 feet based on site specific constraints, dimension the distance on the temporary signal plan sheet to properly override the standard drawing.

11.7.4 Signal Head Alignment

The signal heads should be aligned over the receiving lane of the single lane, which depending on the placement of the signal poles and roadway geometry may require a slight shift when one-lane alignment moves to the other side. Note how the signal head alignment changes between Stage 1 and Stage II in Figure 11-25 and Figure 11-26.

Figure 11-25 | Stage I Signal Head Location

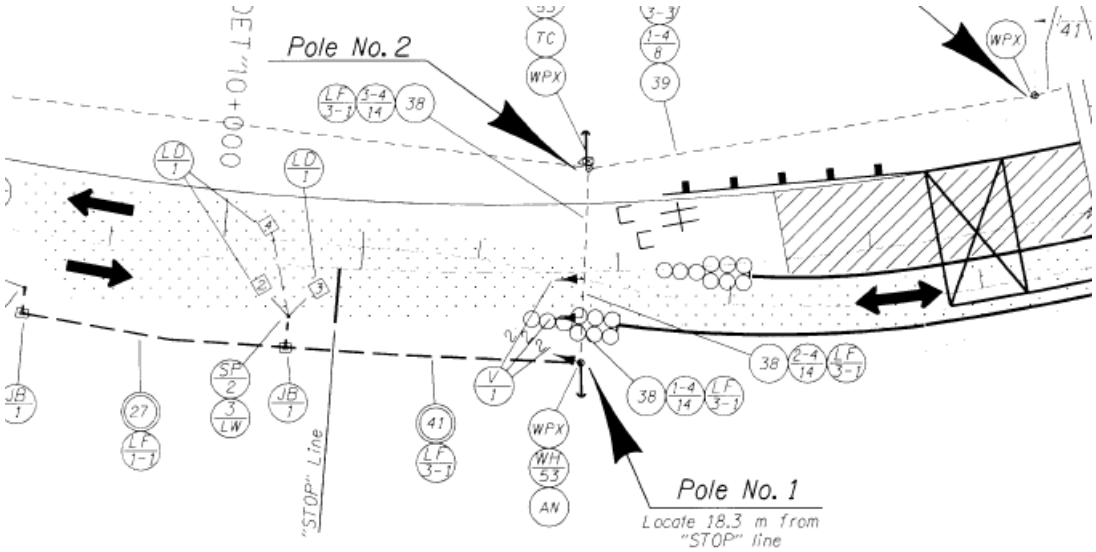
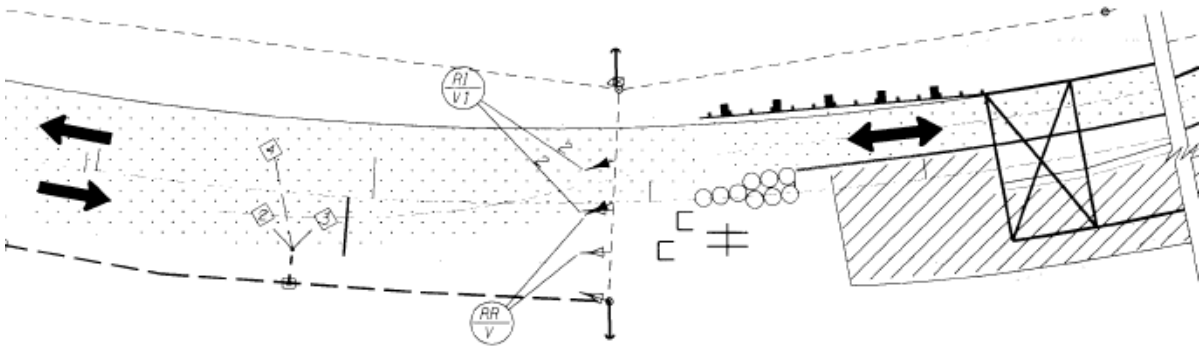


Figure 11-26 | Stage II Signal Head Location



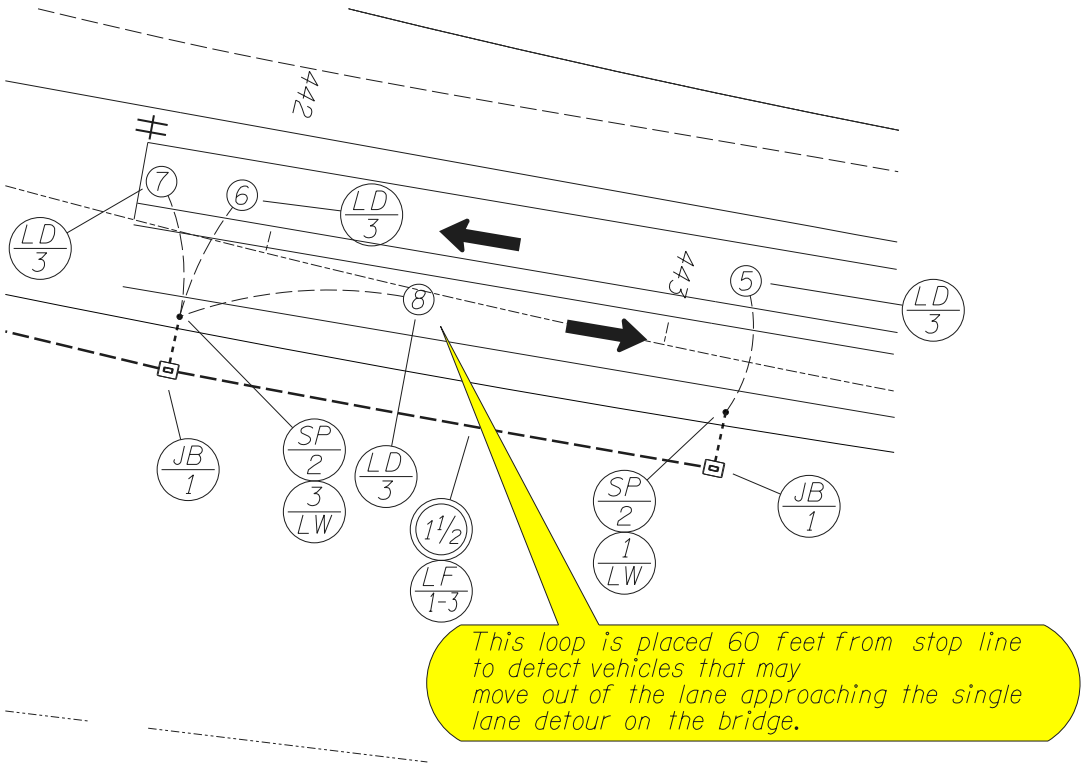
11.7.5 Detection

Temporary bridge signals shall have detection. This is a requirement to ensure the safest and most efficient operation. Detection enables the signal to "rest in red" when there is no demand. When a vehicle approaches during the "rest in red" condition, it must slow down prior to getting a green indication. It also improves the efficiency of an inherently inefficient signal operation (exclusive phasing with long clearance intervals).

The standard placement for detection of the major phases is 100 feet, 15 feet and 5 feet from the stop line, centered in the lane. One detector located 60 feet from the stop line in the OPPOSING lane should also be included to detect vehicles that are likely to move out of the approach lane when entering the single lane. See Figure 11-27.

The standard placement for detection of the minor phases follows the standard used for the minor street of permanent signals; 75 feet, 15 feet and 5 feet. If the minor phase approach is short in distance (i.e. to a driveway) or the pavement doesn't extend very far past the radius, the detection located at 75 feet and 15 feet may be omitted as necessary.

Figure 11-27 | Temporary Bridge Signal Standard Detection



When loops are used for detection, make sure to check the number of turns needed for each loop, as extra turns of wire are likely needed for loops located the furthest from the controller cabinet. See Chapter 6 for how to determine the correct number of turns.

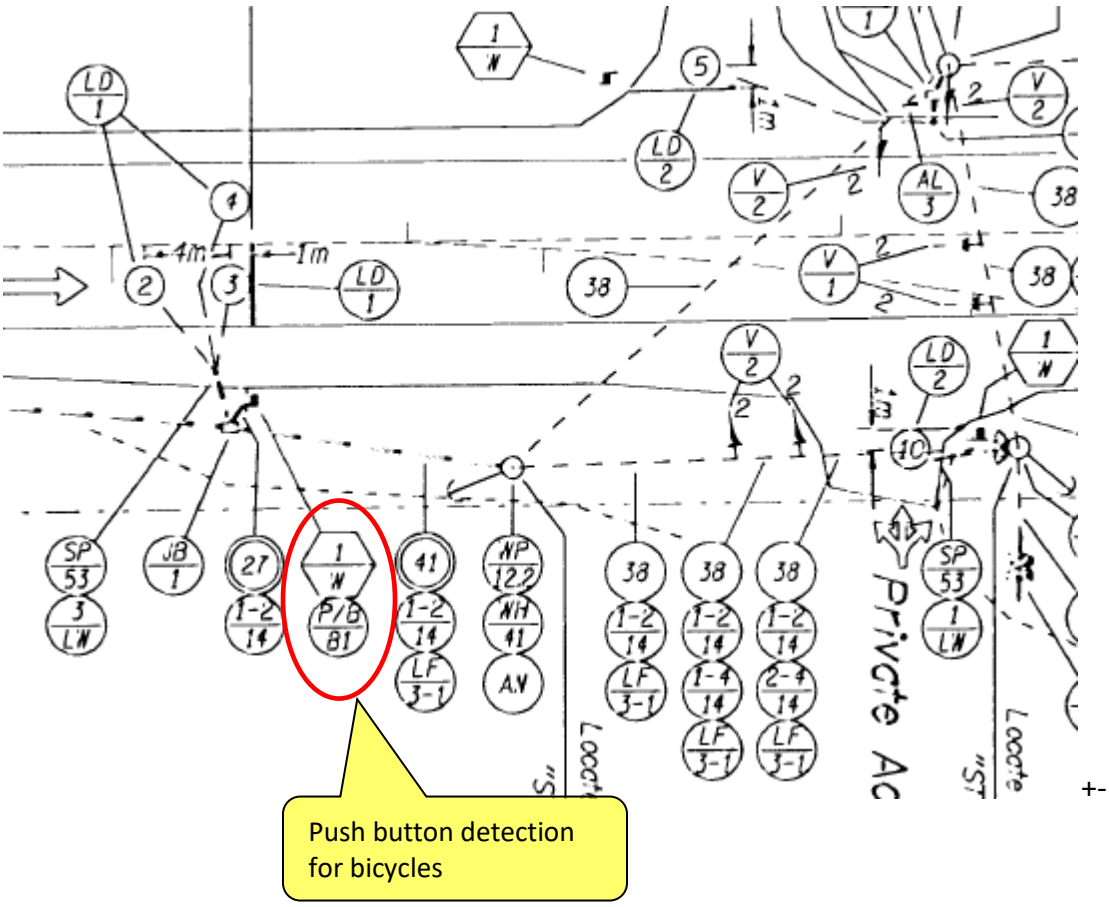
11.7.6 Bicycle Detection

Temporary bridge signals may use detection specifically for bicycles to allow an extension of the green time and clearance phase. The need for bicycle detection should be documented in the Operational Approval, based on factors such as the temporary bridge signal geometry (length, width, vertical grade, and presence of bicycle lanes), frequency of bicycles, speed differential between bicycles and vehicles, etc.

Pushbuttons have been used in the past and provide the most reliable form of bicycle detection for this type of installation; there is no chance of false call from vehicular traffic, and it works for all types of bikes. See Figure 11-28 for an example of push button detection. Other detection technology (i.e. loops, video, etc.) may be used if the detection zones can be placed such that false calls from vehicles will not occur. However, these technologies may not work for some types of bikes. It is important to have proper signing and/or striping in place to let bicycles know how to properly navigate through the signal if detection has been provided.

Portable temporary traffic signals (see section 11.8) cannot accommodate bicycle detection.

Figure 11-28 | Temporary Bridge Signal Bicycle Detection



11.8 Portable Temporary Traffic Signal

This is a very specific type of temporary traffic control. This application requires operational approval, but does not require design approval. Because this product is an off-the-shelf system that the contractor is responsible for timing, there is no need for a temporary signal plan sheet. All of the details for construction and operation of the device is contained entirely within the operational approval letter, the temporary traffic control plan sheets, and specification 00225.45(b) and 00225.65(b). Generally, the EOR for the temporary traffic control plans (not the signal designer) is responsible for detailing the use of this device on the project.

STRE Operational Approval is REQUIRED for use of a Portable Temporary Traffic Signal.

Temporary Signal Plan sheets are NOT needed. Design approval is NOT required.

11.9 Standard Drawings and Specifications Applicable to Temporary Signals

The following is a list of standard drawings and specifications that relate only to temporary signals and should be well understood by the signal designer when designing a temporary signal:

- Standard Drawings
  - TM870 (Bridge Construction)
  - TM455 (Temporary Signal Details)
- Specifications
  - 00225.15 (Temporary Traffic Signal Materials)
  - 00225.45 (Temporary Traffic Signal Construction, Removal, Power Service, Testing and Turn-on)
  - 00225.65 (Temporary Traffic Signal Maintenance)
  - 00225.85 (Temporary Traffic Signal Measurement)
  - 00225.95 (Temporary Traffic Signal Payment)

Other standard drawings/details and specifications (that also apply to permanent signals) will be needed, as applicable, for the installation of a temporary signal. See Chapter 17 and Chapter 18 for more information on standard drawings and specifications.

12 FLASHING BEACON PLAN

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12.1 Operational and Design Approval

There are several different types of flashing beacons which require different levels of Operational and Design Approval. Each type of flashing beacon is discussed in more detail in the following sections of this chapter.

	Type of Flashing Beacon	Operational Approval Required	Design Approval Required
WARNING BEACONS	Warning Beacon for obstructions	RTE Approval	NO if ground mounted using solar power (plan sheet still required) YES if mounted overhead OR using commercial power
	Warning Beacon for standard warning signs (continuous operation)	RTE Approval	NO if ground mounted using solar power (plan sheet still required) YES if mounted overhead OR using commercial power
	Warning Beacon for ramp meter signs	RTE Approval	YES – shown on the RAMP METER plan sheet. See Chapter 13.
	BE PREPARED TO STOP WHEN LIGHTS FLASH actuated system	STRE Approval	YES
	Actuated system for bridges	STRE Approval	YES
	Actuated system for tunnels	STRE Approval	YES
	Actuated system for mid-block crossings	STRE Approval	YES
	Actuated system for Emergency Vehicles	STRE Approval	YES
	Rectangular Rapid Flashing Beacon (RRFB)	STRE Approval	YES
	Speed Limit Sign Beacon (school speed zones only)	STRE Approval* *for the school zone itself. Region Traffic decides if beacon is used.	NO if ground mounted using solar power (plan sheet still required) YES if mounted overhead OR using commercial power
	Stop Sign Beacon	RTE Approval	NO if using solar power (plan sheet still required) YES if using commercial power
	Intersection Control Beacon	RTE Approval	YES
	Pedestrian Hybrid Beacon	STRE Approval	YES

12.2 Power Source

Flashing beacons can be powered by commercial power or solar power. The decision on which one to use should be made in conjunction with the Region Electrical Crew. There are pros and cons to each one, shown below.

COMMERCIAL POWER	
Pros	**Cons**
Reliable	Monthly Power Bill
Easy Access and Cost Effective Installation in Urban Areas	May not be Available or Cost Effective in Rural Areas

SOLAR POWER	
Pros	**Cons**
Good performance with unimpeded view of the sun	More costly initial installation
No monthly power bill	Requires maintenance/replacement of solar system in the future (array and batteries)
Good option where use of commercial power is impractical	Locations with impeded views will require larger (or additional) arrays/batteries
	May be subject to theft or vandalism

Standard solar power systems are designed for an unimpeded view of sun during daylight hours. If solar power is going to be used in a location that has an impeded view during the daylight hours (blocked by trees, buildings, etc.) contact the Traffic Signal Engineer to correctly size the array and number of batteries. If solar power is used, the following applicable standard details should be used:

- DET4416 - Solar Power School Zone Flasher – Vertical
- DET4436, DET4437 & DET4438 - Rectangular Rapid Flashing Beacons
- DET4670 – Solar Flashing Beacon Wood Post Attachment
- DET4681 – Solar Flashing Beacon PSST Attachment

If commercial power is used, the support post is required to be either a pedestrian pedestal or vehicle pedestal. Standard sign supports such as wood posts and PSST are NOT allowed for mounting a flashing beacon when commercial power is used due to the necessity of conduit and wiring along the length of the support which negatively affects the break-away characteristics of the post. A separate base mounted service cabinet (BMCF) as per Standard Drawing TM485 is also necessary.

Design Approval is required if commercial power is used!

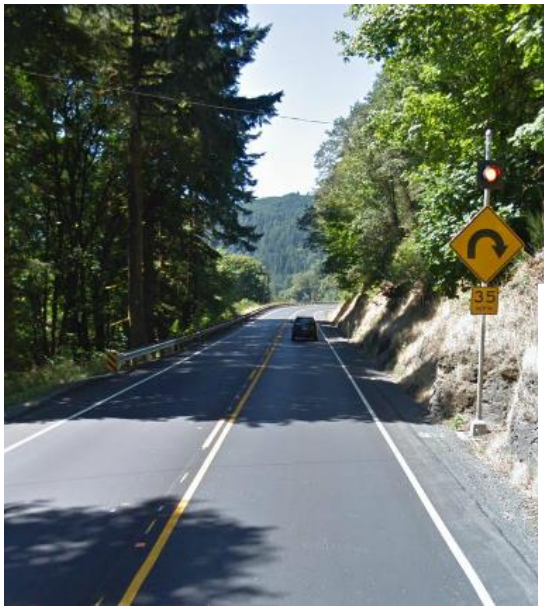
12.3 Beacon Operation

Depending on the application of the flashing beacon, they may operate in the following ways:

- Continuously. This operation is used when the condition or regulation exists at all times, for example; obstructions in or near the roadway, “signal ahead” and “curve ahead” warning signs.

- Only during certain times/day-of-week. This operation is used when the condition or regulation exists for a predetermined duration, for example; school speed zone regulatory signs and ramp meter warning signs. This type of operation typically includes the phrase, “WHEN FLASHING” in the sign legend.

- Actuated (either passive or pushbutton). This operation is used when the condition or regulation exists only when there is actual demand, for example; peds using a mid-block crossing, bikes/peds using a tunnel or bridge, and BE PREPARED TO STOP WHEN FLASHING systems. This type of operation also usually includes the phase, “WHEN FLASHING” in the sign legend (one major exception is mid-block crosswalk signing, which does not use “WHEN FLASHING” legend).



All Actuated beacons require STRE Operational Approval!

12.4 Warning Beacon

A warning beacon provides supplemental emphasis for appropriate warning or regulatory signs or markers. See MUTCD Section 4L.03 for more information. The following subsections list the common types of warning beacon used on the state highway.

Warning beacons are generally ground mounted, but they may be mounted overhead for greater conspicuity.

12.4.1 Warning Beacons for Obstructions

On the state highway, warning beacons are typically only used to emphasize one type of obstruction: impact attenuators located within the gore area of highway bifurcations.

For this application, two vertically oriented, 12 inch circular yellow indications (custom signal head type) are mounted on a vehicle pedestal. The bottom of the signal backplate shall be 7 feet minimum above the roadway surface. The pedestal should be located behind the impact attenuator.

Figure 12-1 | Warning Beacon for an Obstruction, Example 1

Figure 12-2 | Warning Beacon for an Obstruction, Example 2

12.4.2 Warning Beacons for Warning Signs (Continuous Operation)

The common signs where warning beacons are used include:

- Signal Ahead Signs
- Curve Signs
- Intersection Ahead Signs

For post mounted applications, one Type 1Y signal head is mounted directly above the sign on the support post. If solar power is used, the support post may be either a standard wood pole or a Perforated Steel Square Tube (PSST). There are two standard details, DET4681 (PSST) and DET4670 (wood post) that should be used. If commercial power is used, the support post is required to be a vehicle pedestal.

For overhead mounted applications, two Type 1Y signal heads are mounted on either side of the sign. A mast arm should be always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

Figure 12-3 | Warning Beacon for a Warning Sign, Post Mounted

Figure 12-4 | Warning Beacon for a Warning Sign, Overhead

12.4.3 Warning Beacons for Ramp Meter Signs

Ramp meter signs with warning beacons are part of the standard installation for a ramp meter and are shown on the “RAMP METER” plan sheet, not a “FLASHING BEACON” plan sheet. See Chapter 13 for information on ramp meter plan sheets.

12.4.4 Actuated Warning Beacons – Bridges

Actuated warning beacons for bridges consist of one Type 1Y signal head located above the warning sign. The warning sign legend should contain "WHEN FLASHING" text to inform the motorist of when the condition is applicable.

For post mounted applications, one Type 1Y signal head is mounted directly above the sign on the support post. If solar power is used, the support post may be either a standard wood pole or a Perforated Steel Square Tube (PSST). There are two standard details, DET4681 (PSST) and DET4670 (wood post) that should be used. If commercial power is used, the support post is required to be a vehicle pedestal.

For overhead mounted applications, two Type 1Y signal heads are mounted on either side of the sign using adjustable brackets (for a mast arm) or span wire hangers (for a span wire). A mast arm should be always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

A pushbutton is the standard form of detection. Pushbuttons shall be provided according the requirements stated in Chapter 5, and located where they are easily accessible for all intended users (pedestrians and/or cyclists).

Bridges are usually illuminated and therefore, commercial power for the actuated warning beacon system can typically be obtained from the illumination service cabinet. Work with the ODOT Bridge Section if any conduit or wiring for the actuated warning system needs to go across the structure.

A custom control system using time-delay relays is used for these systems. Contact the Traffic Signal Engineer for assistance in designing the proper control system.

Figure 12-5 | Warning Beacon for a Warning Sign, Actuated Operation, Post Mounted

12.4.5 Actuated Warning Beacon – Tunnels

Actuated warning beacons for tunnels consists of an Oregon specific sign (OBW1-8) which has four 8 inch circular yellow indications within the sign boarder. See Figure 12-6 which shows sign OBW1-8 from the ODOT Sign Policy and Guidelines, Chapter 8. This sign assembly should be mounted overhead on the tunnel entrance, centered over the tunnel entrance. Ground mounted installations are not allowed.

A push button is the standard form of detection. Pushbuttons shall be provided according the requirements stated in Chapter 5, and located where they are easily accessible for all intended users (pedestrians and/or cyclists).

A custom control system using time-delay relays is used for these systems. Contact the Traffic Signal Engineer for assistance in designing the proper control system.

Tunnels are always illuminated and therefore, commercial power for the actuated warning beacon system can typically be obtained from the illumination service cabinet.

Figure 12-6 | Actuated Warning Beacon – Tunnel Signing

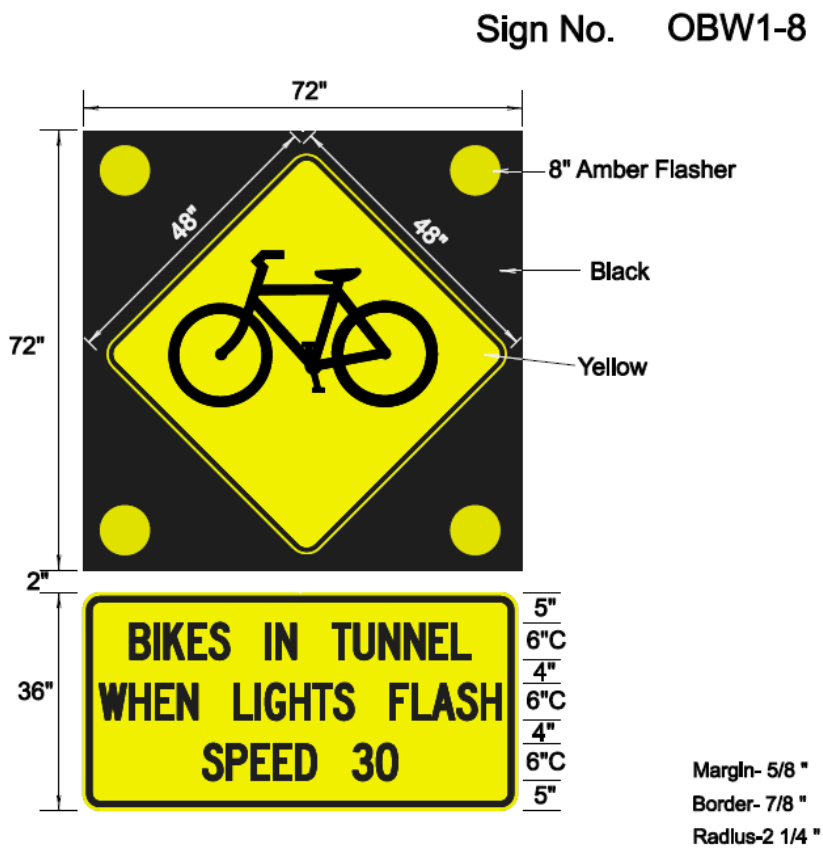


Figure 12-7 | Actuated Warning Beacon – Tunnel, Example 1

Figure 12-8 | Actuated Warning Beacon – Tunnel, Example 2

12.4.6 Actuated Warning Beacon – PREPARE TO STOP WHEN LIGHTS FLASH system

PREPARE TO STOP WHEN LIGHTS FLASH warning beacons are typically used in advance of a traffic signal, or a special application thereof, such as for a location of roadway that has poor sight distance and experiences frequent back-ups. They are also commonly used for moveable bridges (See Chapter 23 for more information on Movable Bridges).

PREPARE TO STOP WHEN LIGHTS FLASH warning beacons consist of an Oregon specific sign (OW15-14) with two Type 1Y signal heads located above the sign. See Figure 12-9 which shows sign OW15-14 from the ODOT Sign Policy and Guidelines, Chapter 4.

This assembly should be mounted overhead centered over the travel lane(s).

Figure 12-9 | Actuated Warning Beacon – Queue Detection, Example1

Sign No. OW15-14

Loop detection is the standard. Other forms of detection may considered (i.e. video, etc.) if deemed appropriate as per the guidance contained in chapter 6. The location of the detection and sign is critical to the proper operation of the beacons and is determined by an engineering study and documented in the STE Operational Approval.

If this type of system is used in advance of a traffic signal, it needs to be connected to the traffic signal controller.

If this type of system is NOT used in advance of a traffic signal, a custom control system using time-delay relays is used. Contact the Traffic Signal Engineer for assistance in designing the proper control system.

Figure 12-10 | Warning Beacon Supplementing a Warning Sign, Passive Activation Operation, Overhead

12.4.7 Actuated Warning Beacon – Mid-block Crosswalks

Actuated warning beacons for mid-block crosswalks are used at marked crosswalks where additional emphasis has been deemed necessary by an engineering study. The flashing beacon supplementing the pedestrian crossing sign is activated by the pedestrian, helping alert motorists that a pedestrian wants to (or is actively) crossing the roadway. This type of beacon is not used as much for new installations due to the effectiveness of newer technology (i.e. Rectangular Rapid Flashing Beacon - RRFB) which provides the same operation. However, the design requirements for an actuated warning beacon for mid-block crosswalk are less stringent than the requirements for an RRFB.

For ground mounted applications, one Type 1Y signal head is mounted directly above the sign on the support post. A second Type 1Y signal head may be mounted below the sign if desired. If solar power is used, the support post may be either a standard wood pole or a Perforated Steel Square Tube (PSST). There are two standard details, DET4681 (PSST) and DET4670 (wood post) that should be used. If commercial power is used, the support post is required to be a vehicle pedestal.

One assembly is required per approach, located on the right hand side of the roadway.

For overhead mounted applications, two Type 1Y signal heads are mounted on either side of the sign. A mast arm should be always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

A pushbutton is the standard form of detection. Pushbuttons shall be provided according to the requirements stated in Chapter 5.

Figure 12-11 | Warning Beacon for a Warning Sign, Actuated Operation, Ground Mounted

12.4.8 Actuated Warning Beacon – Emergency Vehicles

Actuated warning beacon for emergency vehicles are a good alternative to traditional fire signals (described in Chapter 17). They are less expensive and provide an accurate, advance warning to drivers that they need to yield to an emergency vehicle accessing the roadway.

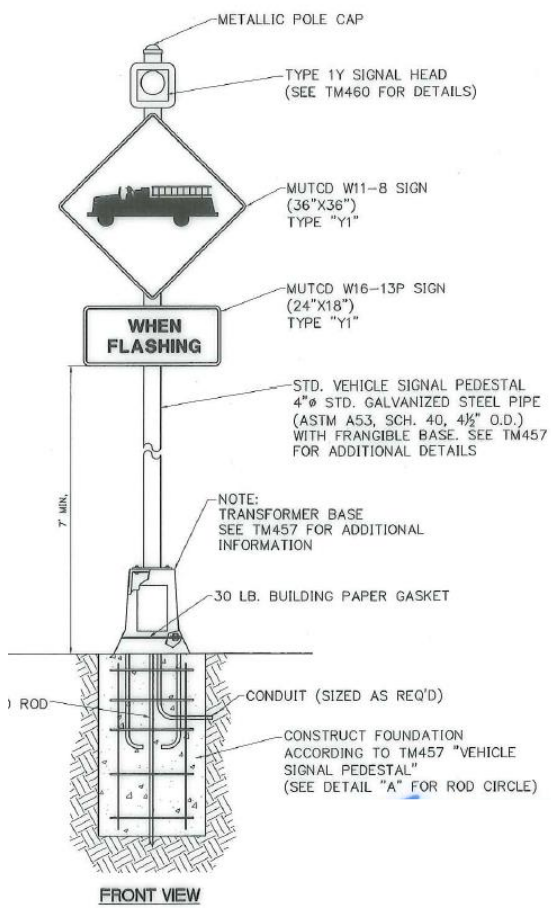
For ground mounted applications, one Type 1Y signal head is mounted directly above the sign on the support post. A second Type 1Y signal head may be mounted below the sign if desired.

One assembly is required per approach, located on the right hand side of the roadway.

For overhead mounted applications, two Type 1Y signal heads are mounted on either side of the sign. A mast arm should be always be used if feasible. Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum.

Contact the Traffic Signal Engineer for assistance in designing the proper control system.

Figure 12-12 | Warning Beacon for an Emergency Vehicle Sign, Actuated Operation, Ground Mounted



12.5 Rectangular Rapid Flashing Beacon (RRFB)

A rectangular rapid flashing beacon is different from an actuated warning beacon for mid-block crosswalk discussed in Section 12.4.7. The RRFBs operation is the same, but it uses a unique shape and flash pattern to supplement a W11-2 (Pedestrian) or S1-1 (School) crossing warning sign with a diagonal downward arrow (W16-7p) plaque only. Due to the unique features, an RRFB has very specific design requirements that don't apply a standard actuated warning beacon for a mid-block crosswalk.

12.5.1 MUTCD Interim Approval

The RRFB has been granted interim approval by FHWA. The signal designer should be familiar with the contents of the interim approval documentation, as some design elements have been specified. All of the design guidance provided in this chapter conforms to the FHWA interim approval requirements.

The interim approval and subsequent official interpretations can be found on the MUTCD website at: http://mutcd.fhwa.dot.gov/res-interim_approvals.htm

12.5.2 Device Assembly Requirements

The interim approval contains requirements for the device assembly itself, such as dimensions, flash rate, and light intensity. The Traffic Signal Standards Unit has prequalified RRFB assemblies that meet the device requirements listed in the interim approval and listed them on the "Green Sheets" (see Chapter 20 for more information on the Green Sheets).

The Pedestrian Signal Plan Sheet must contain a note that states, "Use Green Sheet Listed Systems Only" to ensure that appropriate equipment is specified and installed.

In addition, a "Details" plan sheet will also be required using the appropriate drawings contained in Standard Details DET4436 thru DET4438. These standard details contain drawings for several different installations, including mounting options (pedestrian pedestal, signal pole, vehicle pedestal or mast arm), and use options (one sided or two sided assemblies). Foundation information for pedestal mounting is also included. See Chapter 9 and Chapter 17 for more information on "Details" plan sheets and standard details.

12.5.3 Location of Assemblies

RRFBs are located at or immediately adjacent to an uncontrolled, marked crosswalk. For each approach on which RRFBs are used, two assemblies are required, one on the right-hand side of the roadway and one on the left-hand side of the roadway. On a divided highway or a roadway with a median island pedestrian refuge, the left hand side assembly should be installed in the median. The assemblies should be located at or immediately adjacent to the marked crosswalk.

12.5.4 Advance Sign Assemblies

Advance sign assemblies may be required if sight distance is not adequate to the crosswalk where the RRFBs are used. This requirement, if necessary, will be contained in the Operational Approval. These advance sign assemblies shall be activated and cease operation simultaneously with the RRFBs at the crosswalk location.

12.6 Speed Limit Sign Beacon

The only speed limit sign beacon that is allowed on the state highway system is for school speed zones, in accordance with Oregon Revised Statute 811.111.

Beacons for school speed zones consist of two Type 1Y signal heads (one mounted above the sign and one mounted below the sign) on a vehicle pedestal as shown in Standard Detail DET4416.

The location of this sign is determined as per the requirements shown in the ODOT Sign Policy and Guidelines, Chapter 7. Work with the Sign Designer and Region Traffic to ensure this sign is located correctly.

One option to be aware of for the school zone warning beacon is the use of a rear-facing Type 1Y signal head. The rear-facing beacon should be used in the situation where side road traffic (that DOES NOT have a warning beacon) enters from within the designated school zone.

Figure 12-13 | Speed Limit Beacon for School Speed Zone

12.7 Stop Sign Beacon

Stop sign beacons are installed above the STOP sign and can be an effective and less costly measure to install when compared to an intersection control beacon.

Stop sign beacons require one Type 1R signal head mounted directly above the sign on the support post. If solar power is used, the support post may be either a standard wood pole or a Perforated Steel Square Tube (PSST). There are two standard details, DET4681 (PSST) and DET4670 (wood post) that should be used. If commercial power is used, the support post is required to be a vehicle pedestal.

Figure 12-14 | Stop Sign Beacon

12.8 Intersection Control Beacon

Intersection Control Beacons are used at intersections to supplement the traffic control at the intersection. They are typically used if visibility of the intersection is poor or the type of intersection control is not readily apparent.

Intersection control beacons are always mounted overhead. Standard practice is to mount the flashing beacons on a mast arm pole. The beacons for all directions can then be mounted on a single mast arm. Strain poles and span wires can also be used if the intersection is too wide to be accommodated by a mast arm pole. Mast arm poles can be placed with arms oriented diagonally across the intersection. This may help to place the heads as close to the center of the intersection as possible. If strain poles are used, standard practice is to place two strain poles at opposite corners (diagonally) across the intersection. A tether cable is not required for flashing beacon installations.

Intersection control beacons typically have beacons that face each approach of the intersection. However, there may be cases where only the mainline approaches or only the side street approaches have beacons, as determined by the engineering study documented in the RTE Operational Approval. Each approach requiring beacons shall have 2 beacons:

- Type 1Y signal heads for free flow operation
- Type 1R signal heads for stop controlled operation

The red indication for stop controlled operations is only supplemental a STOP sign and therefore a STOP sign is required on each approach having a red flashing beacon. Flashing yellow indications shall not face conflicting vehicular approaches.

Clearances above the pavement are the same as for traffic signal heads, 18 feet minimum to 19 feet maximum. Lateral placement of the beacons should be as shown in Figure 12-15.

A Base Mounted Cabinet with Flasher option (BMCF) controls the operation. See Standard Drawing TM485 for the wiring diagram. ODOT uses a Model 204 Flasher, which provides two alternating flash circuits. Beacons are wired with one 7-conductor No. 14 AWG control cable for each direction (flash circuit).

Figure 12-15 | Intersection Control Beacon Placement

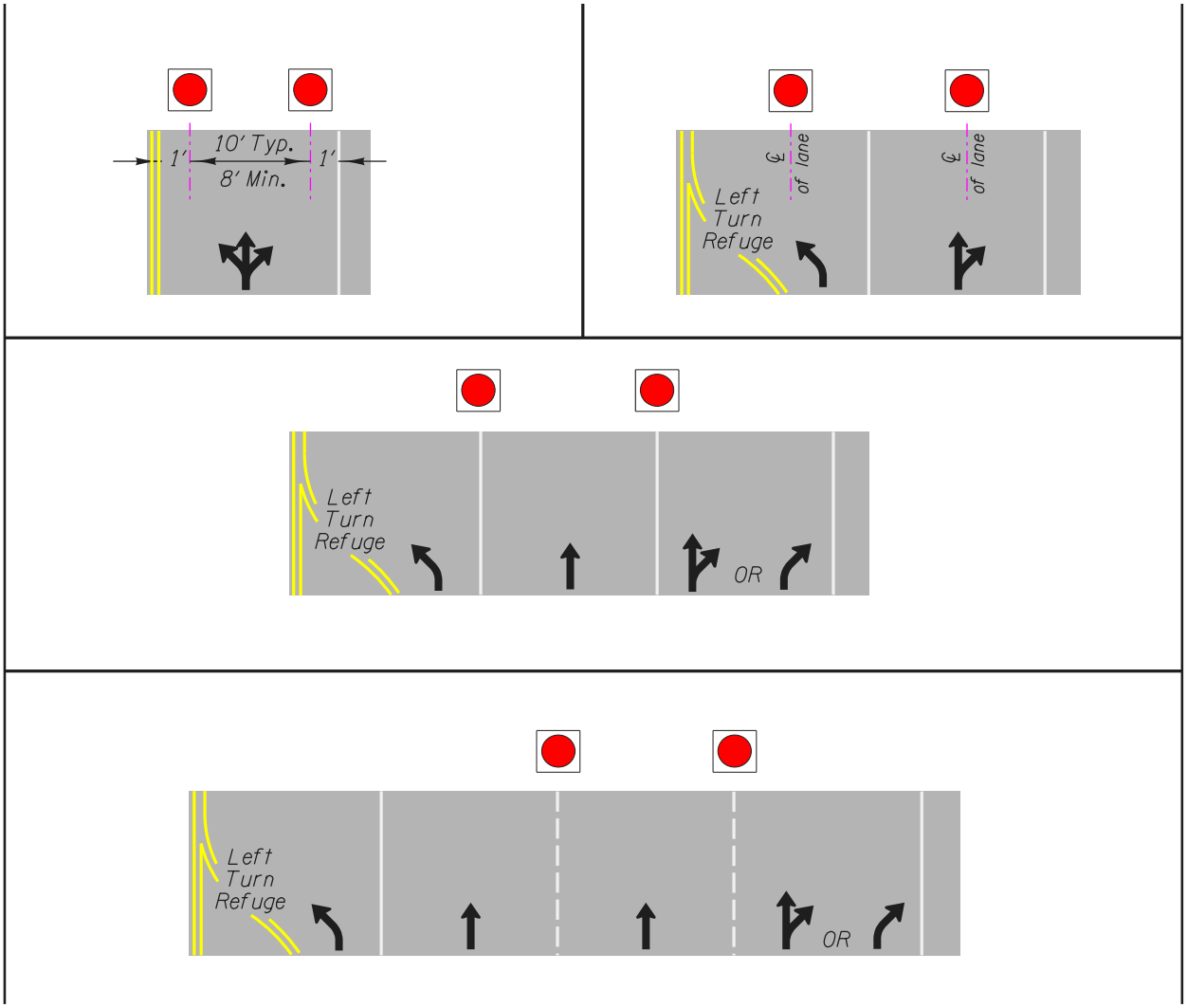
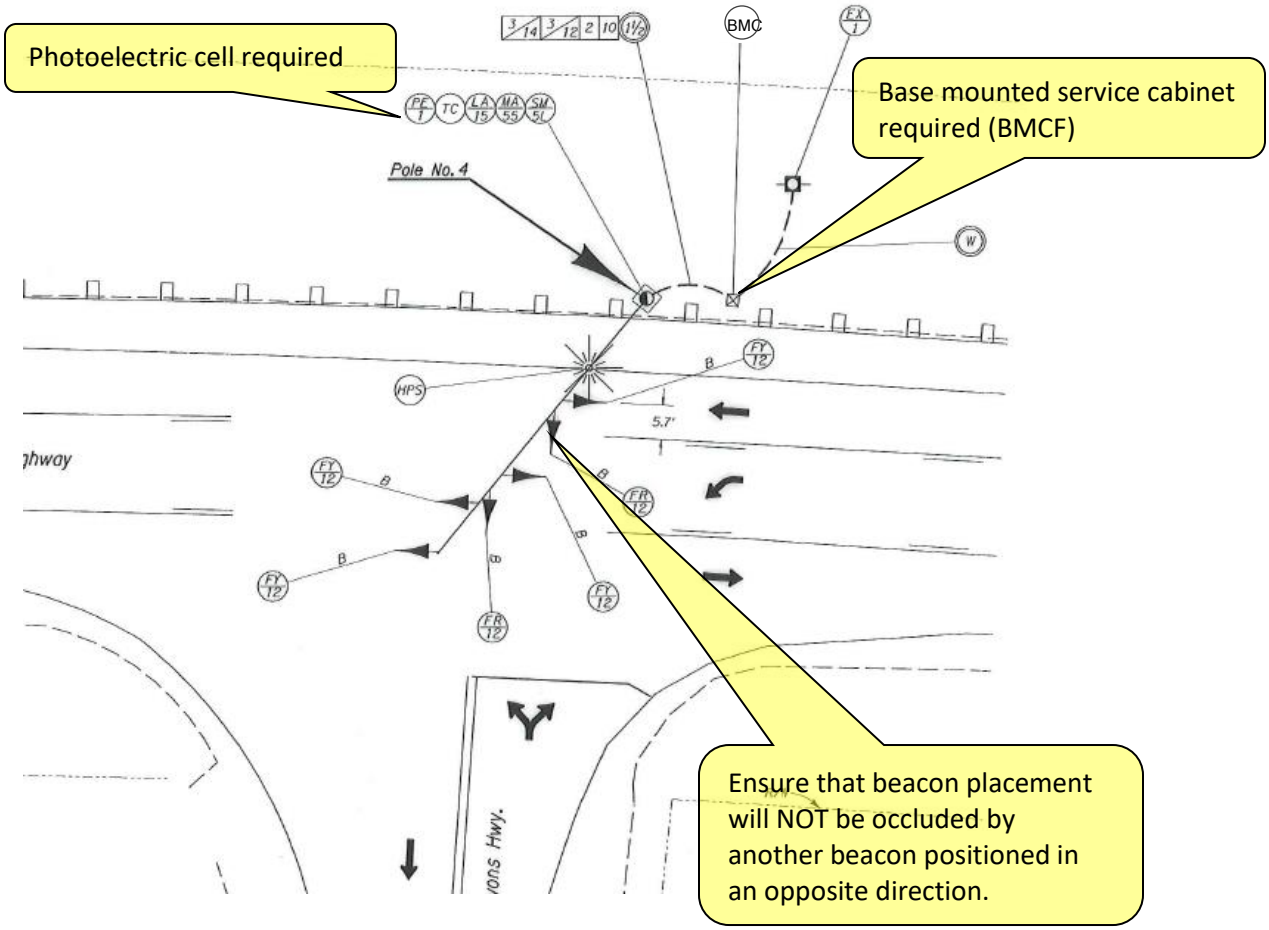


Figure 12-16 | Intersection Control Beacon, Mast Arm Example 1

Figure 12-17 | Intersection Control Beacon, Mast Arm, Example 2

Figure 12-18 | Intersection Control Beacon, Span Wire, Example 3

Figure 12-19 | Sample Flashing Beacon Installation Plan



12.9 Pedestrian Hybrid Beacon

A pedestrian hybrid beacon is a special type of beacon that is used to both warn and control traffic at an unsignalized location to help pedestrians cross the roadway. See Chapter 4F of the MUTCD. To date, only one pedestrian hybrid beacon has been installed on the state highway system during the experimental phase, predating the 2009 MUTCD guidance.

A pedestrian hybrid beacon should NOT be installed within 100 feet of a side street or driveway controlled by a STOP or YIELD sign.

12.9.1 Signal Indications

Two type 10 signal heads are required per approach. These can be installed overhead or ground mounted depending on the site conditions.

Overhead placement of both type 10 signal heads is required for the following conditions:

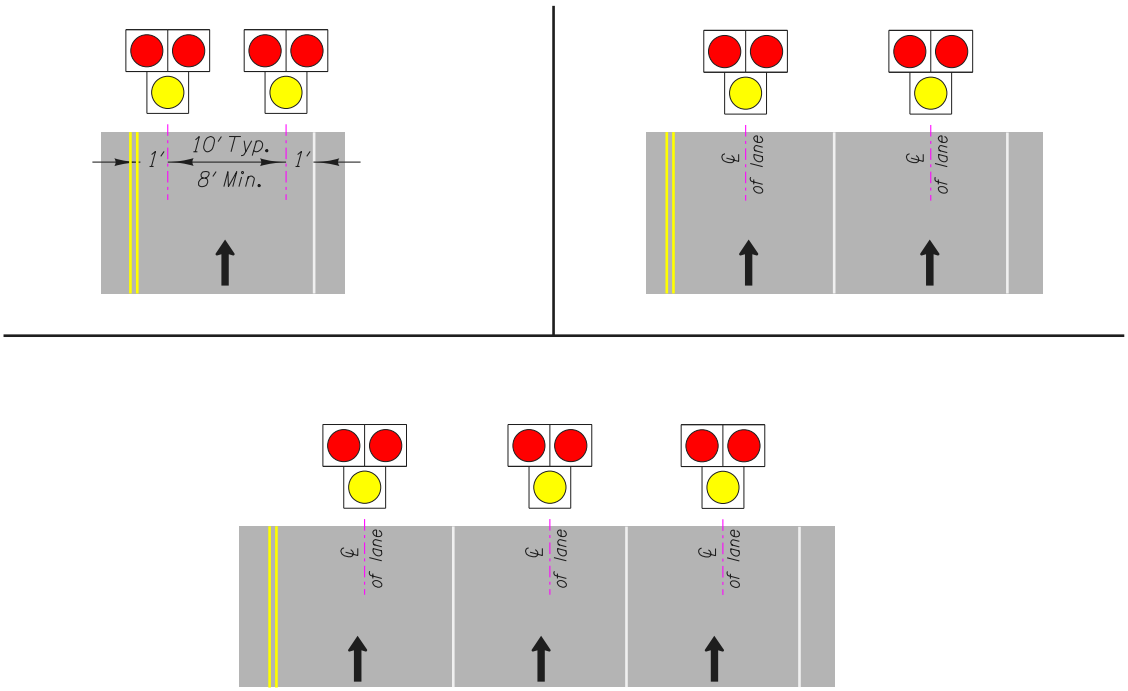
- the posted speed is greater than 35 mph
- the posted speed is 35 mph or less on a two-way facility and there is NOT a median of sufficient width
- the approach has 3 or more lanes
- where traffic or operating conditions may obscure visibility of a ground mounted installation

If the heads are ground mounted on a two-way facility, a median island of sufficient width (6 feet or greater) is required to accommodate proper placement of the signal head located on the left-hand side of approaching traffic.

If the approach has 3 or more lanes, a type 10 signal head centered in each lane is required.

Pedestrian signal indications and push buttons shall be provided according to the requirements stated in Chapter 5.

Figure 12-20 | Overhead Placement of Type 10 Signal Heads



12.9.2 Controller and Service

Pedestrian hybrid beacons use a standard base mounted service cabinet and 332S signal controller cabinet with a 2070 controller.

12.9.3 Poles

If mounted overhead, standard mast arm poles should be used. If ground mounted, vehicle pedestals should be used.

12.9.4 Striping and Signing

Pedestrian hybrid beacons require a marked crosswalk with a stop line installed at least 45 feet in advance.

A minimum of one CROSSWALK STOP ON RED (R10-23) sign per approach shall be mounted adjacent to the type 10 signal head.

Figure 12-21 | Pedestrian Hybrid Beacon – Overhead Mounted, Example 1

Figure 12-22 | Pedestrian Hybrid Beacon – Ground Mounted, Example 2

13 RAMP METERS

This chapter discusses only ramp meter specific design information. Other general information that also may also pertain to ramp meters (e.g. signal wiring, detection, etc.) can be found in the previous chapters of this manual.

Installation of a new ramp meter or modification of an existing ramp meter requires Region Traffic Engineer Operational Approval as per chapter 3.

13.1 Ramp Meter Operation

Ramp meters are used to control the frequency of traffic entering a highway facility. By controlling the rate of vehicles entering the highway, the traffic flow on the highway facility becomes more consistent and allows for more efficient use of existing highway capacity. They are programmed to release one vehicle at a time. Just prior to activating, the ramp meter indications will flash yellow (from the yellow indication of the Type 2 signal head) for a short, predetermined amount of time to warn traffic that the ramp meter is starting up. The ramp meter will then display a solid yellow interval followed by an all red interval prior to the start of the normal red-green alternating ramp meter cycle.

For ramp meters that control two or more lanes of traffic, each indication for each lane must operate on a separate phase to properly alternate the red-green phase between each lane.

Ramp meters remain dark when not in use.

13.1.1 Location of the Ramp Meter Stop Line

The location of the ramp meter stop line is determined by engineering judgment. Each ramp alignment is unique and the site specifics play a major role in determining the most appropriate location. The basic goal is to place the stop line far enough down the ramp to provide reasonable storage of vehicles but not so near the highway that acceleration and merging onto the highway becomes a problem. Some things to consider determining the most appropriate location:

- Design Hour Queue Length: The operational analysis and RTE Operational Approval will determine the required length for storage.
- Ramp alignment length (from ramp entrance to the painted gore point): the ramp alignment length should accommodate the design hour queue length if possible.
- Number of lanes controlled by the ramp meter: The number of lanes needed will be addressed in the operation analysis and RTE Operational approval. This will directly affect the required queue length. Single and dual lane ramp meters are common.
- The vertical grade: A downhill vertical grade will allow the stop line to be placed closer to the highway, while an uphill vertical grade will require additional space between the stop line and the merge point.

- The length of acceleration lane (from painted gore point to the downstream acceleration lane taper point): A standard length acceleration lane will allow the stop line to be placed closer to the highway, while a substandard length acceleration lane may require additional space between the stop line and the merge point.
- Sight distance from stop line to the highway: The location where vehicles stop should have adequate sight distance to the highway to help facilitate a safe and efficient merge.
- Percentage of truck traffic using the ramp: Trucks require more distance to come up to speed and may require additional space between the stop line and the merge point.

Work with Region Traffic and the roadway designer when determining the appropriate location.

13.2 Ramp Meter Signal Indication Mounting

There are two choices for mounting ramp meter signal indications; vehicle pedestal and overhead (mast arm). The vehicle pedestal mount is typically used unless there is a specific reason that requires an overhead mount, such as:

- The ramp meter will control <u>more</u> than 2 lanes of traffic. See Figure 13-1 for an example.

- The ramp meter will control 2 lanes of traffic with the stop line located beyond the physical gore point of ramp. See Figure 13-2 for an example.

- Physical constraints prevent proper location of pedestal(s), such as: retaining walls, bridges, barrier, sound walls, etc.). See Figure 13-3 for an example.

Figure 13-1 |Ramp Meter Controls More Than 2 lanes of Traffic – Requires Overhead Mount

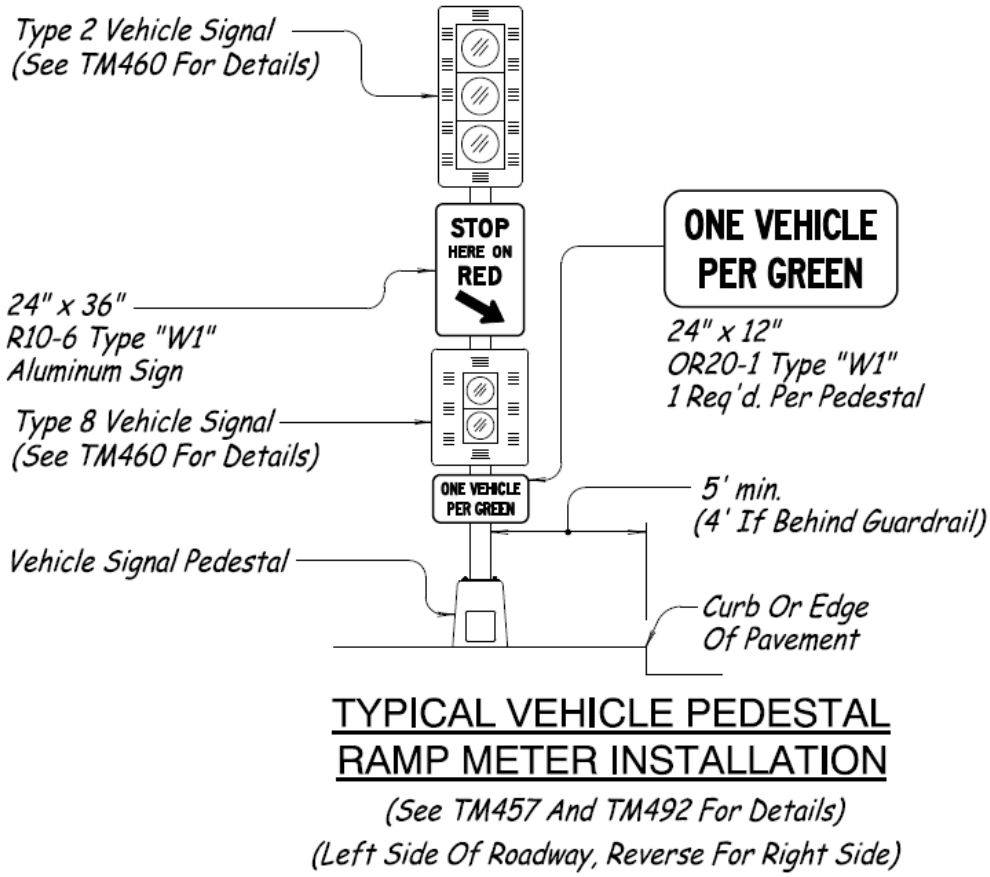
Figure 13-2 |Ramp Meter Controls 2 lanes of Traffic with Stop Line Located Beyond Physical Gore Point – Requires Overhead Mount

Figure 13-3 | Physical Constraints (Barrier on Left Hand Side) - Requires Overhead Mount

13.2.1 Pedestal Mounted Assembly

The ramp meter indications mounted on a vehicle pedestal includes the following four components as per standard drawing TM492 (listed from top to bottom of pedestal): A Type 2 vehicle signal head, a “STOP HERE ON RED” aluminum sign, a Type 8 vehicle signal head, and a “ONE VEHICLE PER GREEN” aluminum sign. See Figure 13-4.

Figure 13-4 | Ramp Meter Pedestal Mounted Assembly (Std. Dwg. TM497)



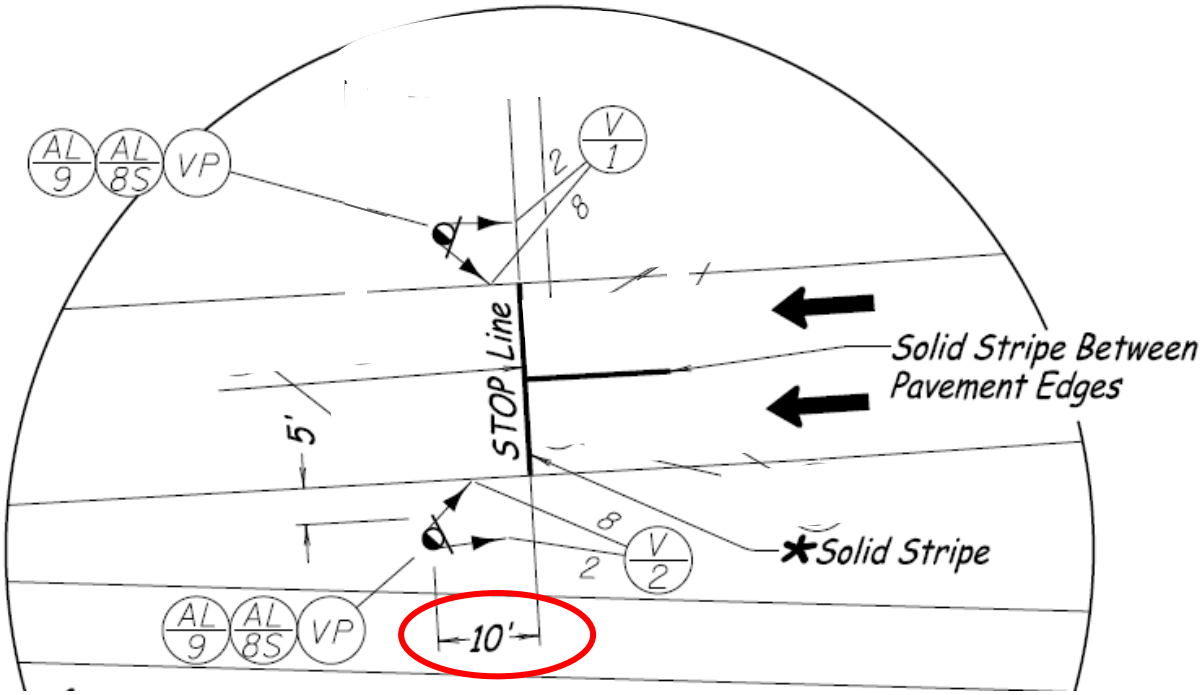
For a ramp meter that will control a single lane of traffic, this pedestal assembly is required only on the right-hand side for a ramp. See Figure 13-5. For a ramp meter that will control two lanes of traffic, this pedestal assembly is required on both the sides of the ramp. See Figure 13-6.

Figure 13-5 |Ramp Meter Pedestal Mounted Assembly Example – Controlling a Single Lane of Traffic

Figure 13-6 |Ramp Meter Pedestal Mounted Assembly Example – Controlling Two Lanes of Traffic

The pedestal mounted assembly is placed 10 feet from the stop line location.

Figure 13-7 | Location of Pedestal Mounted Assembly from the Stop Line



13.2.2 Overhead Mounted (Mast Arm)

Overhead mounted ramp meter signals require a Type 2 vehicle signal head and an aluminum "ONE VEHICLE PER GREEN" sign for each lane that is controlled by the ramp meter. The "ONE VEHICLE PER GREEN" sign used overhead is 24"x30". Type 8 heads are NOT used when indications are mounted overhead. The overhead signal indications are located 55 feet from the stop line. Two aluminum "STOP HERE ON RED" signs are located at the stop line, one on each side of the ramp. See Figure 13-8 and Figure 13-9 for an example.

Figure 13-8 | Overhead Mounted Details

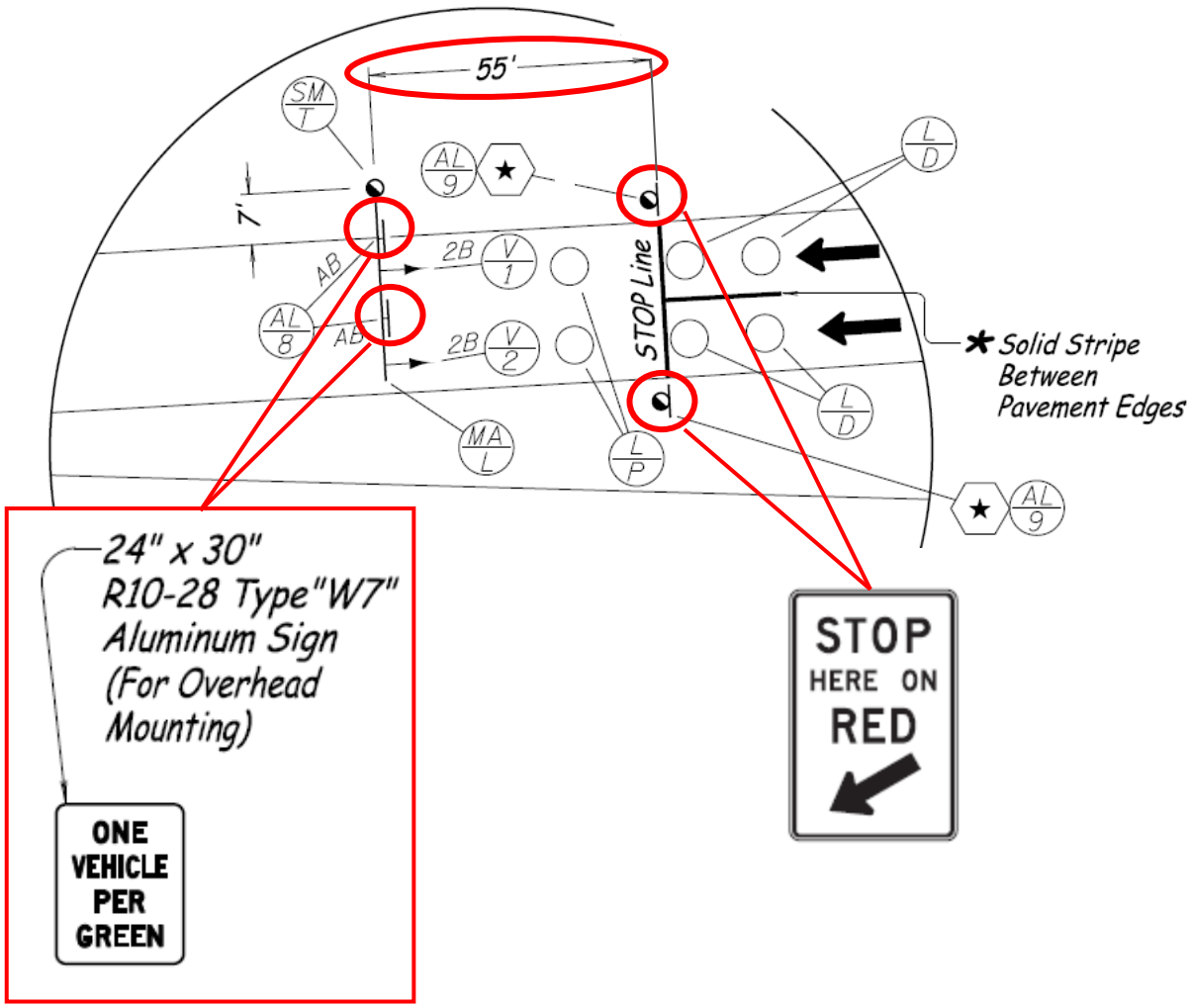
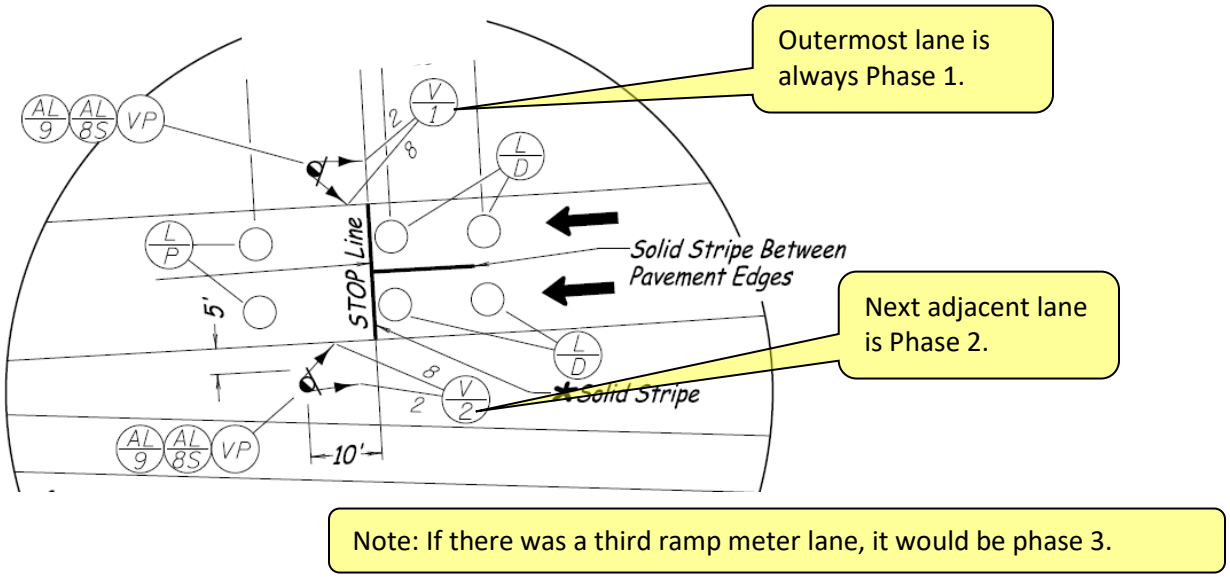


Figure 13-9 | Overhead Mounting Example

13.2.3 Ramp Meter Phasing

Each lane controlled by the ramp meter will be assigned a unique phase, starting with phase 1. When two (or more) lanes are controlled by the ramp meter, Phase 1 is always the outermost lane of the ramp, which each adjacent lane towards the highway being assigned the next consecutive phase. See Figure 13-10.

Figure 13-10 | Ramp Meter Phasing



13.3 Ramp Meter Signs

The standard layout for ramp meter signing is shown below. Starting at the ramp terminal and going forward toward the painted gore point, the following signs should be used (See Figure 13-11 thru Figure 13-13):

- "RAMP METERED WHEN FLASHING" aluminum sign with flashing yellow beacon: This sign is required for all ramp meter installations. It is located at the entrance to the ramp and it must be visible to each legal move that enters the ramp. This may require more than one sign depending on the ramp terminal geometry. This sign is intended to provide warning before the motorist commits to entering the ramp, allowing the motorist to seek an alternate route if desired.

  This sign is mounted on a pedestrian pedestal as per standard drawing TM492. It is detailed on the Ramp Meter plan sheet and paid for under the Ramp Meter lump sum bid item.

- "BE PREPARED TO STOP" aluminum sign with flashing yellow beacon and "WHEN FLASHING" rider: This sign is required if there is not adequate sight distance to the ramp meter signal indications. The need for this sign will be documented in the RTE operational approval. It is located upstream from the anticipated queue length. Two signs (one on each side of the ramp) required.

  This sign is mounted on a pedestrian pedestal. It is detailed on the Ramp Meter plan sheet and paid for under the Ramp Meter lump sum bid item.

- "FORM 2 LANES WHEN METERED" aluminum sign: This sign is required only for single lane ramps with ramp meters that control two lanes of traffic. It is located upstream from the anticipated queue length. Two signs (one on each side of the ramp) required.

  This sign is mounted on an appropriate standard sign support (i.e. wood post or square tube sign support). It is detailed on the Signing plan sheet (NOT on the Ramp Meter plan sheet) and is measured and paid for under the applicable sign and post bid items.

- "STOP HERE ON RED" aluminum sign: This sign is required at the stop line. If the ramp meter only controls one lane of traffic, only one of these signs on the right side of the ramp is required. For all other applications, two of signs are required, one on each side of the ramp.

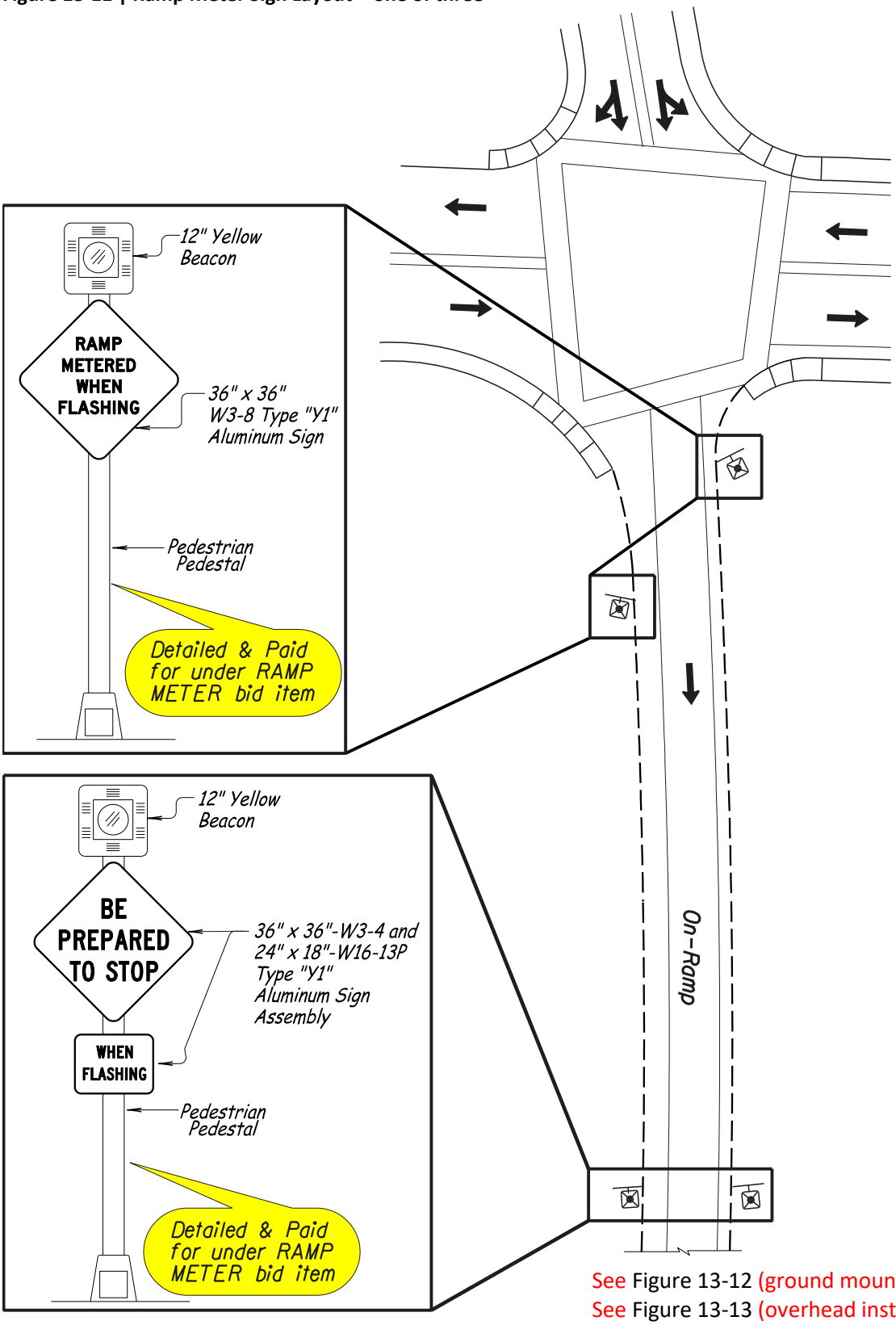
  For ground mounted installations, this sign is part of the standard ramp meter assembly which is detailed on the Ramp Meter plan sheet and paid for under the Ramp Meter lump sum bid item.

For overhead mounted ramp meters, this sign is ground mounted at the stop line on an appropriate standard sign support (i.e. wood post or square tube sign support) which is detailed on the Signing plan sheet (NOT on the Ramp Meter plan sheet) and is measured and paid for under the applicable sign and post bid items.

- "ONE VEHICLE PER GREEN" aluminum sign: This sign is required for all installations, one for each lane of traffic controlled by the ramp meter. For ground mounted ramp meter installations, this sign is a part of the standard ramp meter assembly. For overhead mounted ramp meters this sign is installed with an adjustable sign bracket adjacent to each signal indication. In both cases, it is detailed on the Ramp Meter plan sheet and paid for under the Ramp Meter lump sum bid item.

Other signs on the ramp (i.e. merge, lane transition, curve w/advisory speed, etc.) will need to be taken into consideration when locating the signs and equipment specific to the ramp meter. Work with the Region sign designer.

Figure 13-11 | Ramp Meter Sign Layout – one of three



See Figure 13-12 (ground mounted installation)
See Figure 13-13 (overhead installation)

Figure 13-12 | Ramp Meter Sign Layout – two of three (ground mounted ramp meter installation)

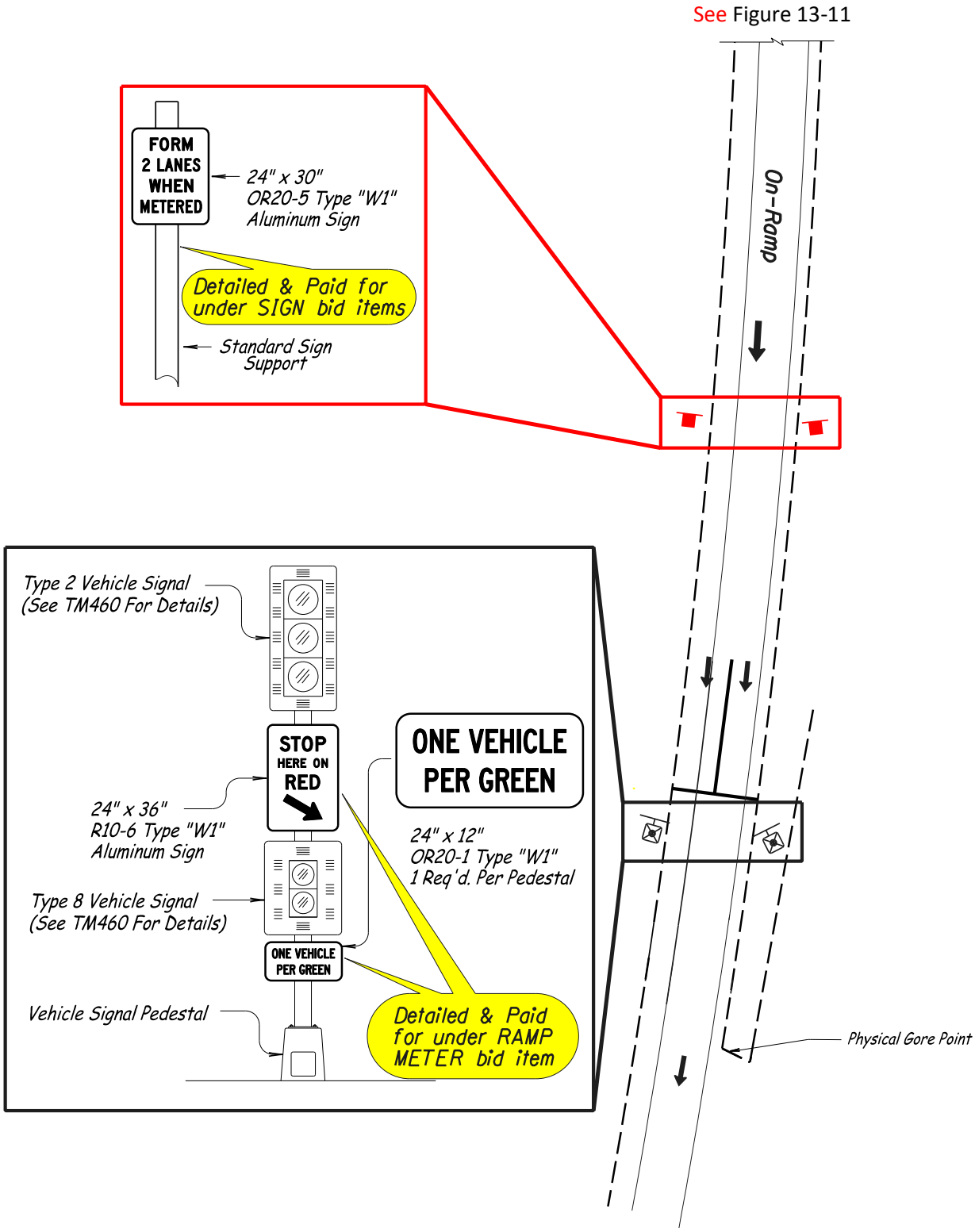
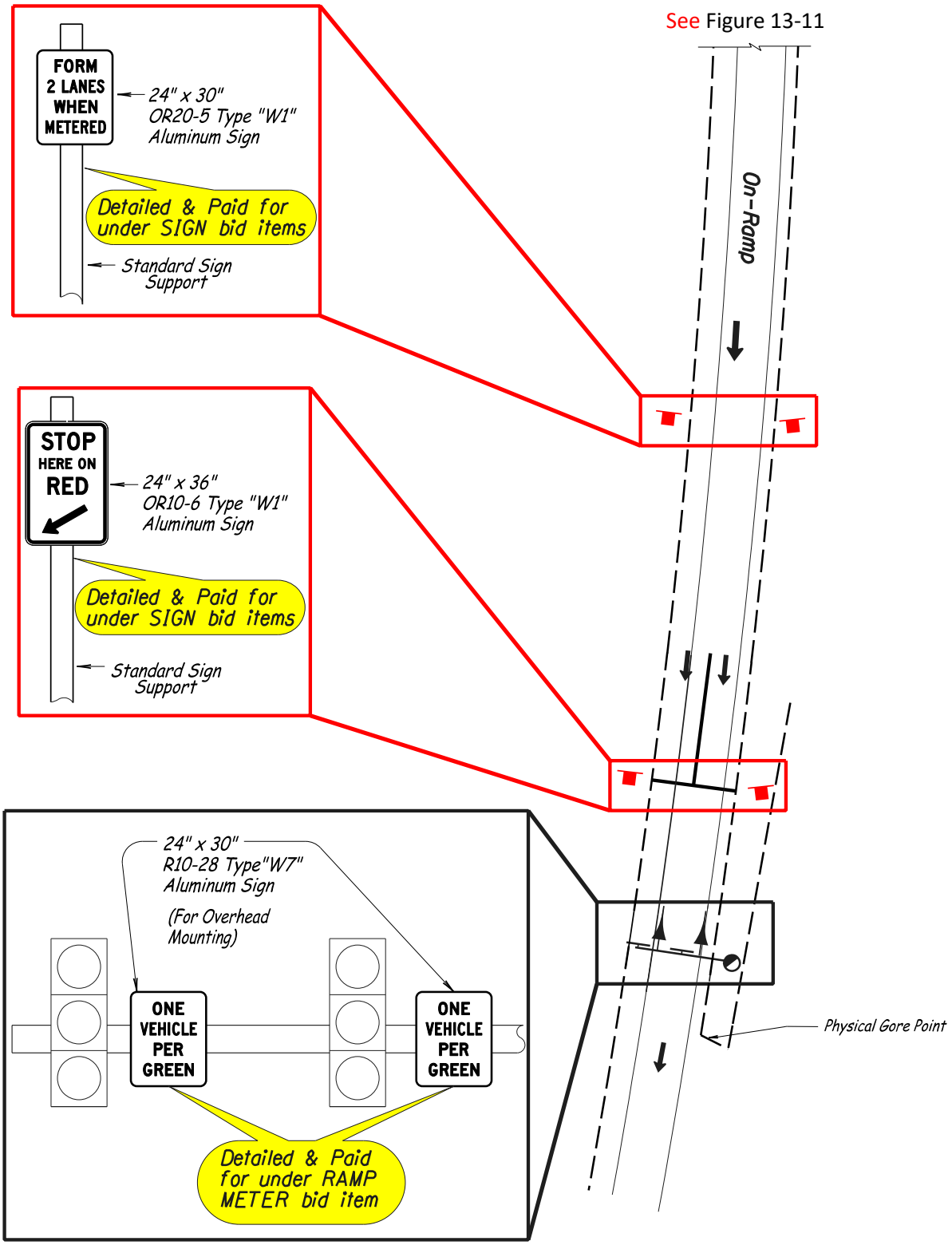


Figure 13-13 | Ramp Meter Sign Layout – three of three (overhead ramp meter installation)

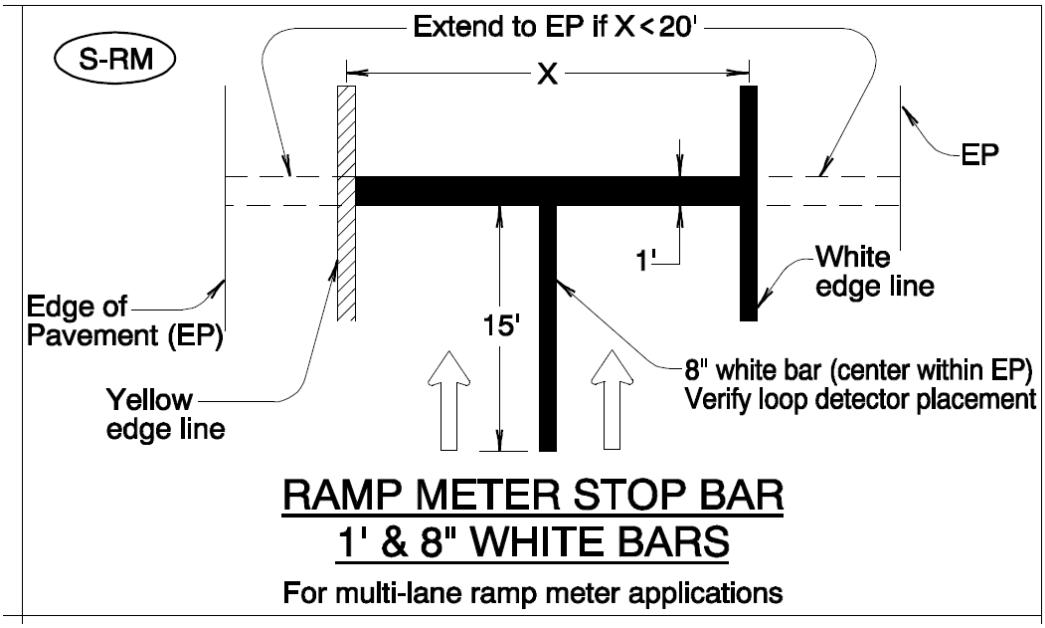


13.4 Ramp Meter Striping

The ramp meter requires a stop line. For single lane ramps with a ramp meter that controls two lanes, an 8” wide white line is extended back from the stop line as per Standard Drawing TM503, detail “S-RM”. See Figure 13-14.

Ramp meter striping is detailed on the striping plans and paid for under the striping bid items. Work with the striping designer.

Figure 13-14 | Ramp Meter Striping (TM503)



13.5 Ramp Meter Cabinets and Controllers

Ramp metering devices are controlled by an ATC controller in a model 334 ground-mounted controller cabinet. The ATC controllers are agency supplied and purchased by the agency through a price agreement managed by ITS.

The service cabinet for ramp meters is the standard base mounted service cabinet (BMC) that is also used for traffic signals.

The controller cabinet and service cabinet should be located near the ramp meter signal indications for ease of maintenance and operational convenience. Include a maintenance landing pad for maintenance vehicle access near the controller (See Standard Drawing **RD160**).

13.6 Ramp Meter Detection

Radar detection is the standard form of detection for ramp meters. This section provides ramp meter detection specific information. Refer to Chapter 6 for more general information related to detection.

13.6.1 Detector Functions & Location

Ramp meter detection serves four different functions (see Figure 13-15):

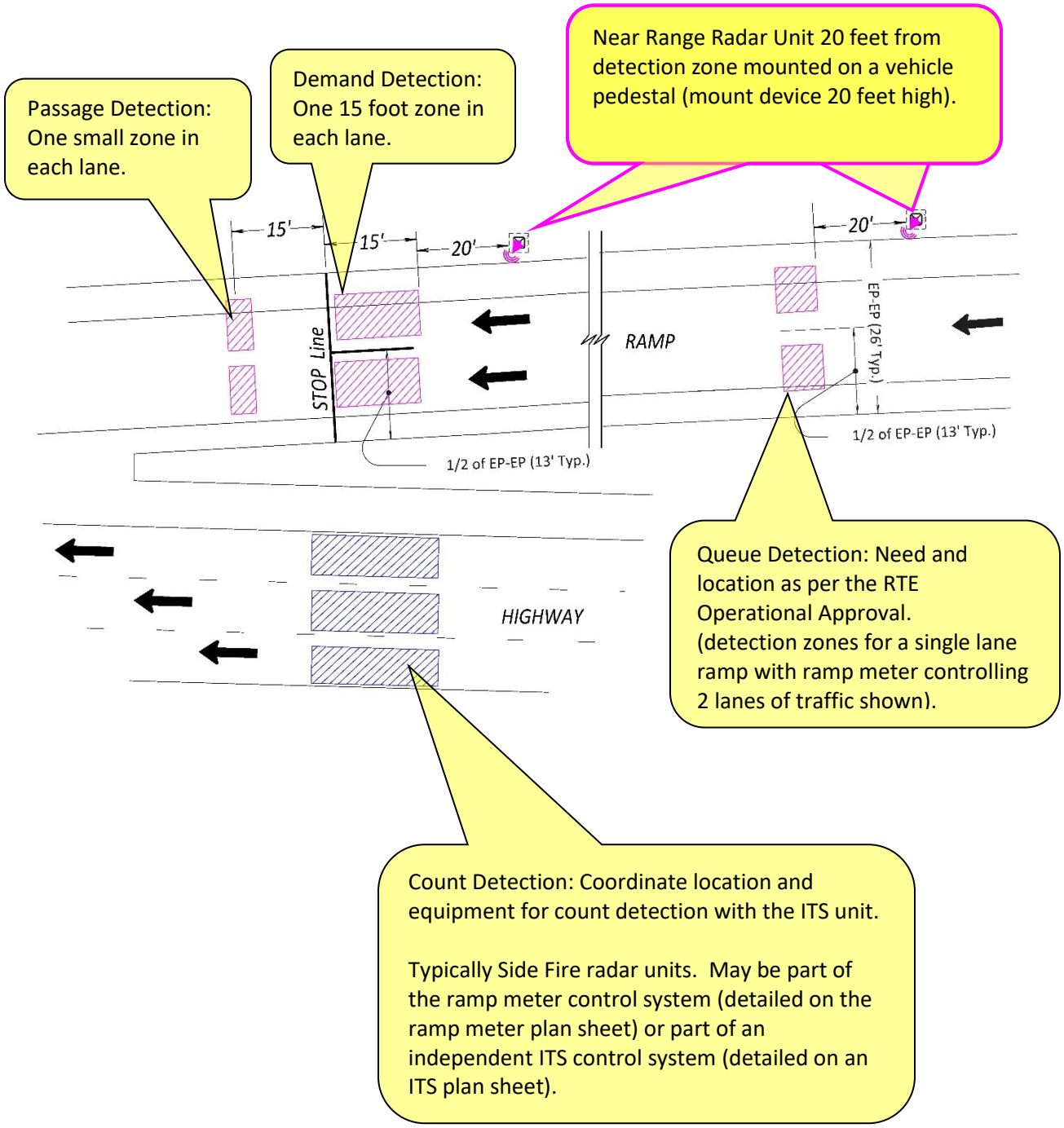
- Demand: This type of detection is 15 feet long and located at the stop line. It is used to place a call into the controller to bring up the green phase of the ramp meter cycle.

- Passage: This type of detection is a small zone located 15 feet downstream from the stop line. It is used count ramp meter traffic, perform truck extension, and violation extension.

- Count: This type of detection is located on the freeway main line. Typically this detection is installed prior to the ramp entrance point, but the exact location on the freeway is determined by the ITS unit. Coordinate with the ITS Unit for determining the count detection location, equipment, and responsibility for design work.

- Queue: This type of detection is a small zone located upstream of the stop line used to detect an extensive queue length. When an extensive queue length is detected (by a vehicle stopping on the queue detector for a pre-determined amount of time), the meter rate is increased as necessary to quickly dissipate the extensive queue. These queue detectors also activate the “BE PREPARED TO STOP” with “WHEN FLASHING” sign if one is present. The need for and location of this detection is determined by an engineering study, documented in the RTE operational approval.

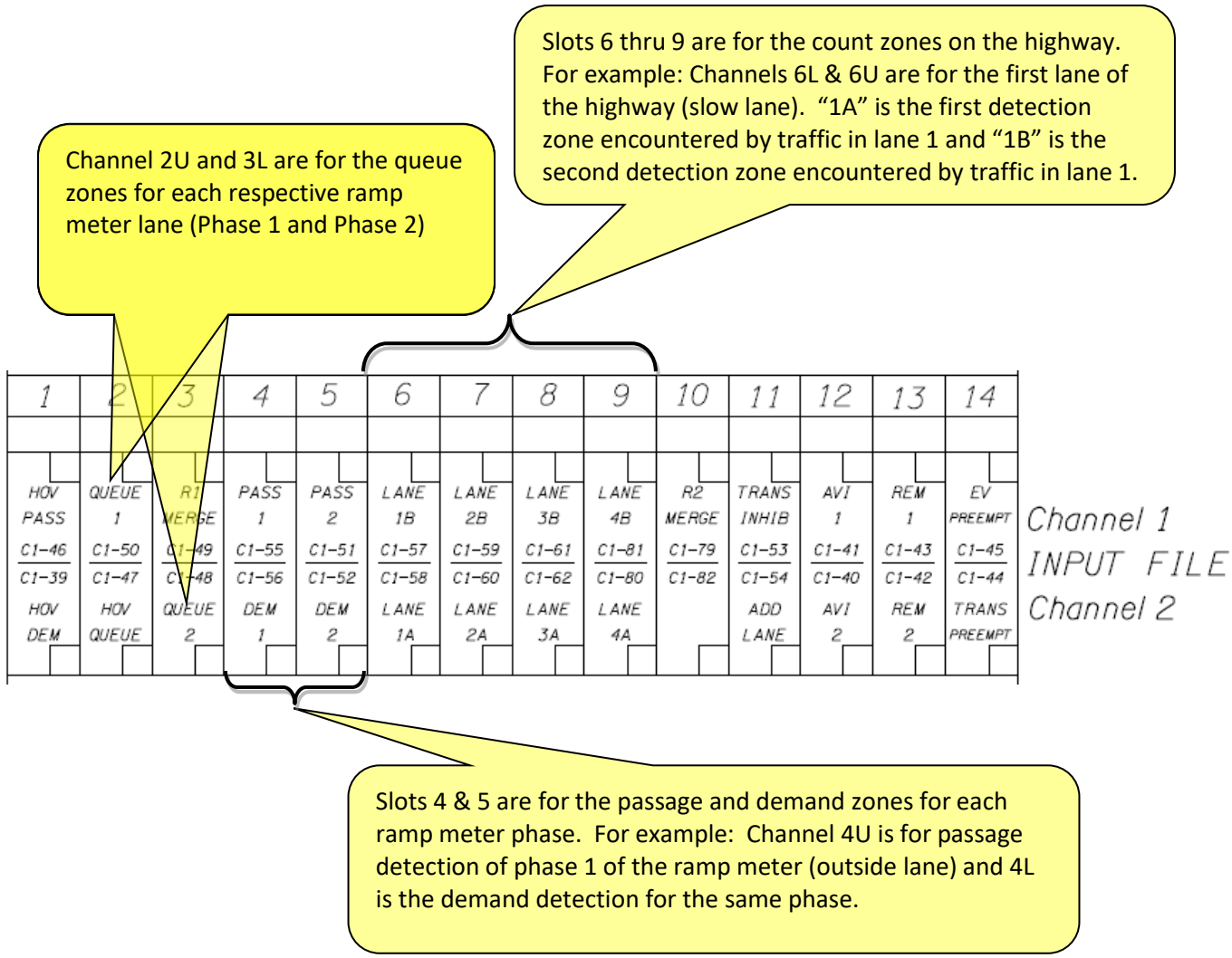
Figure 13-15 | Ramp Meter Detection – Function & Location



13.6.2 334 Controller Cabinet Input Detection File

An SDLC connection is the default standard. When an SDLC connection is used, the input file will remain blank on the cabinet print. See Chapter 6 and chapter 20 for more information. Figure 13-16 shows the 334 controller cabinet detector input file, with the standard termination layout for each ramp meter function if SDLC is not used.

Figure 13-16 | 334 Controller Cabinet Input Detection File



13.6.3 Detector Wiring Diagram

The detector wiring diagram for a ramp meter is no longer needed on the ramp meter plan sheet when non-invasive detection (radar) is used. The ramp meter timer will configure and document the detection zone set up. If not using SDLC, coordinate with the ramp meter timer to ensure that the cabinet print accurately reflects the appropriate equipment in the input file.

14 PEDESTRIAN SIGNAL PLAN

14.1 General

A pedestrian signal is a very specific type traffic signal, typically installed mid-block, consisting of Type 2 signal heads to control vehicles and pedestrian signals with push buttons to control pedestrians. The signal heads remain green until the push button is activated. Vehicle actuation may be present to better protect the dilemma zone, but often no vehicular detection is used. A few pedestrian signals have been installed in the past, but are no longer allowed on the state highway system because other types of devices are now be used to aid pedestrians crossing the roadway, such as rectangular rapid flashing beacons (RRFB) and pedestrian hybrid beacons. See Chapter 12 for more information on RRFB and pedestrian hybrid beacons.

Pedestrian signals have also been installed at intersections and are more commonly referred to as “half-signals”, as the mainline traffic is controlled by signal indications that cycle based on pedestrian actuations while the side street traffic is controlled by STOP signs. Half-signals are prohibited on the state highway system.

The “pedestrian signal” plan sheet title name should not be used, and is retained only for historical and archiving purposes. Many of the of the archived plans classified as pedestrian signal plan sheets are actually overhead continuous operation warning beacons with pedestrian crossing signs, not true pedestrian signals.

For reference, three examples of pedestrian signals are shown in the following figures.

Pedestrian signals and Half-signals are PROHIBITED on the State Highway.

Figure 14-1 | Pedestrian Signal Installed at Intersection (Half-Signal), Example 1

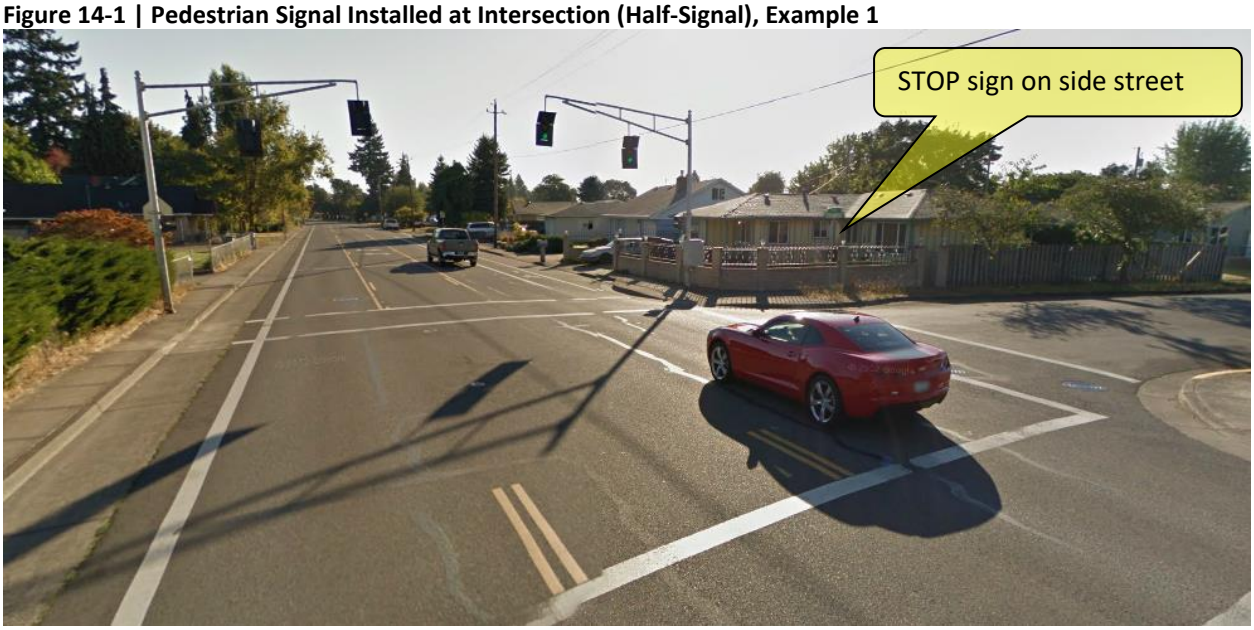
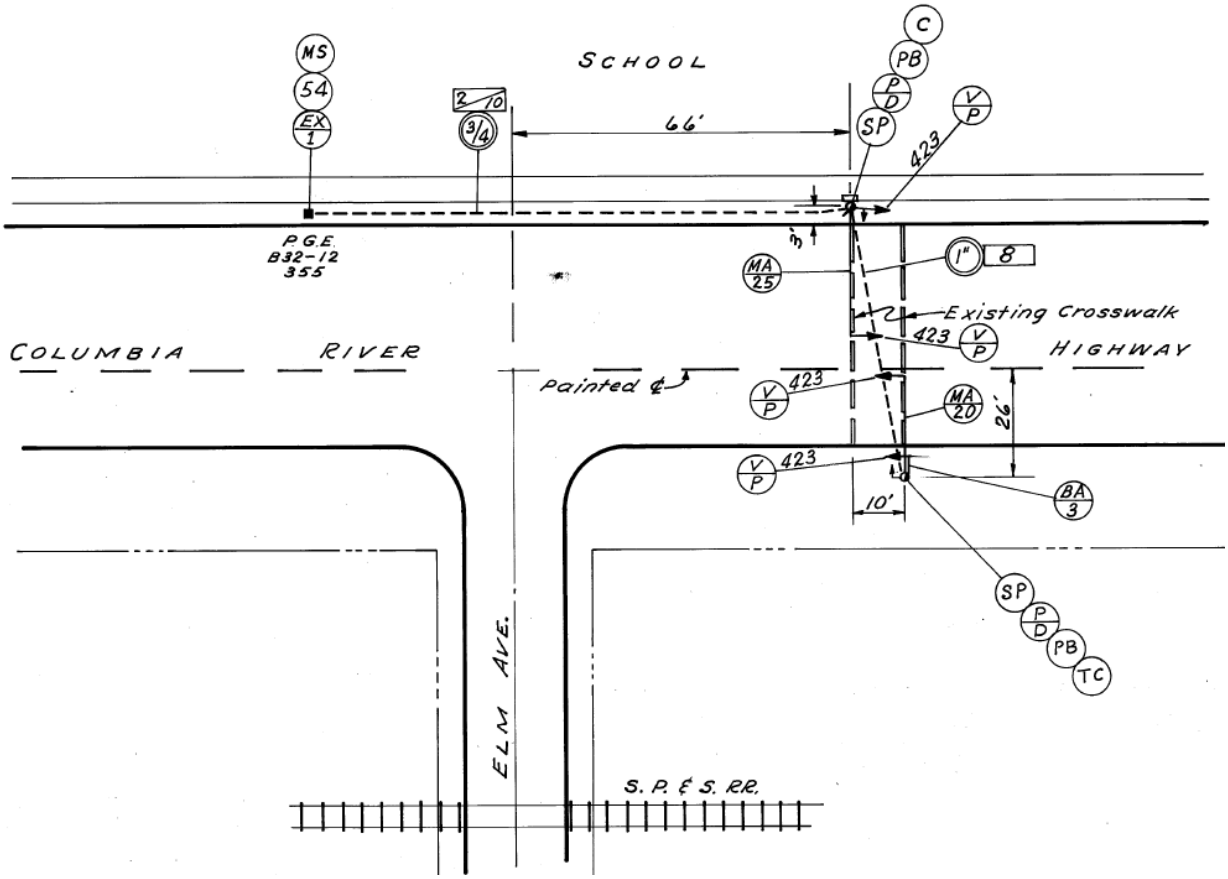


Figure 14-2 | Pedestrian Signal Installed Mid-Block, Example 2

Figure 14-3 | Pedestrian Signal Installed Mid-Block (plan sheet from the 1970's), Example 3



15 RED LIGHT ENFORCEMENT PLAN

15.1 General

This chapter will discuss red light enforcement plan details from two perspectives; the ODOT signal designer and the third party signal designer:

- Typically the ODOT signal designer will have a very minimal amount of involvement associated with this type of plan sheet because red light enforcement plans are ALWAYS designed by third parties and constructed under the district permit process. The role of the ODOT signal designer will range from no involvement at all to just design review.

- The third party signal designer is responsible for designing and producing the plan sheet.

15.2 Operation and Approvals

The installation of a red light running system requires STRE Operational Approval. See the current version of the "Red Light Running (RLR) Camera Guidelines for State Highways" for more information on conducting the engineering study, the Operational Approval process, and standard conditions of approval.

The plan sheets require Design Approval as per Chapter 2.

15.3 When is a Plan Sheet Required?

A red light running plan sheet is required for all intersections where this technology will be used. A plan sheet is also required if the red light running system is removed. These plan sheets are always designed by a third party that is affiliated with the company providing the red light running equipment. ODOT signal designers do not design red light enforcement systems. While ODOT has ownership of the intersection and signal equipment within right-of-way, the red light running equipment is NOT owned or maintained by ODOT.

15.4 Mitigation Requirements

Prior to installation of a red light running system, modifications to the traffic signal design may be required as a means to improving intersection safety. These modifications, if needed, shall be shown in a "Signal Plan" sheet that is separate from the "red light enforcement" plan sheet. The modifications typically include the following:

- Change in the number, size and/or location of the vehicle signal heads
- Enforcement "tattle tale" lights
- Speed zone changes (which may result in loop detector placement changes)

15.5 Red Light Running Signing

Installation of a red light running system requires specific signing on all major routes entering the jurisdiction and near the location where each camera is installed. These signs should be shown in a signing plan sheet. See the current version of the "Red Light Running (RLR) Camera Guidelines for State Highways" and the "ODOT Sign Design Manual" for more information.

15.6 Construction

Installation of a red light running system is always constructed under the district permit process.

15.7 Separation of Systems

The traffic signal system and the red light running system are required to be completely separate from each other. The only exception is current clamps (and wiring from the current clamps) that are used inside the traffic signal controller around the field output wires that enable the red light running system to determine which signal indication is on. A current clamp is an electrical device having two jaws which open to allow clamping around an electrical conductor. This allows properties of the electric current in the conductor to be measured, without having to make physical contact with it, or to disconnect it for insertion through the probe.

The wiring from the current clamps then exits the signal controller cabinet through a conduit to the first junction box. These wires do not have to be in a separate conduit if there is enough room in an existing conduit with traffic signal wiring. From the junction box closest to the signal controller cabinet, **every** piece of equipment used for the red light running system (cameras, conduit, wiring, detection, etc.) shall be separated from the traffic signal equipment. For example, the following scenarios are not allowed:

- Placement of red light running equipment on a traffic signal mast arm or pole
- Placement of red light running wiring in conduits and junction boxes that are used for the traffic signal. EXCEPTION: the junction box nearest the signal controller cabinet and the conduit between the two)
- Use of the power to the traffic signal. EXCEPTION: unless ODOT District authorizes the use. In the case where the red light running system power is provided by the traffic signal, it must be on its own clearly identified circuit breaker.

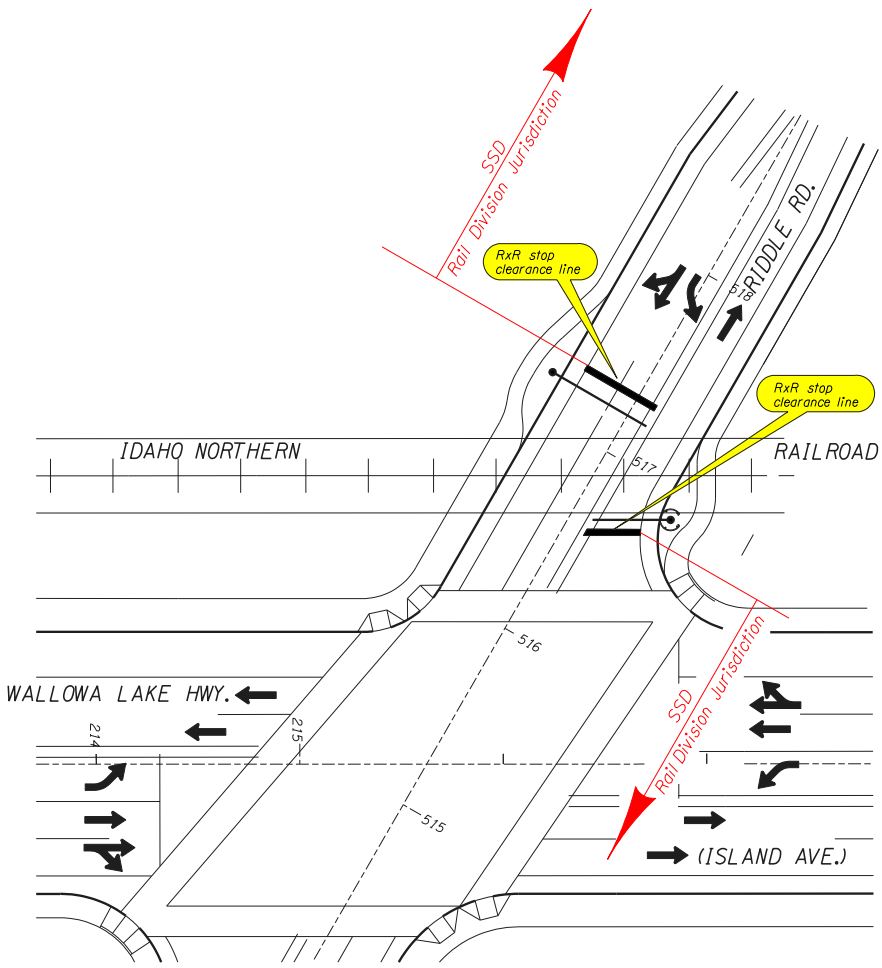
15.8 Removal of Red Light Running Systems

If removal of the system is required, a "Red Light Enforcement" plan sheet is required showing the removal of the equipment. All wiring, junction boxes, external equipment (cameras, mounts, etc.), and equipment in signal controller cabinet must be removed. Conduits and loop detection may be abandoned.

16 RAILROAD & PREEMPTION PLAN

ODOT Rail Division's jurisdiction for the regulation of railroad-highway grade crossings extends a distance equal to the safe stopping distance (SSD), for the posted or statutory speed, measured back from the location of the stop clearance line at the railroad crossing (OAR 741-100-0005).

Figure 16-1 | SSD at Railroad At-Grade Crossings and Signalized Intersections



SSD Requirements*	
Speed (MPH)	SSD (Feet)
15	80
20	115
25	155
30	200
35	250
40	305
45	360
50	425
55	495
60	570
65	645

*When in doubt, contact ODOT Rail Division when a railroad crossing is located within **500 feet** of a traffic signal

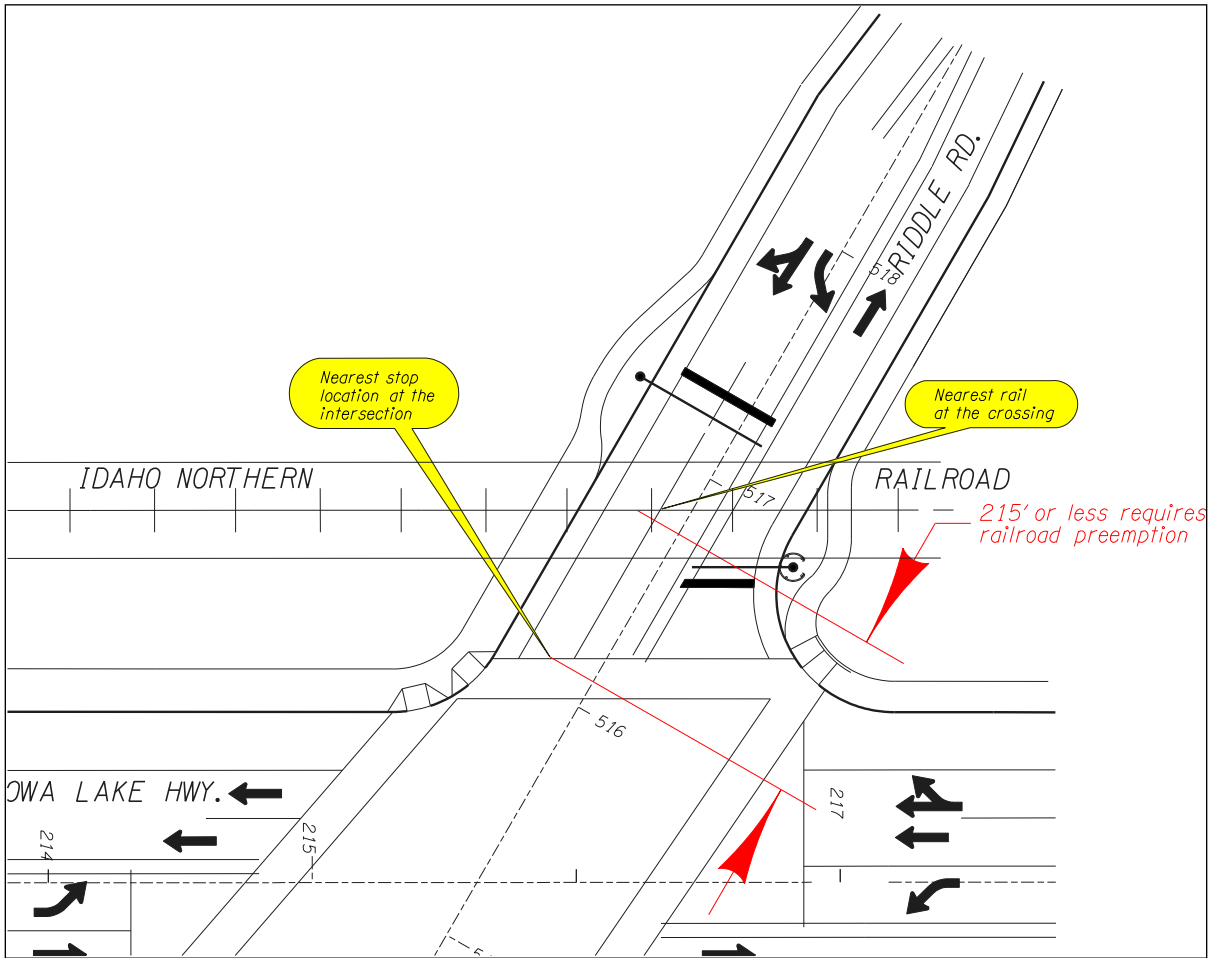
Because Rail Division has jurisdiction within the SSD from the stop clearance line, it is important to include them in the scoping project development so that there is enough time to obtain a Rail Crossing Order if needed. It is also important to include the Rail Division Manager in the scoping as they will be developing an agreement with the Railroad Company (*Right of Way Manual*, Chapter 10).

NOTE: Failure to coordinate with ODOT Rail Division can result in excessive delays to your project schedule!

16.1 When is Railroad Preemption Needed?

Railroad preemption is required if a traffic signal has an approach located within 215 feet of a railroad crossing (*ODOT Traffic Signal Policy and Guidelines*). Depending on the site-specific circumstances, railroad preemption may be desirable or required for an approach located further than 215 feet from a railroad crossing. This will be determined by the Field Diagnostic Review. Rail Division also stores this information in its Rail Crossing Safety System database.

Figure 16-2 | Railroad Preemption Distances



16.2 Field Diagnostic Review

The Field Diagnostic Review is part of the requirements found in 23 CFR Part 646 – Railroads, part 646.214 – Design. This will occur early in the design process (Project Scoping or prior to DAP plans), and is coordinated by the Rail Division. The review will typically include the following members:

- Project Team Leader
- Rail Division representative
- Railroad Company representative
- Region Traffic Signal Operations representative
- Construction representative
- Designers (signal, roadway, and others as needed)

The field diagnostic review team will meet on-site to determine the required safety upgrades to the railroad crossing. The findings from the field diagnostic review will be the starting point for:

- Identifying design constraints and work to be done;
- Completing the Railroad-Highway Public Crossing Safety Application (which is required to obtain the Rail Crossing Order from Rail Division); and
- Obtaining any Region and/or State Traffic Roadway Engineer approvals.

16.3 Rail Crossing Order

Each public railroad crossing is required to have a Rail Crossing Order. Rail Crossing Orders are issued by the Rail Division and authorize the alterations to the grade crossing. Private crossings are not regulated by the Rail Division and therefore do not require a Rail Crossing Order. The majority of projects involving railroad crossings will require a Rail Crossing Order to alter the subject grade crossing. New at-grade crossings are rarely approved by Rail Division because state law directs ODOT to eliminate railroad crossings at-grade, wherever possible. Grade separated railroad crossings are strongly preferred by the railroads and ODOT.

Rail Crossing Orders contain specific requirements related to the installation, operation and maintenance of the traffic control devices, roadway geometry and roadway features. The Rail Crossing Order must be completed prior to PS&E. In order to obtain a Rail Crossing Order, a Railroad-Highway Public Crossing Safety Application must be completed and submitted to Rail Division. This application is typically done by the project team leader or designer, with assistance from the Rail Division.

Existing Rail Crossing Orders can be accessed at the following websites, or by contacting the Rail Division:

Internet site: https://ecm.odot.state.or.us/cf/railsearch/

IntrAnet site: https://ecmintra.odot.state.or.us/cf/railsearch/

NOTE: Failure to comply with the Rail Crossing Order is AGAINST THE LAW.

16.4 Railroad Utility Permits

If any signal equipment crosses over or under the railroad right-of-way, the railroad requires a utility permit. This permit is separate from other construction permits that the contractor must obtain as per standard specification 00170.02 and the Rail Crossing Order. It should be obtained as early as possible in the design phase (prior to PS&E) to avoid unnecessary delays during design and construction. Follow all design requirements stated in the permit.

Typical signal work that triggers the need for this permit includes conduits for detection, traffic signal interconnection and/or railroad interconnection. The signal designer should contact the State Utility and Railroad Liaison for assistance in obtaining this permit.

Contact: State Utility and Railroad Liaison
Heather Howe
503-986-3658
Heather.C.HOWE@odot.state.or.us

16.5 Railroad Preemption Operation

ODOT's standard for railroad preemption is comprised of the following sequence:

1. Pedestrian Clear-Out Interval (PCOI)
2. Vehicle Clear-Out Interval (VCOI)
3. Return to Normal Operation

The rail diagnostic team determines the type of preemption operation and necessary traffic control devices to accommodate the desired operation. The road authority may submit an engineering study to the State Traffic Engineer to request a deviation from the standards. The State Traffic Engineer in consultation with the ODOT Rail Crossing Safety Manager may authorize a signaled intersection operation consistent with the findings of the study.

16.5.1 Pedestrian Clear-Out Interval (PCOI) – Advance Preemption

This value is shown on the Railroad Preemption Plan sheet and is provided by the Region Traffic Operations Engineer.

The P.C.O.I. is used to give pedestrians time to finish crossing a crosswalk prior to the vehicle clear-out interval. Without the P.C.O.I. pedestrians may get stranded in the crosswalk when the vehicle clear-out interval sequence starts. This is because the traffic signal controller will immediately truncate the WALK or flashing DON'T WALK interval upon receiving the input go into the vehicle clear-out sequence.

The operation of a P.C.O.I requires train detection provided by the railroad to activate an "advance preemption railroad input". The advance preemption railroad input

initiates the "pedestrian inhibit" traffic signal software feature which starts the following operation:

1. No change to vehicle phase sequence
2. All active pedestrian phase WALK intervals immediately advance to and complete the flashing DON'T WALK interval
3. All pedestrian phase calls are inhibited from being serviced
4. PTR signs remain off
5. Rail crossing equipment (flashing lights, audible devices and gates) remain off and up.

The road authority calculates and supplies the railroad company with the P.C.O.I. value based the guidance given in the "ODOT Railroad Preemption Design and Operations" document. This value is placed in the railroad controller by railroad employees.

16.5.2 Pedestrian Clear-Out Interval (PCOI) – Advance Preemption Used to Move Vehicles

The P.C.O.I. may also be used to clear vehicles queued between the intersection and the tracks (like the V.C.O.I operation described in the following section) and help provide a free-flow condition for the V.C.O.I phases prior to the simultaneous preemption IF NO PEDESTRIAN CALLS ARE ACTIVE. The need for this type of operation will be determined by the diagnostic team. If this operation is used, the appropriate traffic signal railroad preemption sequence text used on the railroad preemption plan sheet can be found in the ODOT workspace under "Rail Matrix Advanced".

16.5.3 Vehicle Clear-Out Interval (VCOI) – Simultaneous Preemption

This value is NOT shown on the Railroad Preemption Plan sheet, but the vehicle clear-out phases and the limited service vehicle phases are listed on the Railroad Preemption Plan Sheet.

The V.C.O.I. is used to give vehicles on the road approach crossing the railroad track (stopped between the railroad tracks and intersection) time to advance through the intersection and away from the railroad crossing. This accomplished by providing green signal indications to the signal phase that crosses the track (commonly called "green clear-out"). In the past, a flashing yellow indication was used for the V.C.O.I. (commonly called "yellow clear-out"), but this practice was ended in the late 1990's because it tended to result in driver confusion.

The V.C.O.I. requires train detection equipment that will provide a "simultaneous preemption railroad input" to activate the rail crossing equipment and the V.C.O.I signal operation sequence. The simultaneous preemption railroad input follows the advance preemption railroad input (and operation sequence of the P.C.O.I.) and initiates the

"railroad preemption" traffic signal software feature which starts the following operation at the traffic signal:

1. PTR signs turn on
2. Rail crossing equipment (flashing lights and audible devices) activate. After a three to six second delay, the railroad automatic gates start to descend. The total time from activation of the flashing lights to when the gates are horizontal may be 10 to 15 seconds.
3. All active pedestrian phase flashing DON'T WALK intervals immediately advance to solid DON'T WALK.
4. Any active vehicle clear out phase displaying GREEN remains GREEN and all non-vehicle clear out phases displaying GREEN immediately terminate by advancing through their YELLOW and RED clearance intervals.
5. Once all vehicle clear out phases display GREEN simultaneously, the signal controller programmed V.C.O.I. is timed followed by the vehicle clear out phases advancing through their YELLOW and RED clearance intervals.
6. All programmed Limited Service vehicle phases and their associated pedestrian phase are serviced in their normal sequence based on demand. Limited Service vehicle phases consist of any phase that does not conflict with crossing the track.

The road authority calculates the V.C.O.I. value based on the guidance given in the "ODOT Railroad Preemption Design and Operations" document. This value is placed in the signal controller.

A V.C.O.I. is not always required. If the diagnostic team determines that vehicles should stop prior to the track under normal signal operation (typically because the distance between the intersection and the track is less than the length of a passenger vehicle) the V.C.O.I. is usually not needed (no vehicles to clear-out between the intersection and the track). This type of operation typically includes a post mounted "STOP HERE ON RED" sign at the railroad stop line, with a "NO TURN ON RED" sign mounted on signal pole or mast arm.

Figure 16-3 | V.C.O.I. is Not Required, Example 1

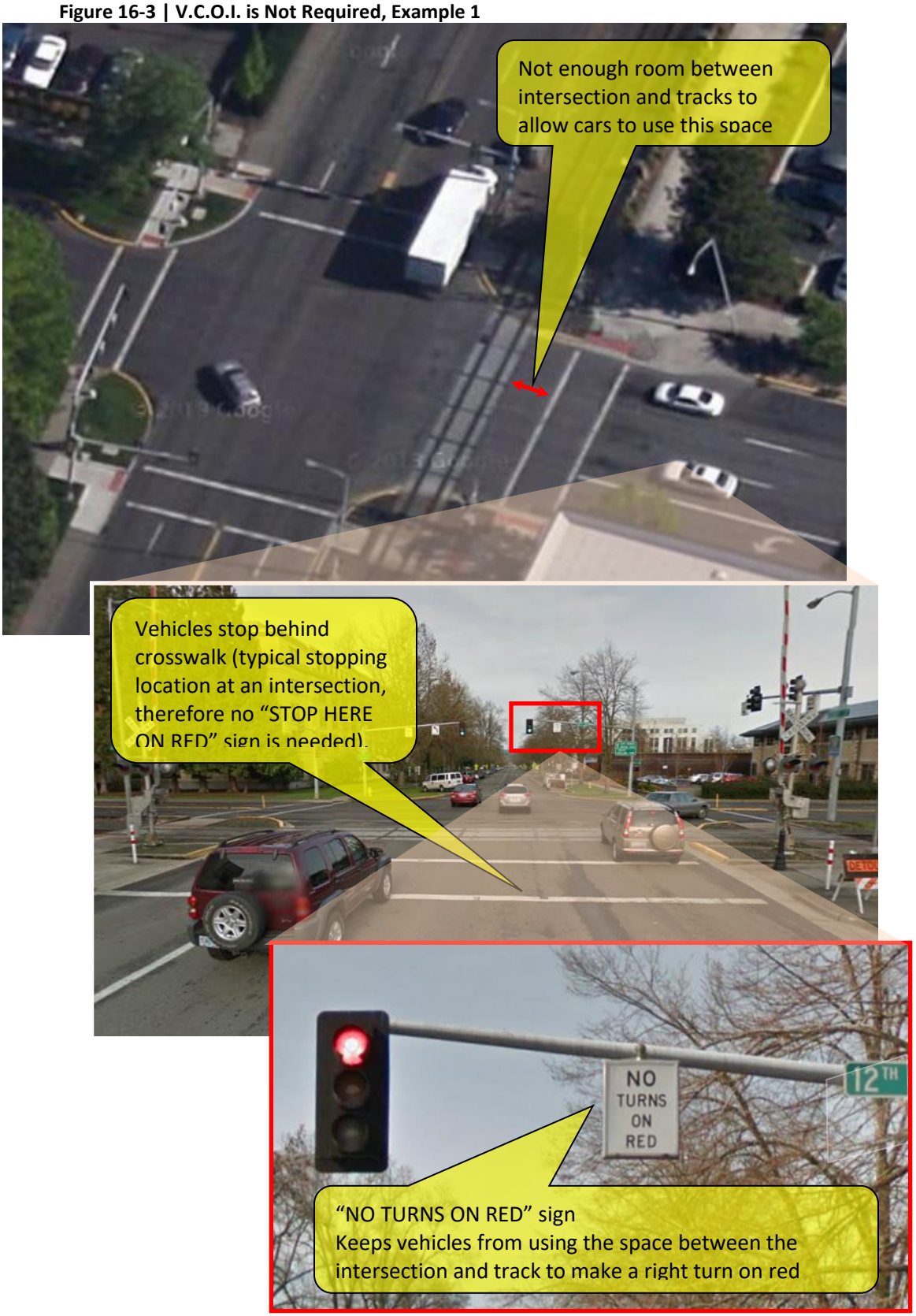
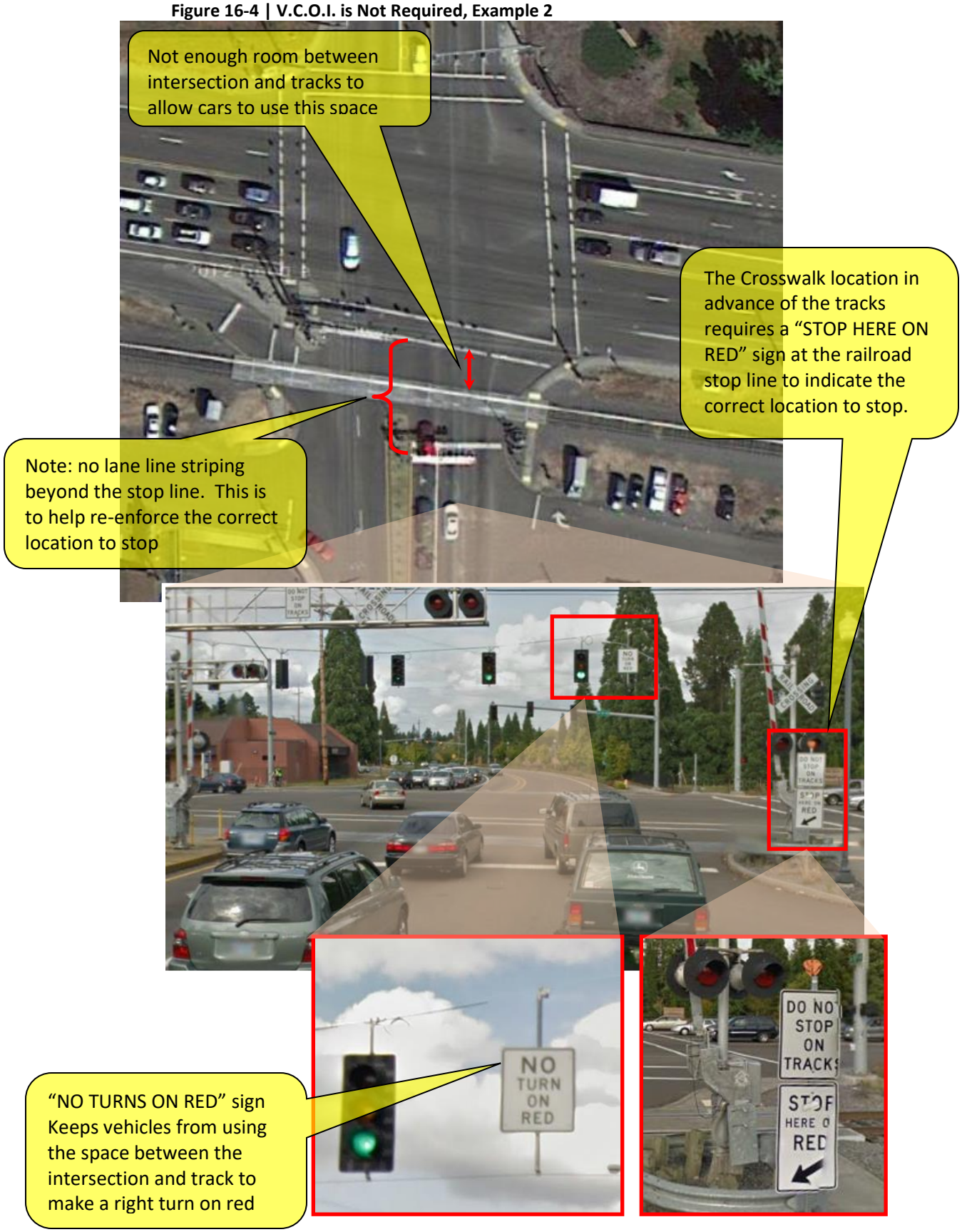


Figure 16-4 | V.C.O.I. is Not Required, Example 2



16.5.4 Return to Normal Operation

After the railroad preemption inputs return to non-preempt status, normal operation of the signal phasing resumes, the PTR sign turns off, the rail signal equipment turns off and gates go up.

16.6 Required Plan Sheets

On a project with railroad preemption, there will be coordination between the Rail Company, the Road Authority and the Rail Division for determining who is responsible for installation, maintenance, and costs of the required traffic control devices. Depending on the scope of the project and the requirements in the Rail Crossing Order, some or all of the plan sheets will be required:

1. Signal Plan Sheet
2. Railroad Preemption Plan Sheet
3. Other Plan Sheets (disciplines outside of signal design, such as Roadway, Striping and Signing)

Refer to the following sections for more in depth information.

16.7 Signal Plan Sheet

The signal plans will need to detail all work that the contractor will be responsible for. DO NOT detail work that the contractor is NOT responsible for.

Listed below is signal equipment that is specific to railroad preemption design and should be detailed on the signal plan sheet:

- Conduit and Wiring from the traffic signal cabinet to the railroad cabinet
- Signs mounted to the signal poles/mast arm/span wires
    - PTR signs
    - NO TURN ON RED signs
- Type 7 signal head

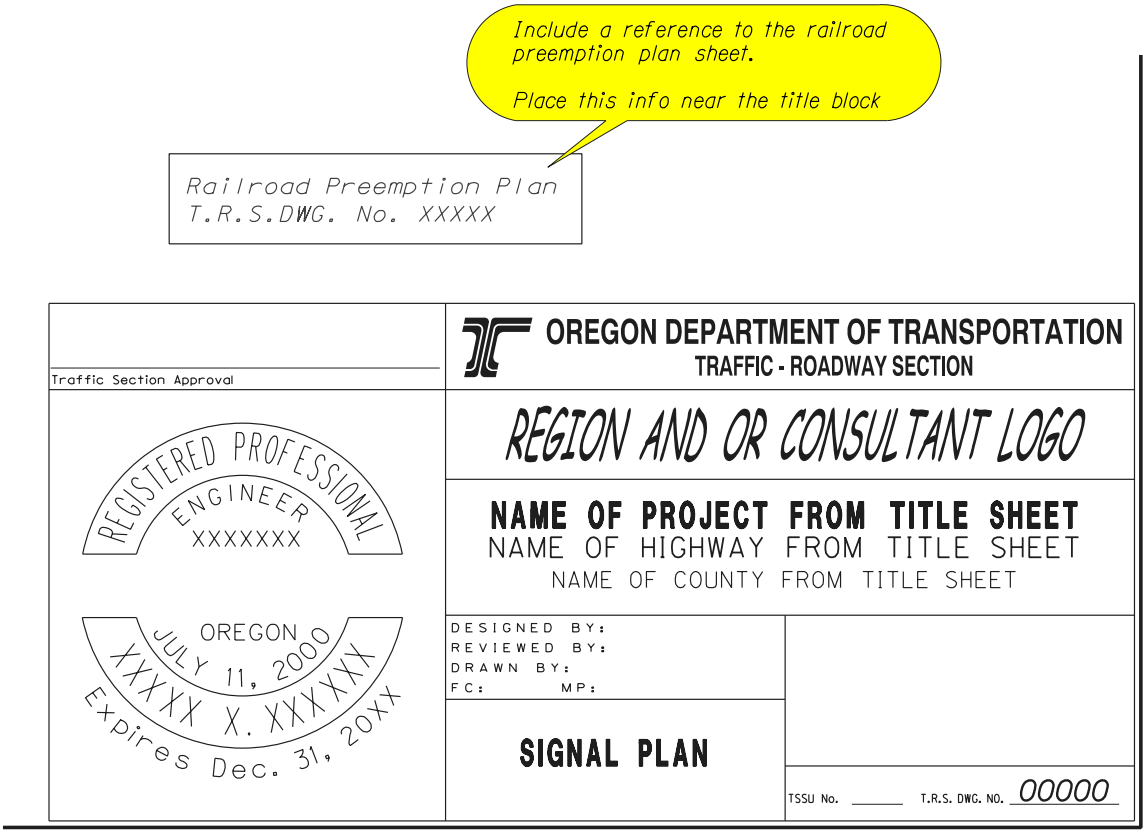
Refer to the following sections for more in depth information on railroad preemption design elements.

16.7.1 Signal Plan Sheet

Notes

The signal plan sheet should contain a note that references the railroad preemption plan sheet. See Figure 16-5.

Figure 16-5 | Plan Sheet Notes

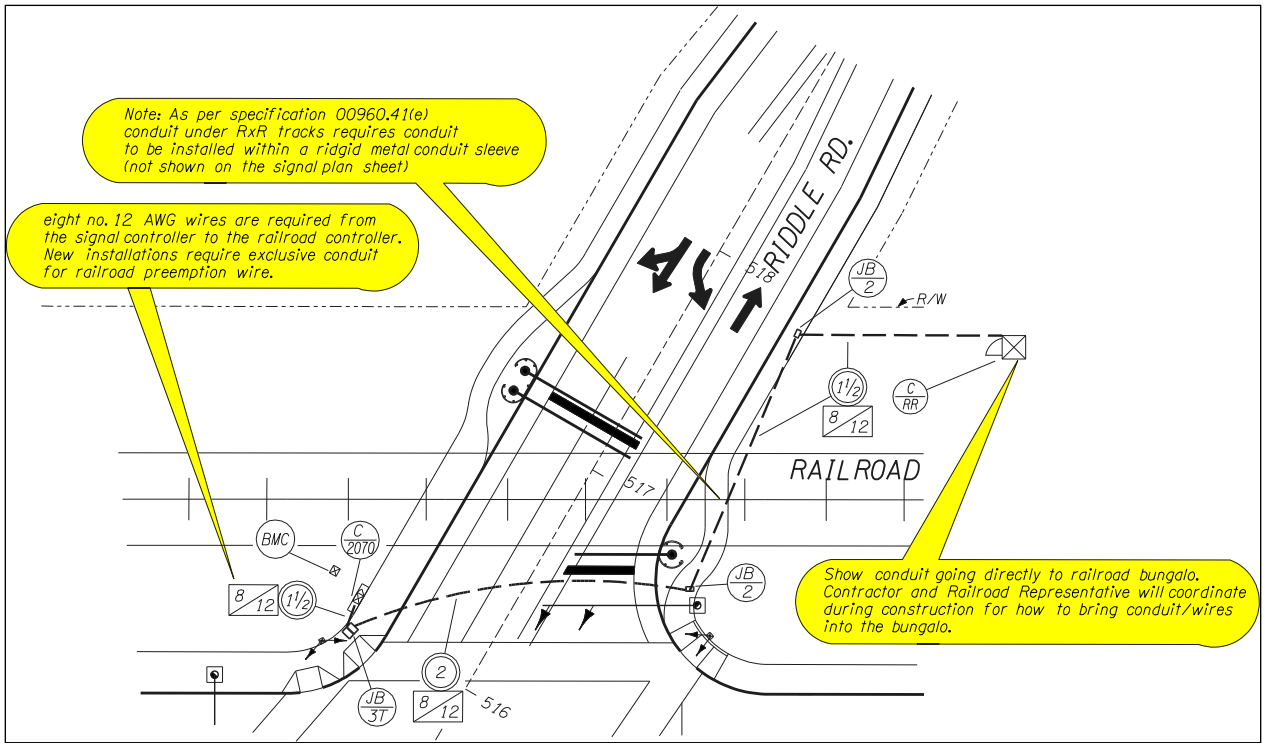


Conduit and Wiring

The railroad preemption operation is triggered by the railroad controller that monitors the railroad tracks and detects an approaching train. These preemption impulses are sent to the signal controller cabinet via wiring from the railroad control cabinet.

The conduit and wiring required to connect the ODOT controller to the railroad controller, providing the ability for railroad preemption, is shown on the signal plan sheet. This wiring consists of eight No. 12 AWG THWN wires or one 10 conductor 12 AWG gauge control cable (as per Region Electrical Crew preference) from the controller cabinet to the railroad cabinet. An exclusive conduit for this wire should be used for new construction. Figure 16-6 shows an example of how this should be detailed on the signal plan sheet.

Figure 16-6 | Railroad Preemption Wiring Example



Signs

Part-time restriction signs may be required at the traffic signal based on the field diagnostic review. These signs typically state a turn restriction, such as “NO LEFT TURN” or “NO RIGHT TURN” during the railroad preemption and are mounted on the signal mast arm. If needed, these signs will be shown on the signal plan sheet.

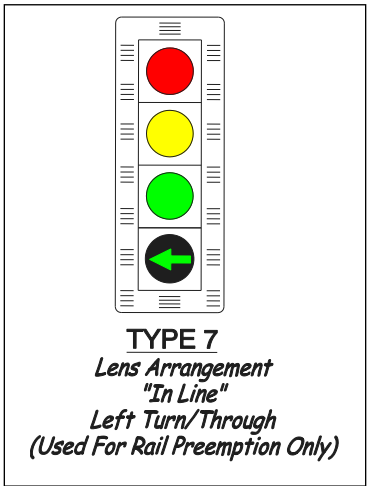
Other static signs such as STOP HERE ON RED, NO TURN ON RED, DO NOT STOP ON TRACKS signs, etc. may be required traffic control devices. If these signs are ground mounted, they should be detailed in a sign plan sheet (not in the signal plan sheet). If these signs are mounted on the signal, they should be detailed in the signal plan sheet.

Figure 16-7 | Part-Time Restriction Sign Example

Type 7 Signal Head

A Type 7 Signal head is required for the vehicle clear-out phase when the vehicle clear-out phase contains a permissive only left turn movement. This allows use of a GREEN arrow only during the Vehicle Clear-Out Interval (V.C.O.I) so that vehicles will be aware they have a protected left turn movement during the railroad preemption sequence. In the past when GREEN balls were used during the V.C.O.I., motorists would often hesitate when making a left turn as they weren’t sure if/why the opposing through traffic was stopping.

Figure 16-8 | Type 7 Signal Head



Pedestrian Features

When upgrading existing traffic signals that have railroad preemption, the P.C.O.I. time will need to be recalculated using the 2009 MUTCD guidelines. The recalculated P.C.O.I. will likely result in a longer P.C.O.I., which requires a Rail Crossing Order for the alteration of the rail detection equipment. If funding is available and the project time line allows, a Rail Crossing Order and alteration of the rail detection equipment should be completed.

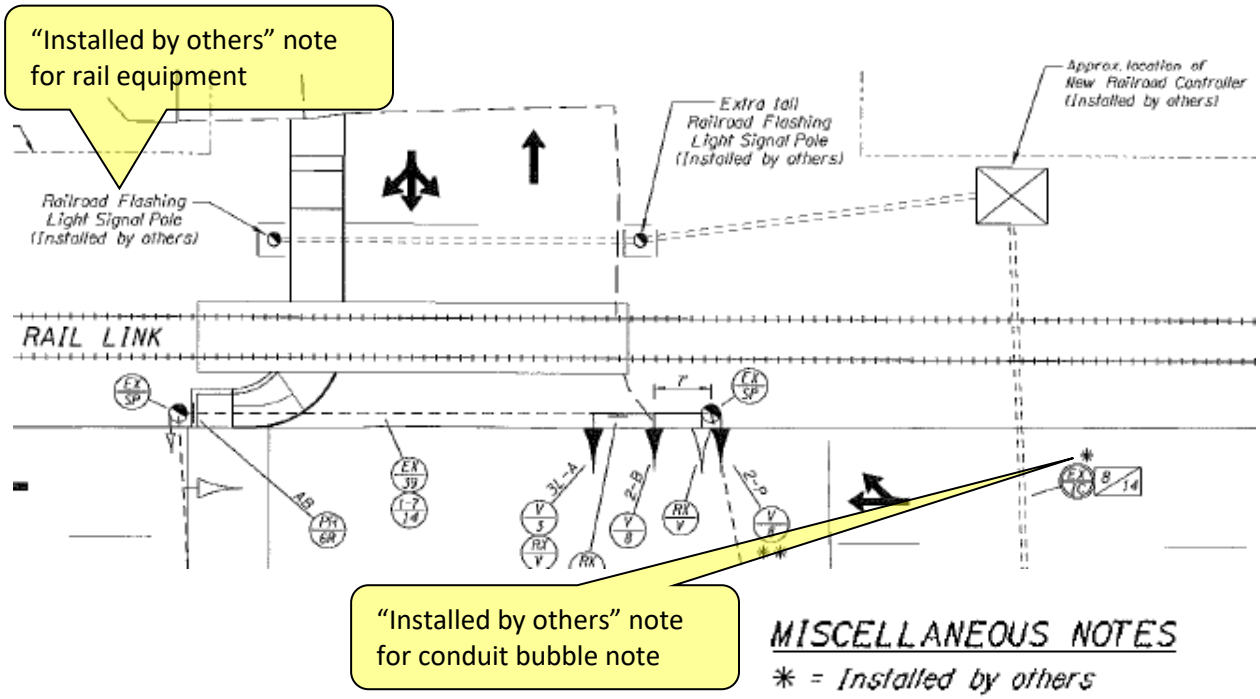
In situations where the recalculated P.C.O.I. is longer than the existing P.C.O.I. and funding is not available or there is not enough time to process a Rail Crossing Order, the use of two pedestrian change intervals may be used. See Chapter 5 "Extended Pushbutton Press Feature" section for more information.

16.8 Other Work – Railroad Grade Crossing System

The railroad company is typically responsible for installing the grade crossing system, including train detection equipment on the rails, gate arms, railroad flashing beacon assemblies, and the railroad cabinet. This work is paid for through Railroad Agreements and typically not shown in ODOT contract plans. The Project Manager's Office will coordinate with the contractor and the Railroad Company to install these items.

The grade crossing system may be symbolically shown, but not detailed, on the signal plan sheets. If needed, these features may also be noted as "installed by others" to clarify which features the contractor is NOT responsible for. See Figure 16-9.

Figure 16-9 | Railroad Equipment Installed by Others



Other disciplines will be responsible for detailing work that may need to be completed as per the Rail Crossing Order.

Roadway plans will detail the following:

- The location of the crossing signal equipment, foundations, railroad signal house.
- The quantity of new crossing surfacing materials
- Sidewalk work to be constructed up to the crossing surface

Sign plans will detail ground mounted signs required by the Rail Crossing Order.

Striping plans will detail the pavement markings required by the Rail Crossing Order.

16.8.1 Railroad Preemption Plan Sheet

Rail Division requires a separate, sealed railroad preemption plan sheet to be included with the Railroad-Highway Public Crossing Safety Application. This plan sheet contains the operational requirements of the preemption. In the past, this plan sheet was included in the contract plans, but is now contained solely within the Rail Crossing Order (as it doesn't include any information pertinent to the contractor's work).

NOTE: The rail diagnostic team determines the type of preemption operation and necessary traffic control devices to accommodate the desired operation. The railroad preemption plan sheet is part of the operational documentation required for the Rail Crossing Order.

The railroad preemption plan sheet will be completed early on in the project, DAP or preliminary plans, prior to completion of the other signal plan sheets for the project. Therefore, the Traffic-Roadway Section will issue a T.R.S. Drwg. No. for ONLY the railroad preemption plan sheet at this time.

The rail preemption plan sheet shall be reviewed by Region Traffic, ODOT Rail Division, and the Traffic Signal Standards Unit.

The final signed and stamped rail preemption plan sheet mylar should be sent to the Traffic Signal Standards Unit for approval. The Traffic Signal Standards Unit will then submit an electronic copy of the approved plan sheet to the ODOT Rail Division for use in the Rail Crossing Order and archive the mylar.

NOTE: The Railroad Preemption Plan Sheet is NOT part of the contract plan set!

Figure 16-10, Figure 16-11, and Figure 16-12 show examples of railroad preemption plan sheets. Each example highlights a few common scenarios:

- Figure 16-10 shows a standard 8 phase signal operation, with a P.C.O.I, V.C.O.I and PTR sign. Note the very simplified plan view that is drafted from an old as-built or from google maps, which is acceptable if a surveyed base map is not available.

- Figure 16-11 shows a 6 phase signal operation with mainline flashing yellow arrow, a PCOI, VCOI, and PTR sign. Note the Type 7 signal head and the FYA; how they are labeled on the plan view and described in the preemption text.

- Figure 16-12 shows a 6 phase signal operation, a P.C.O.I, NO V.C.O.I, and PTR sign. Note the changes shown when a V.C.O.I is not used; how it is described in the preemption text and labeling of additional signs that are critical when omitting the V.C.O.I (i.e. NO TURN ON RED and STOP HERE ON RED).

Figure 16-10 | Sample Railroad Preemption Plan, Example 1

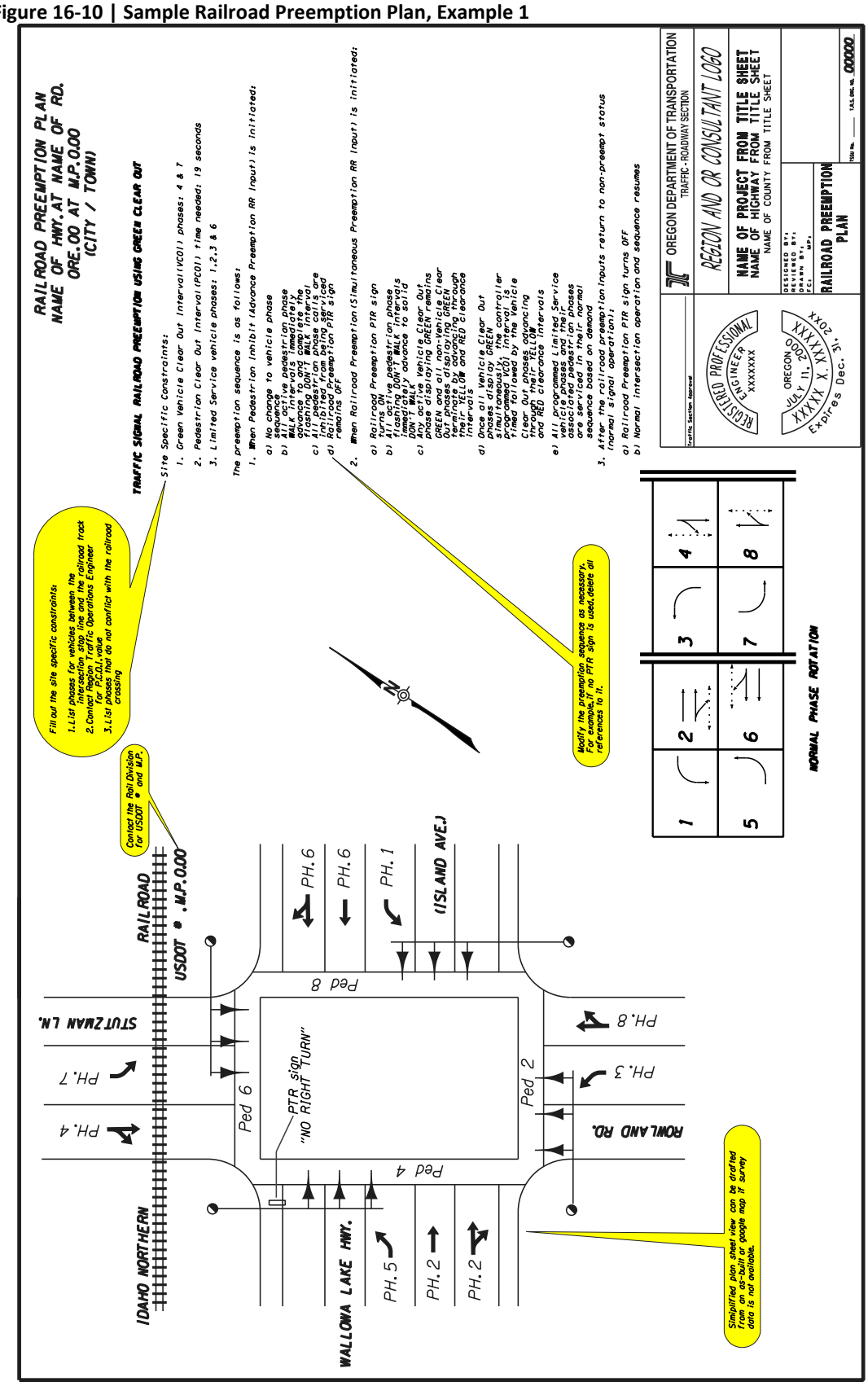


Figure 16-11 | Sample Railroad Preemption Plan, Example 2

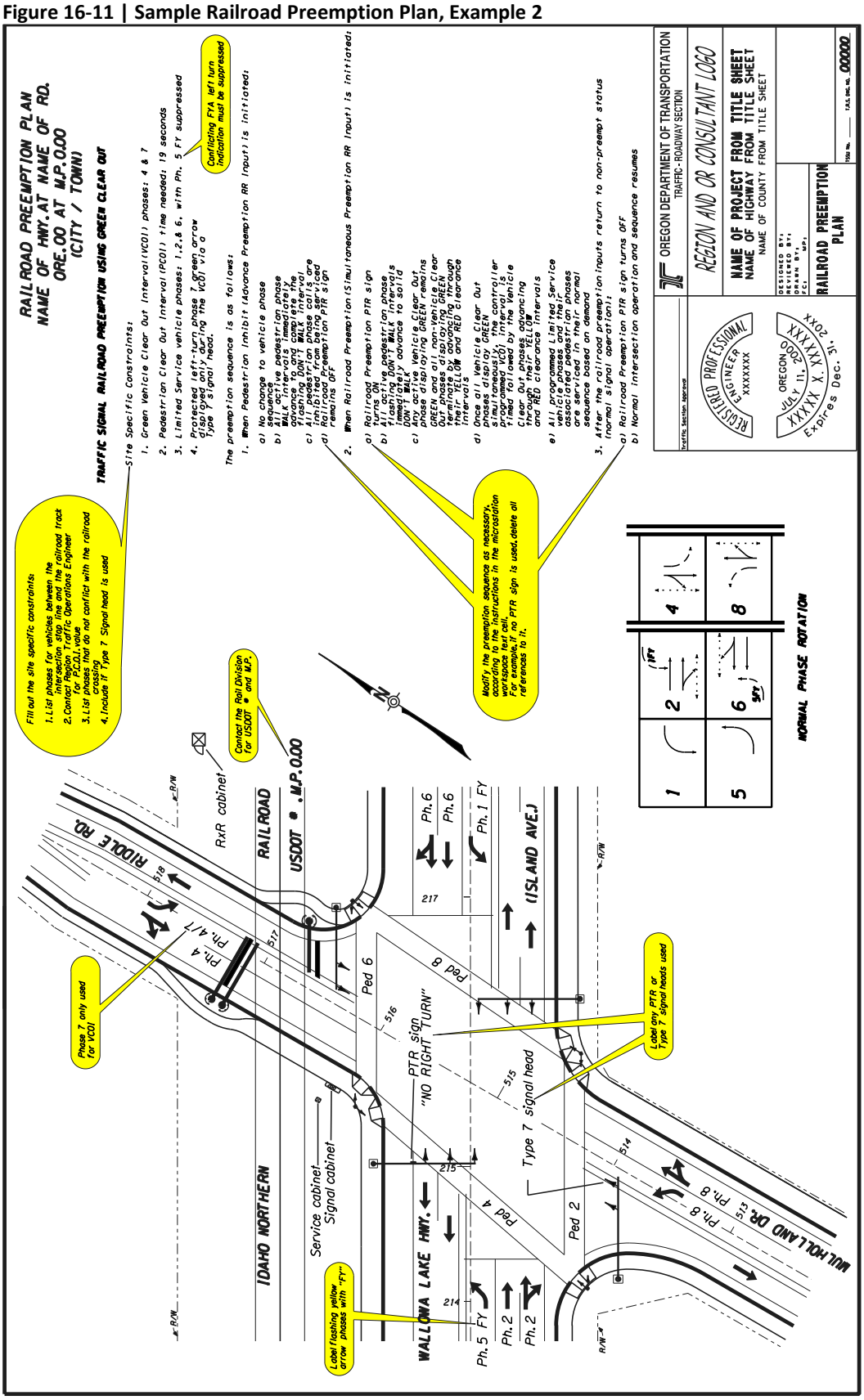
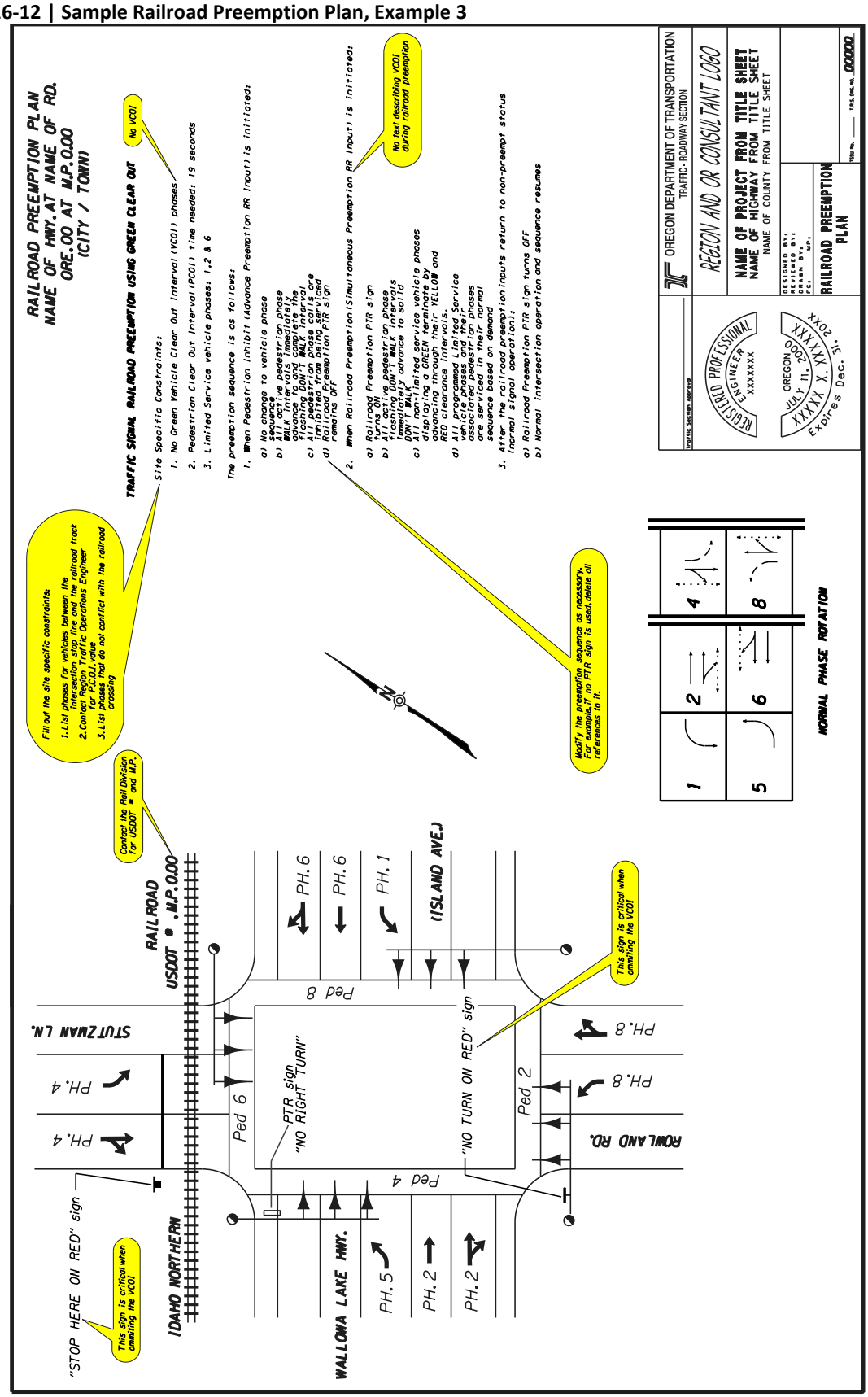


Figure 16-12 | Sample Railroad Preemption Plan, Example 3



The railroad preemption plan sheet shall contain the following:

- Traffic Signal Title Block and upper right hand title information
- T.R.S. Drawing Number
- T.R.S. approval signature
- North arrow
- USDOT Crossing number and railroad milepoint (obtained from the Rail Division)
- Normal phase rotation diagram
- Traffic signal railroad preemption sequence text ("Rail Matrix" in the ODOT workspace), modified to accurately represent the site specific conditions:
    - V.C.O.I. green clear-out phases (if they exist)
    - P.C.O.I. value (obtained by Region Traffic Operations Engineer)
    - P.C.O.I used to serve V.C.O.I phases ("Rail Matrix Advanced" in the ODOT workspace)
    - Limited service phases. If a conflicting FYA indication is present, it must be listed
    - Use of Type 7 signal heads
    - Use of PTR signs
- A plan view of the intersection and railroad crossing (either to scale or graphically represented not to scale) with the following elements labeled:
    - Highway and street names
    - Signal equipment shown symbolically, but not labeled (signal poles, mast arms, vehicle heads)
    - Signal equipment shown symbolically and labeled:
        - PTR signs
        - Type 7 signal heads
    - Pedestrian phases labeled in the corresponding crosswalk
    - Vehicular phases labeled in the corresponding approach lanes
    - Signs (ground mounted or overhead) that directly related to the preemption operation, shown symbolically and labeled:
        - "STOP HERE ON RED" sign
        - "NO TURN ON RED" sign

The railroad preemption plan sheet may contain the following additional features:

- The RxR cabinet
- The signal cabinet
- The service cabinet
- The pedestrian signal heads shown symbolically, but not labeled
- The RxR gate locations
- Stationing (if the plan view is to scale)
- Right-of-way

17 FIRE SIGNAL PLAN (EMERGENCY TRAFFIC SIGNAL)

17.1 General

A fire signal is a special type of traffic control signal that assigns the right-of-way to an authorized emergency vehicle (typically fire trucks). This type of signal is usually installed at a location that doesn't meet other traffic signal warrants, such as the access for the emergency vehicle. They are not used at roundabouts.

Actuated flashing beacon systems for emergency vehicles are a good alternative to the traditional fire signal described in this chapter.

Traditional fire signals are typically more expensive than actuated flashing beacon systems (mast arms vs. vehicle pedestals), especially if the fire signal will be located at an intersection (where a fully actuated signal is then required).

See Chapter 12 for design information on Actuated Flashing Beacon Systems for Emergency Vehicles

17.2 Operational Approval

A fire signal requires an STRE Operational Approval.

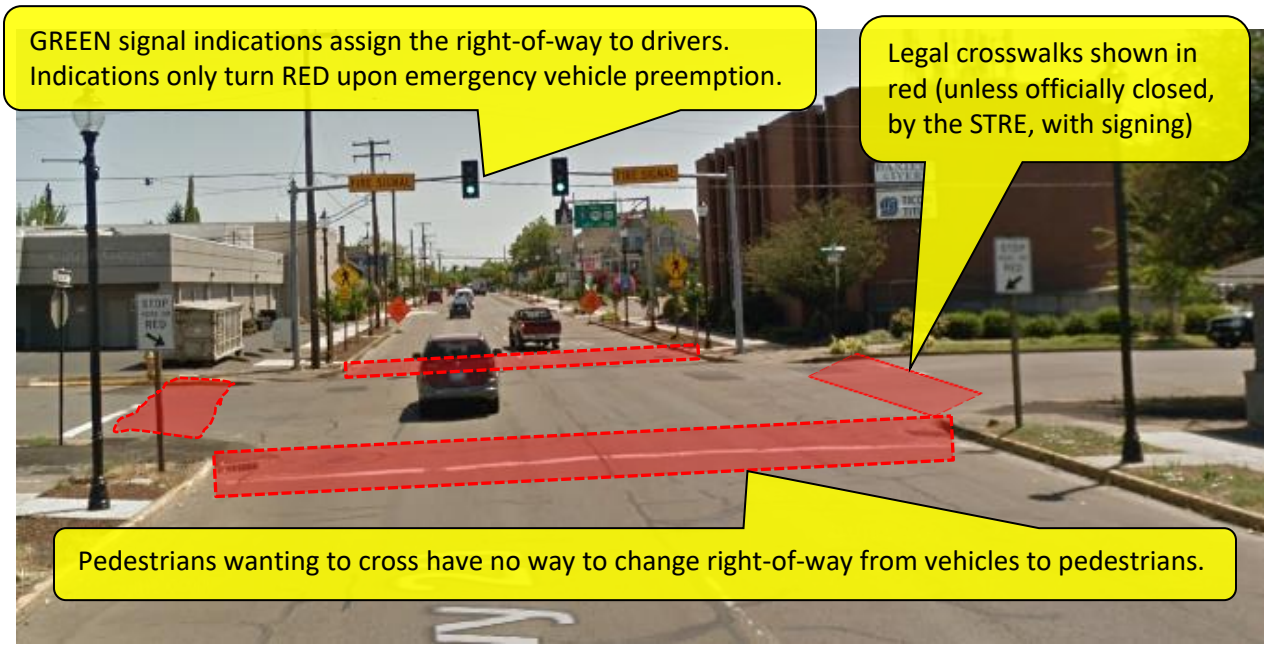
17.3 Fire Signal Located at an Intersection

When a fire signal is located at the intersection of a public road, a standard fully actuated signal shall be provided. While the purpose signal is to help enable emergency vehicles access the mainline, a standard fully actuated signal is not technically a fire signal from a design standpoint and Chapters 5 and 6 of this manual should be consulted for design information.

17.3.1 Solutions for Existing Fire Signals Located at Intersections

Recently developed requirements for ADA ramps, crosswalks, and pushbuttons due to the ODOT ADA litigation settlement have highlighted a need to address existing fire signals (that are not standard fully actuated signals) installed at intersections. The case study shown in Figure 17-1 illustrates the problems created when a fire signal is located at an intersection.

Figure 17-1 | Existing Fire Signal Located at Intersection – Case Study



The five solutions listed below are acceptable in order of preference (note: all of them require an engineering study and STRE approval):

1. Removal of the existing fire signal

2. Removal of the existing fire signal and installation of actuated flashing beacons with sign W11-8. See Chapter 12 for design information.

3. Removal of the existing fire signal and installation of fully actuated traffic signal

4. Change solid green indications of existing fire signal to flashing yellow indications

5. Retain existing fire signal and officially close the crosswalks that are in conflict with the GREEN indications (because there is no way for the pedestrians to change the green indications which are assigning right-of-way to the vehicle, the crosswalks within the stop bar locations are effectively closed).

The appropriate solution to implement will be based on site specific factors (i.e. volumes, warrants, etc.) and the scope of the project that is impacting the existing fire signal. Solutions 1 thru 3 meet current standards and should be implemented if possible. Solutions 4 and 5, while acceptable, are not desirable and should only be considered as a last resort.

Two other potential solutions were considered, but deemed unacceptable for the following reasons:

1. Adding pushbuttons and pedestrian heads to the existing fire signal - this creates a half-signal which is prohibited by the MUTCD.

2. Keeping the crosswalks open that are in conflict with the GREEN indications - this creates a conflict with the appropriate driver response when considering “ORS 811.260 Appropriate Driver Responses To Traffic Control Devices” and “ORS 811.028 Failure To Stop And Remain Stopped For Pedestrians”.

17.4 Fire Signal Located at Mid-Block Access

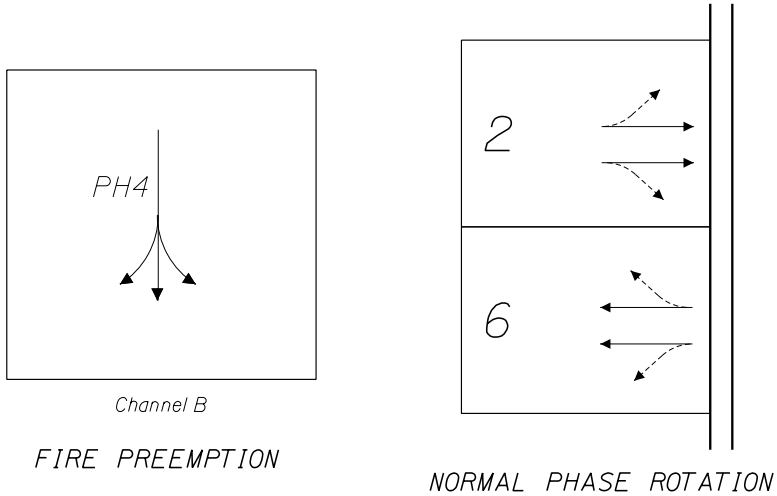
Fire signals are typically located at a mid-block access used only by emergency vehicles and help them access the highway. The following section discusses specific design requirements for mid-block fire signals.

17.4.1 Operation

The operation of a fire signal located mid-block will remain green on mainline until the emergency vehicle preempts the signal. In the past, flashing yellow was commonly used, but is no longer allowed unless it is documented in the STRE Operational Approval. The preemption can be either a manual input (i.e. push button at the fire station) that is pre-timed or a standard preemption detector unit that will wirelessly provide and hold the input until the emergency vehicle has cleared the access.

The mainline phases are 2 and 6. The preemption phase is phase 4 on Channel B. The normal phase rotation and fire preemption operation should be shown on the plan sheet. See Figure 17-2.

Figure 17-2 | Phase Rotations for Fire Signal



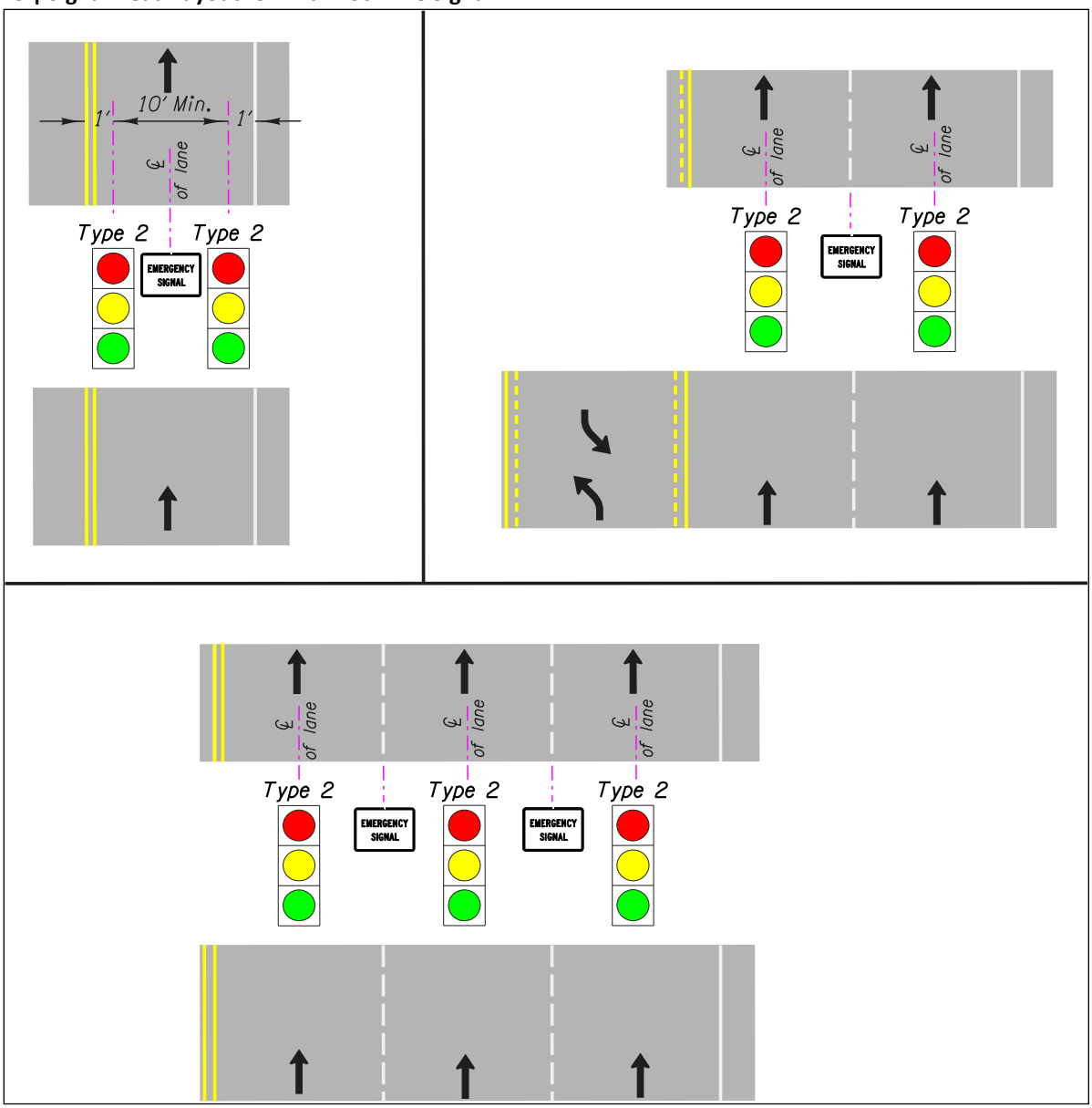
17.4.2 Controller and Service

A 332S controller cabinet with a Base Mounted Service (BMC) should be used.

17.4.3 Signal Head Type and Layout

The mainline approach is required to have at least two Type 2 Signal heads. See Figure 17-3.

Figure 17-3 | Signal Head Layout for Mid-Block Fire Signal



The default standard is NO signal indications for emergency access approach. This is because it is important for the emergency vehicle driver to watch traffic, not a signal indication when accessing the mainline. This is especially true at a fire signal, where the mainline phase is normally green (driver's don't expect the signal to change). However, if the fire department requests a form of preemption confirmation on the access approach, a tattle-tale indicator may be used. See Section 17.4.5 for more information.

The tattle-tale indicator can clearly inform the fire department that the preemption is working (the tattle-tale will be ON when the mainline indications are RED) by a simple, direct hardwire vs. more complex systems that have been used in the past that required additional phases/outputs in a controller cabinet (i.e. Type 2 signal Head, a single green circular indication, and flood lights). As such, these more complex systems are no longer allowed. See Figure 17-4 thru Figure 17-6.

Figure 17-4 | Confirmation Indication – NO LONGER ALLOWED

Figure 17-5 | Confirmation Indication – NO LONGER ALLOWED

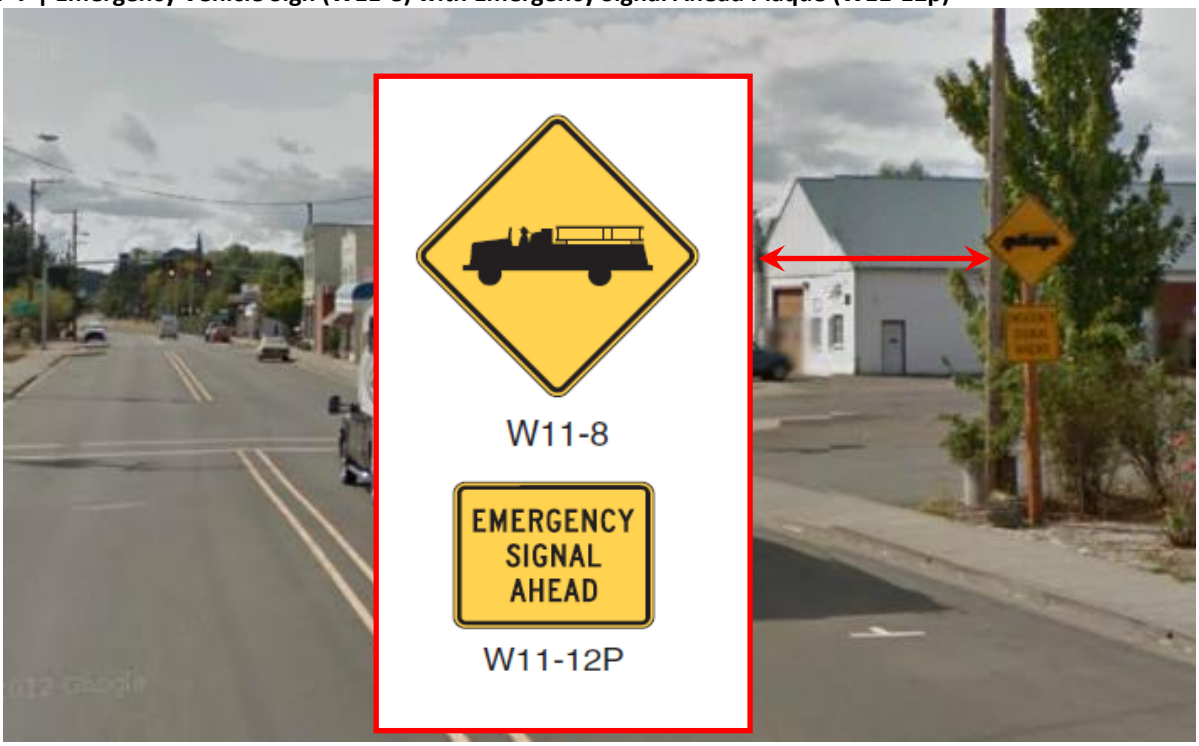
Figure 17-6 | Confirmation Indication – NO LONGER ALLOWED

17.4.4 Signs

Several specific signs are required for a fire signal. Coordinate with the sign designer for any ground mounted signs.

An emergency vehicle sign (W11-8) with an EMERGENCY SIGNAL AHEAD supplemental plaque (W11-12p) is required to be installed in advance of the fire signal. A warning beacon may be used to supplement this advance warning sign if deemed necessary by the Operational Approval.

Figure 17-7 | Emergency Vehicle Sign (W11-8) with Emergency Signal Ahead Plaque (W11-12p)



An EMERGENCY SIGNAL sign (R10-13) shall be mounted overhead, typically between the two signal heads.

Figure 17-8 | Emergency Signal Sign (R10-13)

A STOP HERE ON RED sign (R10-6) shall be mounted near the stop line.

Figure 17-9 | Stop Here on Red Sign (R10-6)

17.4.5 Tattle-tale Indicators

Tattle-tale indicators are typically used at the request of law enforcement to aid in enforcing red light running violations by clearly indicating a RED indication is active from certain viewing angles. The tattle-tale light is directly hardwired to the RED indication. This simple direct hard-wire design also works well for fire signal confirmation indication. If a confirmation indication is requested, use Standard Detail DET4400 and coordinate with the fire department to determine the best placement for the tattle-tale, as it is a directional device.

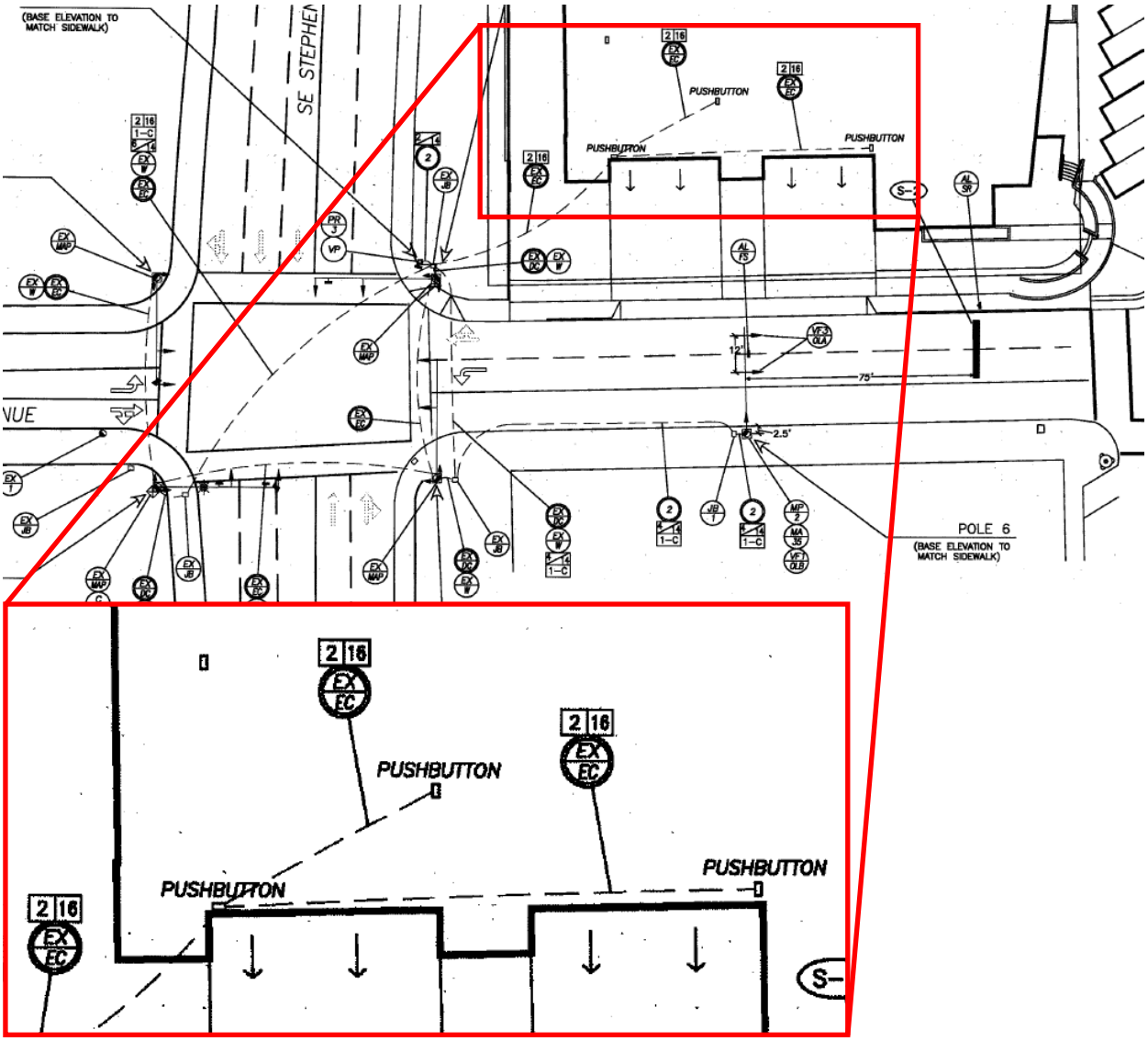
17.4.6 Preemption Devices

Two types of preemption can be used:

- Push Button located inside the fire station
- Preemption detection devices

Push buttons are not as common anymore due to the invention of preemption detection devices and their widespread use. However, this is the only option if the fire department is not using the standard preemption detection devices or the wish to maintain their legacy preemption system. Coordination with the fire department is critical to determine the proper location and mounting for the push button and the conduit routing to the push button. Multiple push buttons may also be needed. See Figure 17-10.

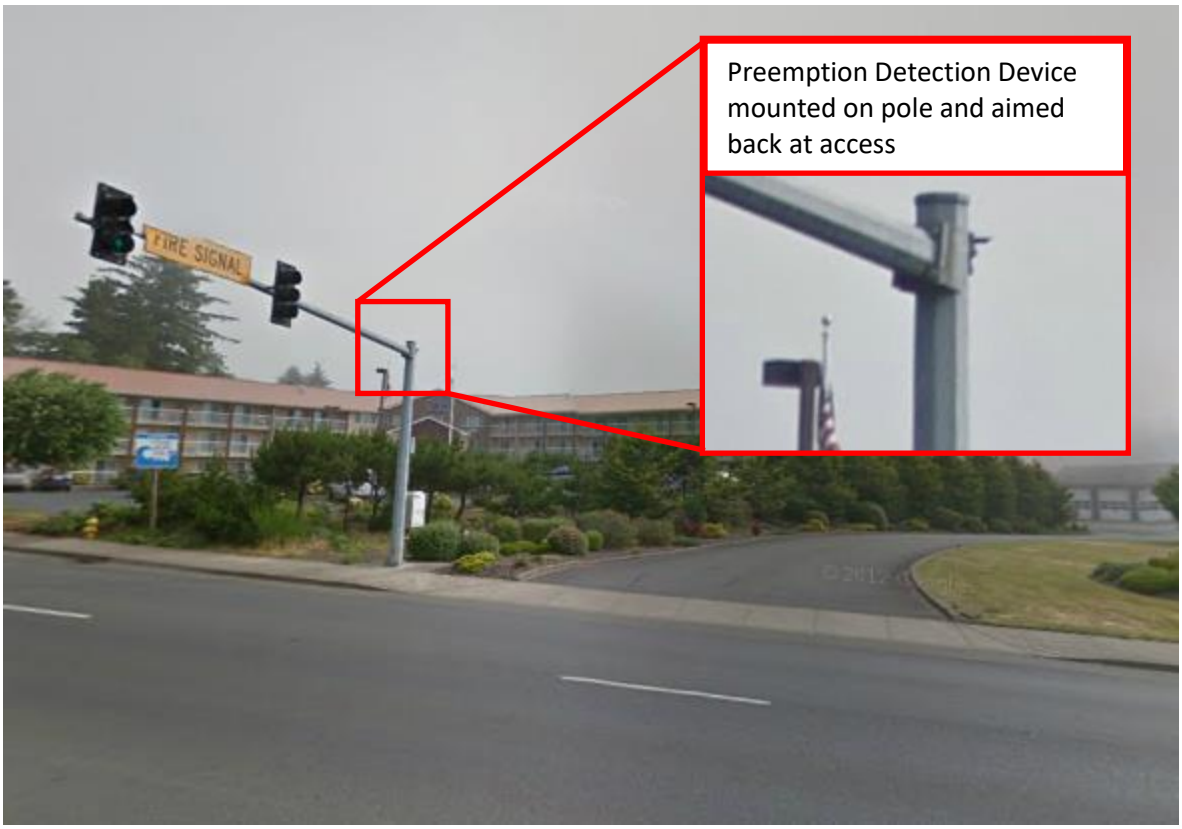
Figure 17-10 | Push Button Preemption – Placement and Conduit Routing Example



Installation of push buttons, conduit and wiring is allowed to be installed off of right-of-way via Intergovernmental Agreement (IGA) for this type of preemption. The IGA is with the associated City or County, who then have an agreement with the Fire Department. Typically the Region Electrical crew will maintain the entire installation, including the equipment that is located off right-of-way. Therefore, it is necessary to show the conduit, wire, junction boxes and push button(s) located off right-of-way on the plan sheet.

Preemption detection devices are the most common type of preemption used for a newly installed fire signal. The device should be placed such that emergency vehicle leaving the station will activate it as soon as possible. This will depend on the configuration of the property and the typical path of the emergency vehicle when it uses the access approach. Multiple devices may be used at different locations to properly hold the preemption input, or a single preemption device may be used in conjunction with a pre-set time if the device would lose the input too soon. Coordinate with the fire department and region signal timer to determine the best preemption operation.

Figure 17-11 | Preemption Detection Device – Placement Example



Loop detection (or any alternative vehicle detection) shall NOT be used as a preemption device. This is due to the fact that if a loop fails, the fire signal will remain preempted

until it is fixed. This would cause enormous traffic back-ups and disrespect for the fire signal.

17.4.7 Detection

Vehicle detection is not needed for a fire signal.

17.4.8 Pedestrian Accommodation

Pedestrian phases shall not be used for a fire signal.

17.5 Emergency-Vehicle Hybrid Beacon

Emergency-vehicle hybrid beacons shall not be used as an emergency traffic signal.

18 STANDARD DRAWINGS AND STANDARD DETAILS

18.1 Standard Drawings

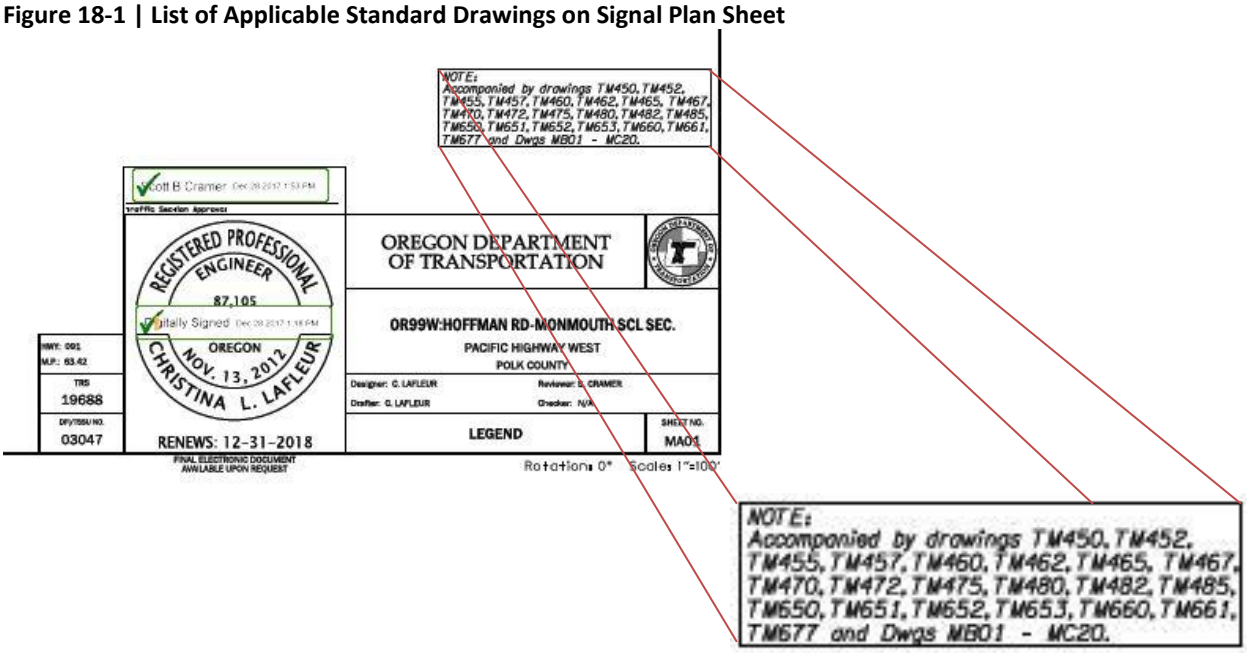
Standard Drawings provide micro detail construction information for typical installations and are referenced by the contract plans via the signal plans. The designer is responsible for selecting the appropriate standard drawings that are applicable to the project. The applicable signal related standard drawings are listed only on the first sheet of the signal plan set. See Figure 18-1. The entire set of applicable standard drawings for the whole project is shown in the main index (usually the second sheet of the contract plans). It is a good idea to check the main index to ensure signal related standard drawings were listed correctly.

The standard drawings that are applicable to signal design are found in the TM400 series (signal design) and TM600 series (traffic structures). Standard drawings for temporary work zones (temp. bridge signals) are found in the TM800 series (work zone).

Standard Drawings cannot be modified by the designer. However, if a standard drawing doesn't quite work for a particular project due to a non-typical condition, the standard drawing content can be used to create a "Details" plan sheet that is then signed and sealed by engineer of record.

The home website for all Standard Drawings and Standard Details is:
http://www.oregon.gov/ODOT/Engineering/Pages/Standards.aspx

Figure 18-1 | List of Applicable Standard Drawings on Signal Plan Sheet



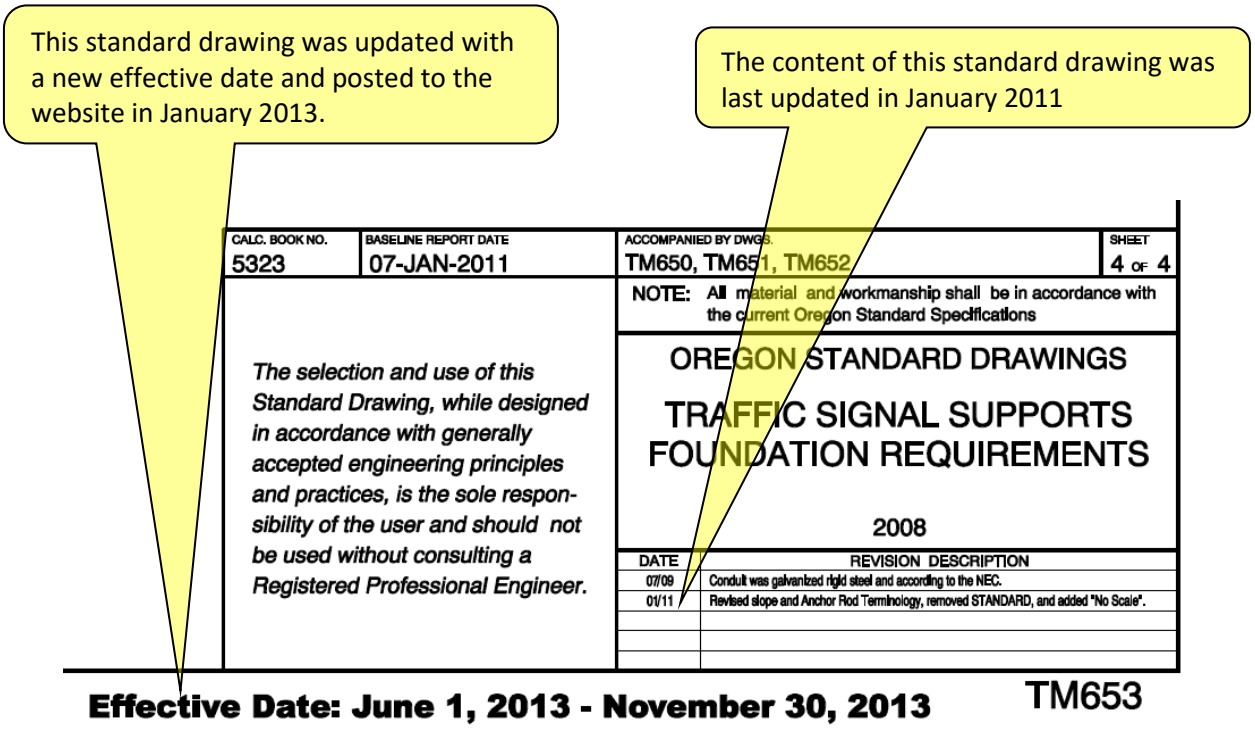
18.1.1 Effective Dates and Updates

An effective date is placed on each Standard Drawing. The bid date of the project will be within the range of the effective date. This assists with identifying the correct drawing for the project. The standard drawings used on the project are valid for the life of the construction.

Standard drawings are maintained by the Traffic-Roadway Section and are updated twice a year, once in January and once in July. At each revision update, every standard drawing will get a new effective date, regardless of any content changes. If any content changes are made, they will be listed and dated in the standard drawing title block. See Figure 18-2. Always check to make sure the standard drawing effective date falls within the project bid let date and be aware of the status of content changes. The effective dates for each revision update are shown below:

- January update – effective date from June 1 to November 30
- July update – effective date from December 1 to May 31 of the following year

Figure 18-2 | Standard Drawing Effective Date and Content Change Information



18.1.2 Baseline Reports

Each standard drawing has been signed and sealed by an ODOT Engineer of Record and are backed by engineering analysis, calculations, and/or other justification to support the content contained within. The engineering analysis, calculations, assumptions and other information used in the development of the standard drawing is documented in the baseline report. See Figure 18-3 showing baseline information in the standard drawing title block and Figure 18-4 for an example of a baseline report. If content changes are made during the revision update periods, the baseline report is also updated.

The baseline reports are available online and the signal designer should review the baseline reports to ensure proper application of the standard drawings on the project.

Figure 18-3 | Standard Drawing Baseline Report Info in Title Block

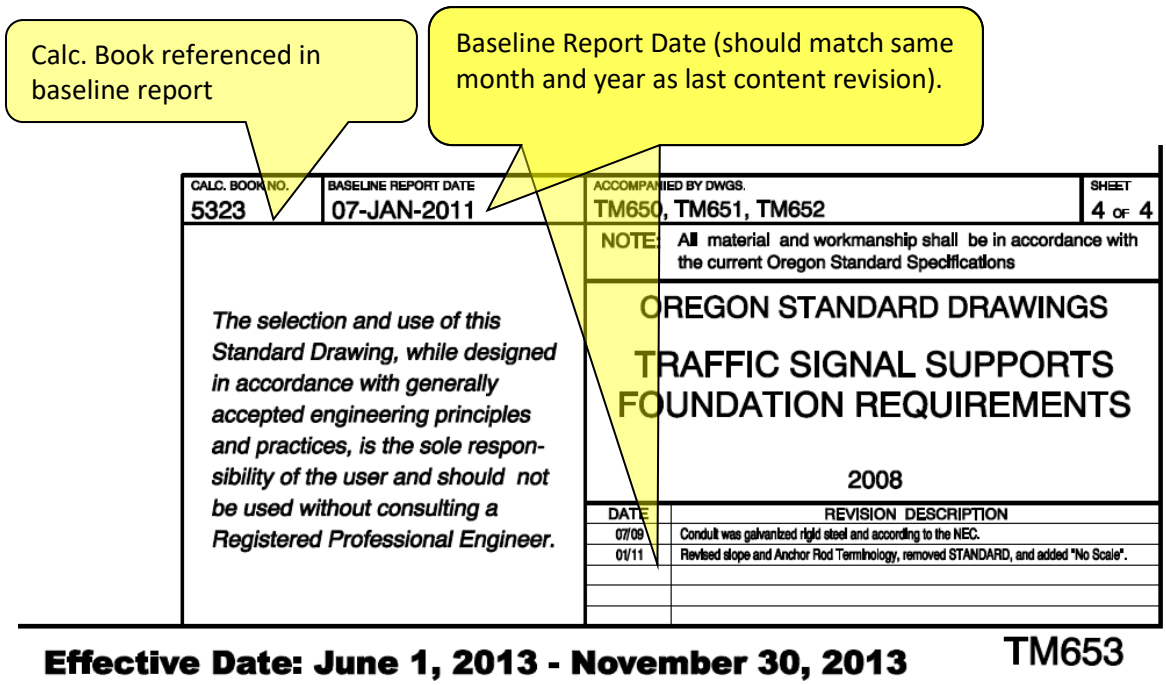


Figure 18-4 | Baseline Report Example

TM653 Standard Drawing Baseline Report

Date: January 7, 2011

Technical Owner: Scott U. Jollo, P.E.

Standard Drawing Number: TM653

Drawing Title: Traffic Signal Supports Foundation Requirements

Origination Date: 2008

REGISTERED PROFESSIONAL ENGINEER 51012PE OREGON JANUARY 12, 1999 SCOTT U. JOLLO

EXPIRES: 06/30/2011

Background Information, Including Reference Material:

AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals with 2001, 2002, 2003, and 2006 Interims

The Standard drawing Calculation book 5323 contains additional design information and calculations that pertain to the Signal Pole Foundation design.

The following is a list of the revisions that have been made to the drawing:

1. June 30, 2005 – TM 653, Standard Traffic Signal Supports Foundation Requirements (both English & Metric), was created by the Traffic Structures group.
2. June 30, 2006 – Added callout to PLAN – TOP OF FOOTING DETAIL stating that "Signal Arm Center Line can be oriented in a direction relative to top of footing". By allowing the foundation to be rotated, right of way issues might be avoided.
3. June 30, 2006 – Added Strain Pole Types column and Mastarm to Pole Types column in the Standard Foundations table.
4. June 30, 2006 – Added foundation note "Shafts 7, 8, and 9 do not include torsion rebar". The torsion reinforcement is not required for these strain poles because the torsion to moment ratio is low enough to not require the torsion rebar.
5. June 30, 2007 – Modified Stand Foundations table by removing required footing depths and modifying associated table notes. The increased loading conditions in conjunction with variable soil strength parameters required geotechnical exploration and foundation design in the preliminary design phase to produce more accurate foundation depths.
6. June 30, 2007 – Removed Soil Types definitions.

Page 1 of 4
TM653
January 7, 2011

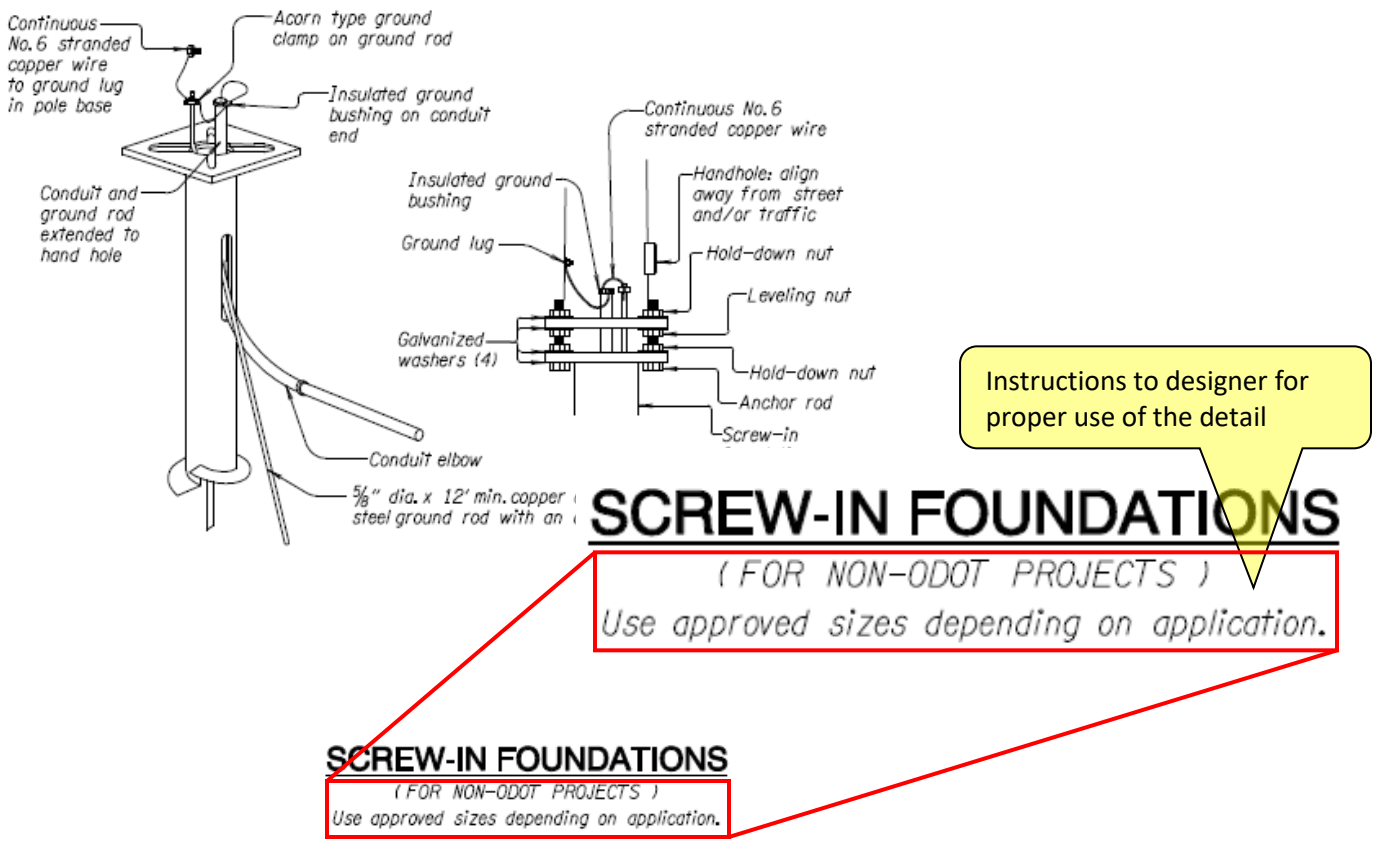
18.2 Standard Details

Standard Details typically contain construction installation information that:

- Is used infrequently,
- Is used on non-state highway roadways,
- Requires modification based on the project specific location, and/or
- Is brand new/unproven technology that needs refinement prior to becoming a standard drawing

Standard Details are used by the designer to create a project specific "details" plan sheet that will be included in the project contract plans set and stamped by the Engineer of Record. The Standard Details can, and should be modified by the designer to fit the unique, project specific requirements. Often there are notes to the designer in the Standard Detail containing further information on the appropriate use and modification of the Detail. See Figure 18-5. There are no baseline reports for standard details.

Figure 18-5 | Standard Detail – Notes to the Designer



Standard Details are maintained and updated by the Traffic-Roadways Section and can be updated at any time, so the designer should always download a copy from the web site to ensure the most up-to-date detail. The Standard Details from DET4400 to DET4499 are used for signal design.

19 SPECIFICATIONS, BID ITEMS, & COST ESTIMATE

Two separate documents are needed to complete the specifications for a project:

- The *Oregon Standard Specifications for Construction*; and
- Project-specific Special provisions.

The *Oregon Standard Specifications for Construction* is also known as Standard Specifications and remain static for 5 to 10 years. In contrast to the Standard Specifications, the Special provisions add, modify, and/or delete portions of the *Oregon Standard Specifications for Construction* based on project-specific needs.

The Oregon Standard Specifications for Construction and Special Provision Boiler Plates can be found at http://www.oregon.gov/ODOT/Business/Pages/Standard_Specifications.aspx

NOTE: Always download new copies of the Special provisions for each project since modifications to the Special provisions can occur at any time.

The following is a list of specifications directly related to traffic signals

- 00225 - Work Zone Traffic Control (for temporary signals)
- 00950 – Removal and reinstallation of highway illumination and traffic signals
- 00960 – Common provisions for highway illumination and traffic signals
- 00963 – Signal Support Drilled Shafts
- 00990 – Traffic Signals
- 02920 – Highway illumination and traffic signal materials

The following is a list of specifications indirectly related to traffic signals

- 00440 – Commercial grade concrete
- 00442 – Controller low strength materials
- 00970 – Highway illumination
- 02530 – Structural steel

In addition, there are numerous calls to other sections of the specifications not highlighted above. For example 02920.33(a) calls out “02560.20” and “02560.40”. This is not to say that section 02560 is not important or unrelated, but it fills a minor role in the overall specifications related to traffic signals.

19.1 Preparing the Special Provisions

Below is an outline of the step-by-step process required in the preparation of the Special provisions for the project:

1. Determine which specifications are applicable to the project.
2. Download the current Special provisions boiler plates of each applicable specification from the Specifications Website.
3. Edit each special provision according to the project needs using Microsoft Word with "Track Changes" turned on. If "track changes" is not used, review and future modifications become difficult.
    a. Instructions are provided in orange italic font within parentheses. For example:

    (Use the following subsection .42 when removed materials are to be stockpiled. Contact Region electrician for Region number, phone number, and all information regarding equipment to be salvaged. List materials and stockpile locations.)

    b. The instructions shall be removed from the Special provisions, and will appear similar to what is shown below:

    ~~***(Use the following subsection .42 when removed materials are to be stockpiled. Contact Region electrician for Region number, phone number, and all information regarding equipment to be salvaged. List materials and stockpile locations.)***~~

    c. Edits are limited to the instructions provided. Anything other than what's contained in the current special provision **REQUIRES** Traffic Standards review and concurrence as per TSB 12-01(B). Changes to measurement and payment require approval by the Specifications Engineer.

The example below, according to the instruction set, is used on projects with loop splices. See Figure 19-1.

Figure 19-1 | Example: Special Provision Boiler Plate (Unaltered)

(Use the following subsection .40(a) on projects with loop splices.)

00990.40(a) General - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:

Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables.

For projects that will have loop splices, the instruction information in orange italics within parenthesis must be deleted. The special provision should look like Figure 19-2:

Figure 19-2 | Example: Special Provision Boiler Plate (Modified for Use on Project)

~~***(Use the following subsection .40(a) on projects with loop splices.)***~~

00990.40(a) General - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:

Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables.

For projects that **DO NOT** have loop splices, the entire subsection must be deleted. The special provision should look like Figure 19-3:

Figure 19-3 | Example: Special Provision Boiler Plate (Deleted text for Use on Project)

~~***(Use the following subsection .40(a) on projects with loop splices.)***~~

~~**00990.40(a) General** - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:~~

~~Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables.~~

The edits shown in Figure 19-2 and Figure 19-3 are simply following the instructions that are provided within the special provision boiler plate (information in orange italics within parenthesis) and therefore do not require additional review or concurrence from Traffic Standards.

If for some reason the current Special Provision doesn't meet the project needs, modifications that fall outside of the instructions within the special provision boiler plates may be proposed. Again, this needs review and concurrence from Traffic Standards. The request for modifications may look something like Figure 19-4, where text has been added (shown in blue underline):

Figure 19-4 | Example: Special Provision Boiler Plate (Proposed Modification for Use on Project)

> ~~*(Use the following subsection .40(a) on projects with loop splices.)*~~
>
> **00990.40(a) General** - In the paragraph that begins "Install wire between pole or…", replace the second sentence with the following:
>
> Do not use junction boxes for splicing, except for loop wire splicing of loop wires to loop feeder cables and interconnect cable to interconnect cable.

It is important to note that the single line strikethrough for removal and signal line underline for additions are generated by track changes, not by changes in formatting. So when "Final" is chosen in the track changes tool all these marks disappear and the final clean document remains. If toggled from "Final" to "Final Showing Markup" all these markups will reappear for review purposes.

Always use Track Changes when modifying the special provision boiler plates!

19.2 Review & Approval of the Special Provisions

Special provisions that have been created by making modifications according to the instructions that are provided within the special provision boiler plate (information in orange italics within parenthesis) do not require review and approval from the Traffic Signal Standards Unit. However, the Traffic Signal Standards Unit will do a courtesy review if requested.

Special provisions that have modifications that fall outside of the instructions that are provided within the special provision boiler plate (e.g. revisions shown in Figure 19-4) require review and concurrence of the Technical Expert (Traffic Standards) and the Specifications Engineer as per Technical Services Bulletin TSB12-01(B):

http://www.oregon.gov/ODOT/Engineering/Doc_TechnicalGuidance/TSB12-01b.pdf

Modifications to the special provision boiler plates that fall outside of the instructions provided within the boiler plate require review and concurrence of the Technical Expert!

19.3 Bid Items

Bid items are defined in the Standard Specifications and special provisions and are the means by which the contract work is paid. The specifications define the title of bid item, the unit of measurement, and what work is included in the bid item. The following sections are used (depending on the scope of the project):

- 00990.90 contains the list for all permanent signal bid items
- 00963.90 contains the list for all permanent signal pole foundations (foundations are the only item that is not inclusive in the 00990.90 bid items)
- 00950.90 contains the list for removal of electrical systems
- 00225.95 contains the list for all temporary signal bid items

These bid item lists are explained in more detail below and can be found on the Specifications website: http://www.oregon.gov/ODOT/Business/Documents/2015_Bid_Item_List.xls. The vast majority of project work should fit within these existing, standard bid items. If the standard bid item lists do not meet the needs of the project, contact the Traffic Signal Standards Engineer for guidance. The solution may involve use of an existing, standard bid item or creation of a new bid item. Use of a new, unique bid item requires approval of the Traffic Standards Engineer and Specifications Engineer.

When detailing design items on signal plan sheets that have the potential to also be detailed in other discipline's plan sheets (e.g. Signs, Illumination, ITS), always coordinate with the other discipline to ensure the design item is only detailed (e.g. all information needed to fabricate and install) in one plan sheet, not on others. Other sheets may make reference to the design item (e.g. see sheet X for installation information) if deemed useful. If the item is detailed on multiple sheets, it causes confusion as to how the item is paid for. This can result in paying twice for the same item or extra paperwork and time to define how the item will be paid for.

New, unique bid items are discouraged and require the approval of the Traffic Standards Engineer.

19.3.1 Permanent Signal Bid Items (00990.90)

The standard bid items available in the 00990.90 section of the specifications applies to permanent signal installations:

- TRAFFIC SIGNAL INSTALLATION – LUMP SUM
  Used for all new installations and for re-builds of existing signals. Includes the new permanent traffic signal, detector system, and removal of existing electrical features. Specifically includes what is shown on the "Signal Plan" sheet, "Detector Plan" sheet, and "Removal Plan" sheet. Excludes the interconnect system.

- TRAFFIC SIGNAL MODIFICATIONS – LUMP SUM
  Used for existing installations where the traffic signal is modified. This excludes the detection system and interconnect system.

- RAMP METER SIGNAL INSTALLATION – LUMP SUM
  Includes the new permanent ramp meter signal, detection system, and removal of existing features. Specifically includes what is shown on the "Ramp Meter Plan" sheet. Excludes the interconnect system.

- DETECTOR INSTALLATION – LUMP SUM
  Used for existing installations where the detection system is modified. This excludes the signal system and interconnect system.

- FLASHING BEACON INSTALLATION – LUMP SUM
  Includes the new permanent flashing beacon and removal of existing features. Specifically includes what is shown on the "Flashing Beacon Plan" sheet.

- INTERCONNECT SYSTEM – LUMP SUM
  Includes the new or modifications to the existing interconnect system and removal of existing features. Specifically includes what is shown on the "Interconnect Plan" sheet.

All of the bid items above, except for the INTERCONNECT SYSTEM – LUMP SUM, are location specific. For example, if the project included three new traffic signals, three separate TRAFFIC SIGNAL INSTALLATION – LUMP SUM bid items would be used, one for each location. Each bid item contains a description of the location (typically labeled "mainline at side street"):

<u>US20 at Main St.</u>
TRAFFIC SIGNAL INSTALLATION – LUMP SUM $125,000

<u>US20 at 9th St.</u>
TRAFFIC SIGNAL INSTALLATION – LUMP SUM $95,000

<u>US20 at High St.</u>
TRAFFIC SIGNAL INSTALLATION – LUMP SUM $140,000

Another example would be a project with a traffic signal modification and loop detector modification at US101 at 21st St and loop detector modification at US101 at 45th St. The bid items for this project would look like:

<u>US101 at 21st St</u>
TRAFFIC SIGNAL MODIFICATIONS – LUMP SUM $25,000
LOOP DETECTORS INSTALLATION – LUMP SUM $8,500

<u>US101 at 45th St</u>
LOOP DETECTORS INSTALLATION – LUMP SUM $13,000

It is also important to note that any items that are detailed on the signal plan sheets are paid for under the applicable traffic signal bid item. Any items that are referenced on the signal plan sheet are not paid for under the traffic signal bid items. A common example of this pertains to signs attached to signal equipment; if a sign is detailed on the signal plan sheet it is paid for under the Traffic Signal Installation bid item which is Lump Sum. If the same sign is only referenced on the signal plan, but detailed on the signing plan sheet, it is paid for under by the square area under that specific sign type (see special provision 00940.90). Note that crosswalk closure supports should now be paid under 00902.90 (see section 19.3.5 for more info).

Make sure that items detailed on the signal plan sheets are NOT detailed on other plan sheets (signing is a common item); otherwise double payment for the same item can occur.

19.3.2 Permanent Signal Bid Items - Foundations (00963.90)

The standard bid items available in the 00963.90 section of the specifications applies to the foundations for permanent signal installations.

- 36 INCH DIAMETER SIGNAL SUPPORT DRILLED SHAFT – FOOT
  Used for all standard foundations that require an “FD” minimum diameter of 36 inches as per standard drawing TM653 (see table in upper left hand corner of drawing).

- 42 INCH DIAMETER SIGNAL SUPPORT DRILLED SHAFT - FOOT
  Used for all standard foundations that require an “FD” minimum diameter of 42 inches as per standard drawing TM653 (see table in upper left hand corner of drawing).

If the project has a non-standard foundation, work with the structural designer to determine the correct “FD” minimum diameter and which bid item to use. Use of an “FD” minimum diameter that is not 36” or 42” is very rare and should be avoided if possible.

This is the only signal bid item where a quantity is measured for payment and is not location specific. For the entire project, add up the foundation depths for all 36 inch “FD” minimum diameter foundations. Do the same for all 42 inch “FD” minimum diameter foundations.

19.3.3 Removal of Electrical Systems Bid Items (00950.90)

The standard bid items available in the 00950.90 section of the specifications applies to removal of traffic signal equipment:

- INCIDENTAL TO INSTALLATION BID ITEM - If the removal work meets the criteria for "Method A", which occurs when existing electrical systems are removed and replaced with new electrical systems, no separate bid item for removal is used. The removal work is inclusive to the new electrical system bid item (e.g. TRAFFIC SIGNAL INSTALLATION – LUMP SUM).

- REMOVAL OF ELECTRICAL SYSTEMS – LUMP SUM
  By definition in the specifications, this bid item is used when the removal work meets the criteria for "Method B", which occurs when existing electrical systems are removed and are not replaced with new electrical systems. This bid item is location specific. See section 19.3.1 for more information on location specific bid items.

19.3.4 Temporary Signal Bid Items (00225.95)

The standard bid items available in the 00225.95 section of the specifications applies to temporary signal installations:

- TEMPORARY TRAFFIC SIGNAL INSTALLATION – LUMP SUM
  By definition in the specification, this bid item includes all required materials called for by the plans and specifications. This includes all temporary appurtenances such as what is shown on the temporary "signal plan", the "detector plan", the "interconnect plan", etc. This bid item is location specific. See section 19.3.1 for more information on location specific bid items.

- PORTABLE TRAFFIC SIGNAL – EACH
  This bid item is normally used by the traffic control plans designer, not the signal designer. See Chapter 11 for more information on portable traffic signals and their use in projects.

19.3.5 Crosswalk Closure Support Bid Item (00902.90)

The standard bid item available in the 00902.90 section of the specifications applies to crosswalk closure supports:

- CROSSWALK CLOSURE SUPPORTS – EACH
  Crosswalk closures supports use to have two different methods for payment (as part of the lump sum traffic signal bid item and each) since the majority of these signs were installed at traffic signals. Since the ADA settlement agreement, the use of these sign at unsignalized intersections has greatly increased. To avoid payment confusion at

unsignalized and signalized intersections on a project, the option to include these signs in the traffic signal lump sum bid item was removed. Coordinate with the sign designer to ensure the correct number of signs and who will be responsible for stamping this specification.

19.4 Letter of Public Interest Finding (LPIF)

Letters of Public Interest Finding (LPIF) are required to document why it is in the public's interest to not follow a Code of Federal Regulation (CFR) or Oregon Statue requirement.

FHWA requires competition not only for the award of a construction contract, but also competition for the various materials and processes involved in the work. Whenever competition for materials or processes is eliminated, an LPIF is required.

General examples of materials or processes that require an LPIF are:

- Proprietary or patented materials
- Sole Source materials
- Agency supplied materials
- Salvaged materials
- Work performed by Agency forces

Typical traffic signal items that require and LPIF are:

- ITS equipment (processed by the ODOT ITS Unit – Doug Spencer)
- Video/radar equipment that is called out by brand name (without allowing the option of "or approved equal")
- Preemption detection equipment that is called out by brand name (without allowing the option of "or approved equal")
- LED illumination fixtures that are called out by brand name (without allowing the option of "or approved equal")
- Salvaged poles and controller cabinets

Additional guidance and instructions for developing and processing LPIF's can be found in the LPIF Guidance Document on the OPL website. LPIF examples and templates are also included in the on the OPL website.

You can also request LPIF examples for traffic signal specific items from the Traffic Signal Engineer.

NOTE: The LPIF needs to be submitted and approved at least two weeks prior to PS&E submission. LPIF's should be submitted as early as possible. They are not always approved. The project schedule could be impacted if changes to the plans are needed due to the LPIF not being approved.

19.5 Cost Estimate

Once the appropriate bid items are chosen a cost estimate must be completed for each bid item. The bid item estimates must be based on historical data, available industry data, manufacturer quotes, and project specific research.

For ODOT signal designers, an excel spreadsheet (updated yearly by the Traffic Signal Standards Unit) can be downloaded from the Signal Specs share drive to assist in cost estimating: \\scdata\signal specs (file name "Signals2017-3.xls". The date in the file name will change to reflect the current year)

ODOT internal estimating tools cannot be given to external staff

19.5.1 Anticipated Items

Anticipated items are used to provide a funding mechanism for non-biddable elements of work that may be needed to complete a project. Anticipated items should not be used for items of work that can be competitively bid, e.g. unfinished and incomplete design work. Anticipated items are included with the cost estimate.

For signal work the following items require an anticipated item:

- Power hook-up (when installing a BMCL, BMC, or SC & MS). This should include conduit, trenching, and wiring from the power source to the traffic signal service cabinet. Coordinate with the Region Utility Specialist to determine a reasonable cost estimate.

- Anything that is on price agreement, such as communication gear.

20 CABINET PRINT

The cabinet print is a schematic representation of the components that are inside the controller cabinet. This schematic is used mainly by TSSU, Region Electrical Crew, and Region signal timers.

A hard copy of the cabinet print is required to be in the controller cabinet at all times.

20.1 When is a Cabinet Print Required?

A cabinet print is required for all new signals, the first stage for temporary signals, and any modification to an existing traffic signal that will require a change (addition, deletion, or modification) to the components inside the controller cabinet. The cabinet print must be accurate for proper maintenance and timing of the intersection.

20.2 Who is Responsible for Creating a Cabinet Print?

The signal designer is responsible for creating the initial cabinet print(s). The initial cabinet print should be submitted at DAP, when the basic signal equipment layout and normal phase rotation are known. It is critical that the signal timer has adequate time to review and comment on the detector unit placement/zones and provide zone configuration information (shown on Sheet 7) as early as possible in the design process. The cabinet print should be revised as necessary during the design phase based on comments received and completed before the equipment arrives at TSSU for testing (during construction).

The Traffic Signal Standards Unit is responsible for creating the final version of the cabinet print from the red-line as-builts provided by TSSU after installation.

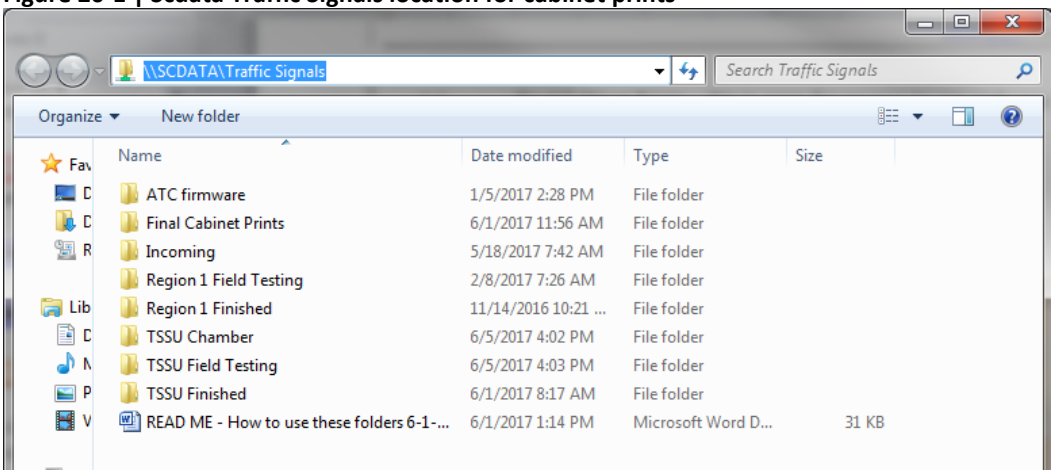
A Cabinet print reflects the conditions shown in the sealed plan sheets and therefore does NOT require a P.E. Stamp.

20.3 Procedure for Producing Cabinet Prints

An internal ODOT folder has been set up to process the various stages of the cabinet print (from start to final version). The location is: \\scdata\Traffic Signals Within this server folder there are seven subfolders, listed in the order they are used in the process. The process for using the subfolders is explained in the READ ME document. See Figure 20-1:

1. **Incoming** – This is open to anyone: read, write, delete, etc.
2. **TSSU Chamber** – This is open to anyone to see and copy files, but only TSSU can write, delete, etc.
3. **TSSU Field Testing & Region 1 Field Testing** – these are open for anyone to see and copy files, but only TSSU can write, delete, etc.
4. **TSSU Finished & Region 1 Finished** – these are open for anyone to see and copy files, but only TSSU can write, delete, etc.
5. **Final Cabinet Prints** – this is open for anyone to see and copy files, but only Traffic Standards can write, delete, etc.

Figure 20-1 | Scdata Traffic Signals location for cabinet prints



Key information for the Traffic Signal Designer:

1. The cabinet print files (both DGN and PDF) are required in the appropriate INCOMING subfolder **at DAP**. The signal designer should address all comments received on cabinet print before the equipment arrives at TSSU (this is typically 2 to 6 months after the project plans are approved). However, a fast track project may reduce that time to 4 to 8 weeks. Non-ODOT designers should e-mail the files to the Traffic Signal Engineer who will then place the files in the subfolder. Plan accordingly, as failure to produce the cabinet prints in a timely manner may impact the design and construction schedule.
2. The Traffic Signal Designer must contact the Region Signal Timer and request they place the signal timing files within the appropriate INCOMING subfolder. The same time frame described above applies.

If modifications to the cabinet print DO NOT match the conditions shown on the most current, sealed plan sheet(s) for the intersection, a new plan sheet is required (as-built).

20.4 Creating the Cabinet Print

Each intersection should have its own cabinet print file. The file name should begin with the TSSU ID number and abbreviated intersection name using the highway route number, for example "04023_99W_LewisburgRd".

The cabinet prints are created in microstation. There are five different types of cabinet print base files available on the Traffic Signal Standards website depending on what type of cabinet is used. Select the correct base file for each intersection on the project:

- 332S cabinet print
- 332 cabinet print
- 336 cabinet print
- 334 ramp meter cabinet print
- 334 count (ATR) cabinet print

The base files are available at: http://www.oregon.gov/ODOT/Engineering/Pages/Signals.aspx under "MicroStation cabinet prints".

An excel file "Detector Configuration" for each cabinet is also required to complete the input file (page 2) and the detection drawing (page 7). The signal timer is responsible for filling out the information correctly in the excel file and the signal designer will import that information into the microstation file. These excel files and information on how to import the excel file using Axiom Office Importer is found at the website mentioned above for base files.

The Signal Designer should also look in the FINAL CABINET PRINTS folder for existing information before starting a new cabinet print file: \\scdata\Traffic Signals\Final Cabinet Prints. A copy of the existing files may be used and modified for the project. However, creating a new cabinet print file will be necessary for a new traffic signal or when replacing an existing cabinet with different style cabinet (e.g. replacing a 332 with a 332S). For signal Designers outside of ODOT, contact the Traffic Signal Standards Unit to obtain existing cabinet print information.

In the microstation base files, the areas that can be modified are typically shown in red. They are populated with the standard phase layout. There are different levels that can be turned on or off depending on the equipment that is installed (see the additional instructions for using the DGN files on the website). The typical areas that require modification include:

- The title block identifying information (i.e. intersection name, City, Hwy, MP, TSSU ID number, date and revision remarks)The input file (front view and side view)
- The Input and Output file (front view and back view)
- The intersection drawing and the intersection detection drawing

The cabinet print needs to show what is actually used and its intended function. If an area is unused, it should be blank. The other information contained in the cabinet print shows standard electrical schematics that apply to each type of cabinet and are generally not modified.

Cabinet prints are formatted for printing on 11x17 paper.

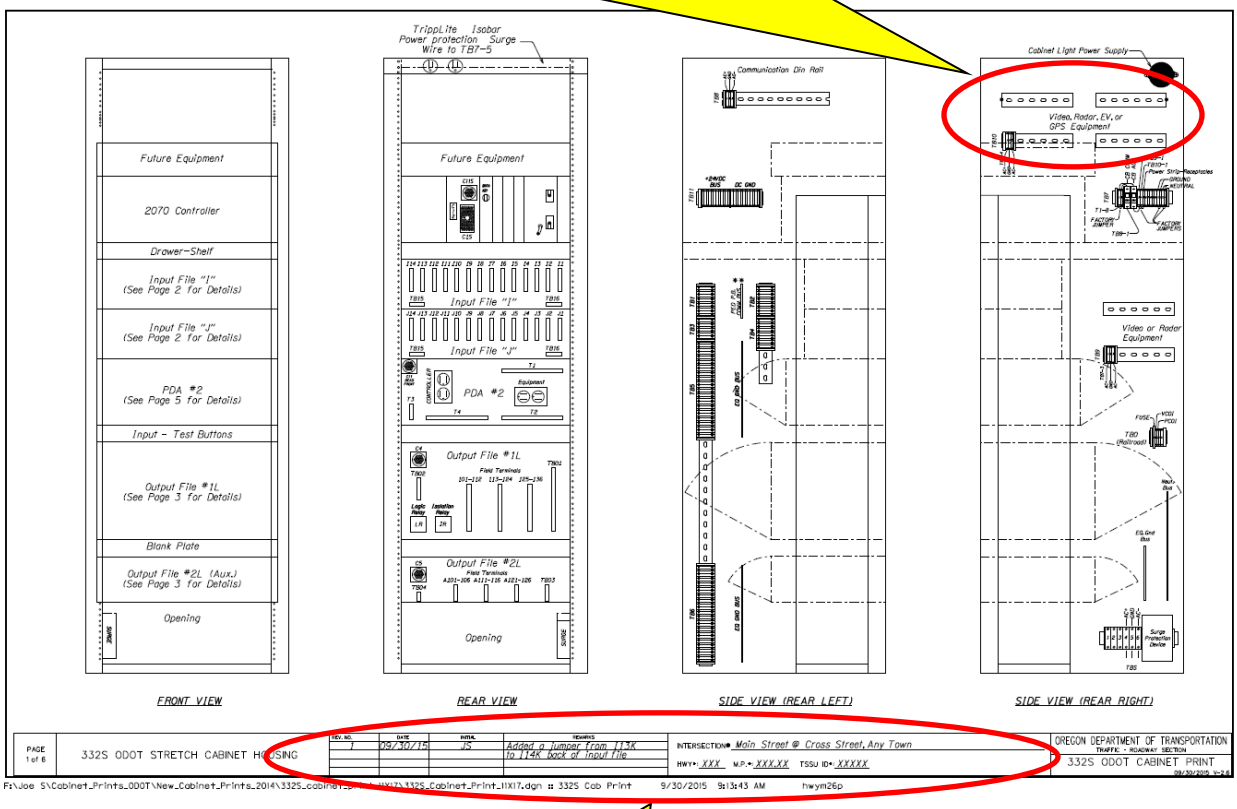
NOTE! All figures in this manual show a 332S cabinet with a C11 connector. The cabinet print layout for the 332 without a C11 connector, 336, and 334 cabinet will be slightly different, but all contain similar elements. The basic information in this manual can be used in conjunction with the appropriate base file.

20.5 332S Cabinet Print (Page 1 – cabinet layout)

Page 1 of the 332S cabinet print shows the front, rear, and both side views of the cabinet. There is not a lot to modify on this sheet, but certain levels and/or references will need to be turned-on or off to show the correct site specific equipment, (i.e. communication equipment, battery back-up, etc.). See Figure 20-2.

Figure 20-2 | 332S Cabinet Print (page 1)

Various equipment on (different levels) can be turned on and off based on site specifics (video detection, communication equipment, etc.). Generally, the info on these levels does not be to be further modified.

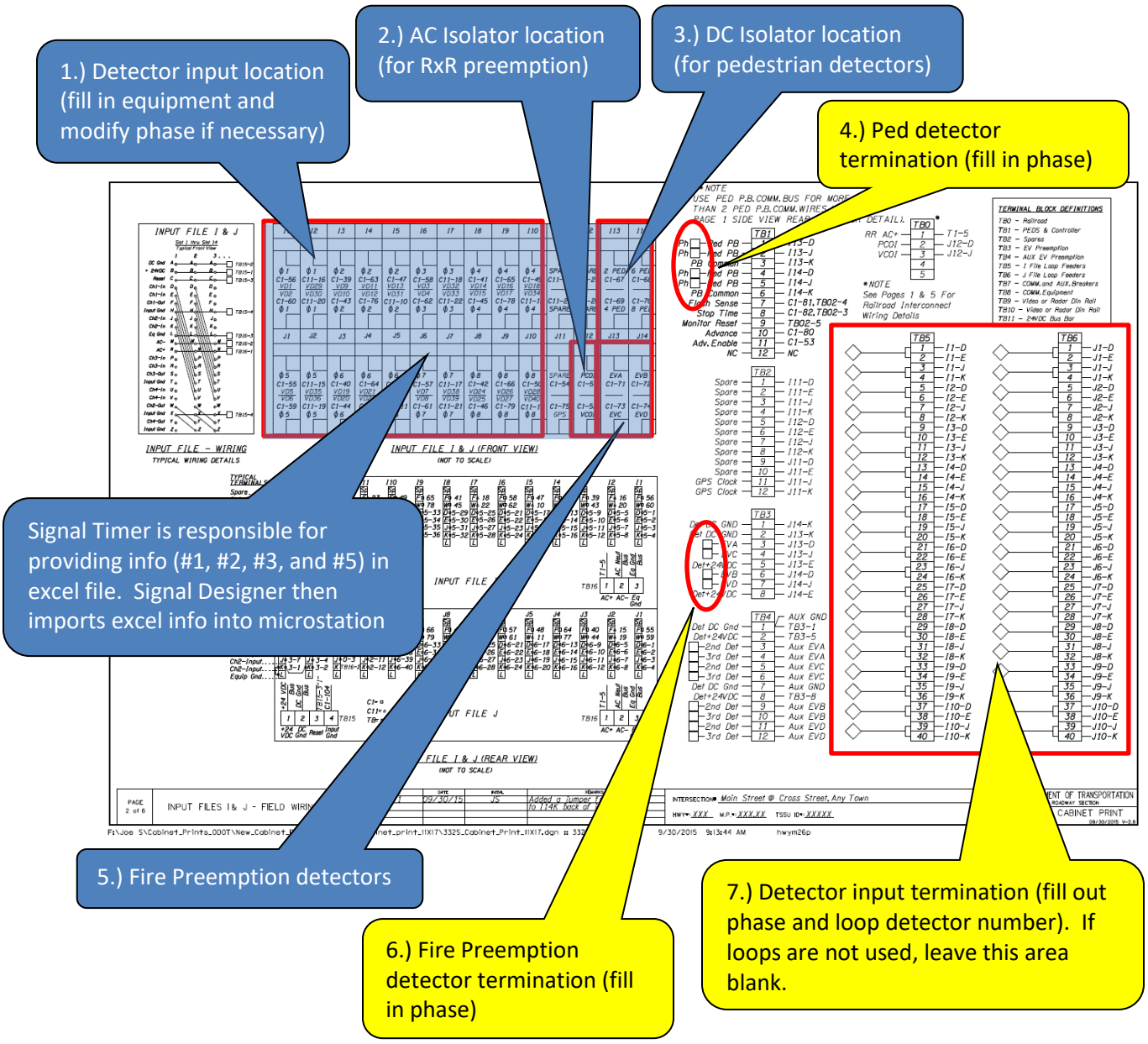


Title block area needs to be filled out as directed

20.6 332S Cabinet Print (Page 2 – Input File)

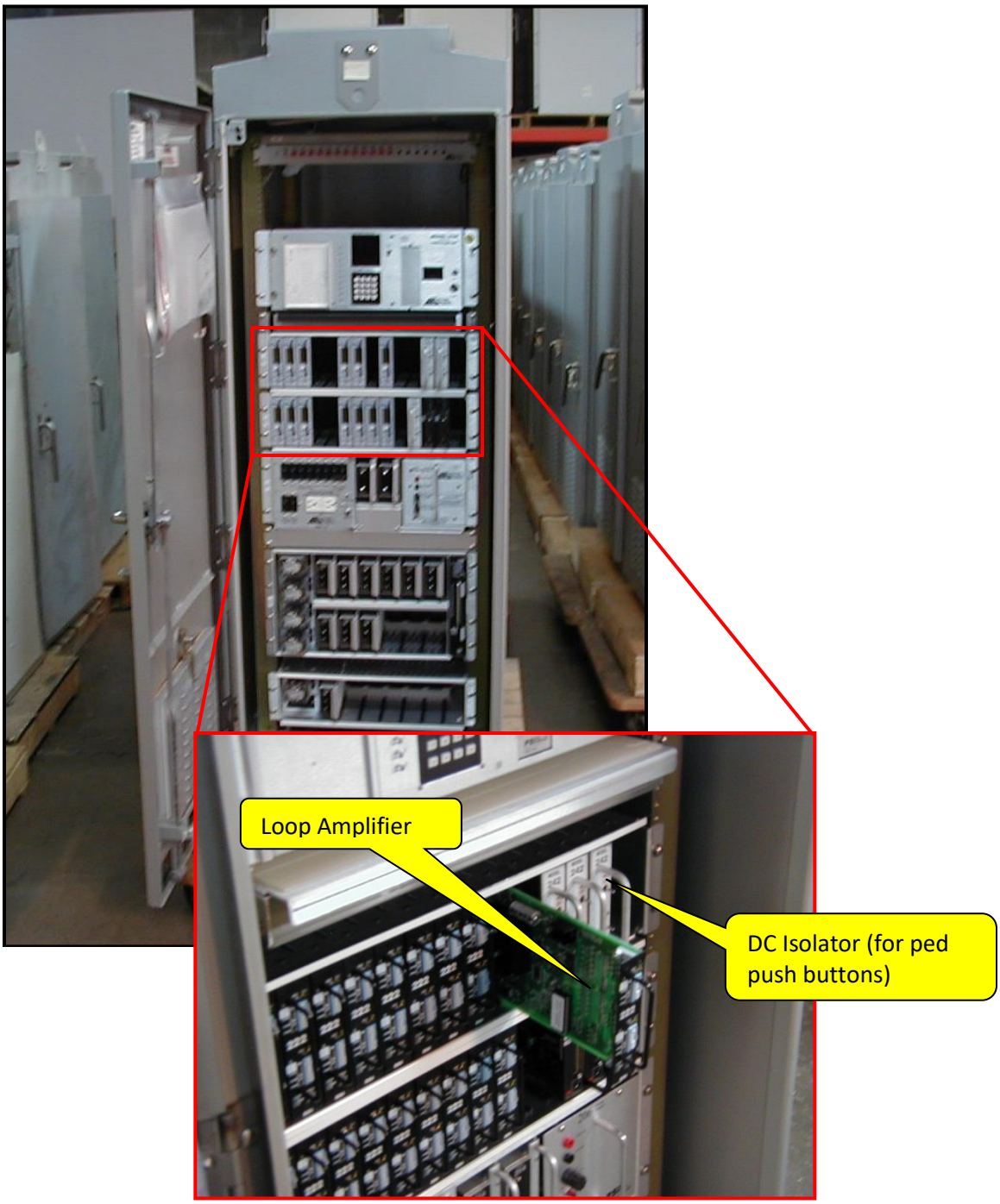
Page 2 of the 332S cabinet print shows the input file. This sheet requires filling in the information for all the input equipment used. The signal timer is responsible for filling out the majority of the input file information in the Detection Configuration Excel file which is then imported into the microstation cabinet print by the Signal Designer. The basic input equipment (i.e. loop amplifiers, video rack cards, radar rack cards, DC isolators, AC isolators, fire preemption, etc.) that needs to be filled in is shown in Figure 20-3, with the signal timer's responsibility shown shaded in blue. Each bubble note in Figure 20-3 is numbered and described in more detail in the next sections. **<u>Important additional information about the input file is in section 20.6.8.</u>**

Figure 20-3 | 332S Cabinet Print (page 2 – Input File)



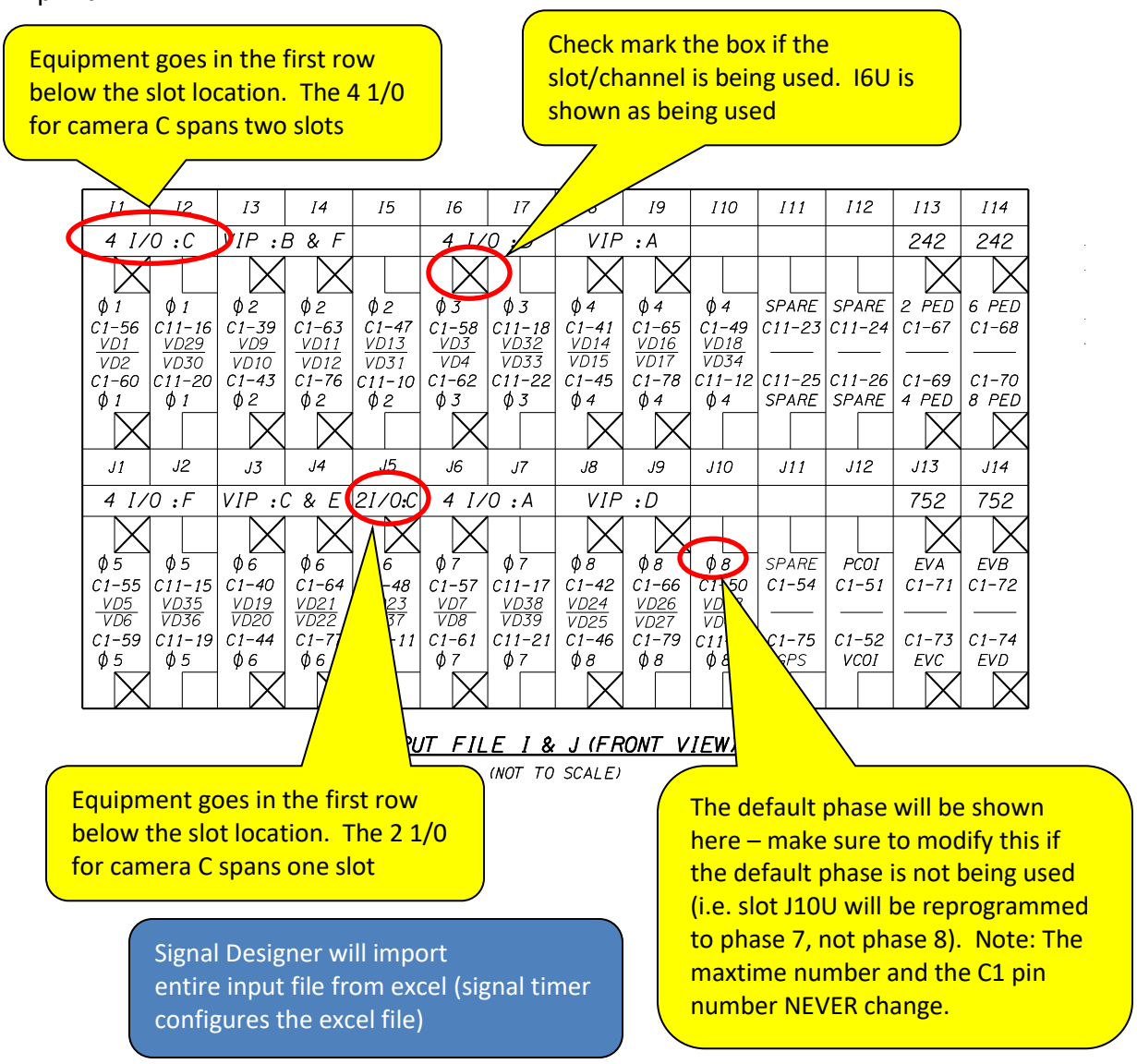
For reference, Figure 20-4 shows the actual front view of the input file in a 332 cabinet.

Figure 20-4 | 332 Cabinet – Input File (Front View) Actual View



20.6.1 Detector Input Location (Signal Timer Responsibility – Use Excel File)

This spans slots one to slot ten (with the possibility of slot eleven and twelve of the "I" file used as needed). When SDLC connection is used, slots 1 thru 10, I11, and I12 will be blank. When SDLC is not used, equipment will be placed in the input file (for loops, video, radar, etc.). The example below shows where the signal timer will fill in the information (using the Detector Configuration excel file which automates the majority of items shown below). See Chapter 20 for more information on completing the cabinet print.



Equipment used in the detector input location:

- 222 = Loop detector amplifier
- VIP: T = Video Image Processor (for camera "T")
- 4 I/O: T = 4 channel input/output module (for camera "T")
- 2 I/O: T = 2 channel input/output module (for camera "T")
- RAD:T = Radar unit (for radar unit "T")

20.6.2 AC Isolator Location (Signal Timer Responsibility – Use Excel File)

This is located in slot J12 (J12U is for the PCOI input and J12L is for the VCOI Input). This location is used for railroad preemption. The equipment module number is 255 (a 252 is used in 332 cabinets). The example below shows where you fill in the equipment.

Equipment goes in the first row below the slot location. The AC isolator for a 332S cabinet is 255

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11		I13	I14
4 I/O :C		VIP :B & F			4 I/O :D		VIP :A					242	242
☒	☐	☒	☒	☐	☒	☐	☒	☒	☐	☐		☒	☒
ϕ 1 C1-56 VD1 VD2 C1-60 ϕ 1	ϕ 1 C11-16 VD29 VD30 C11-20 ϕ 1	ϕ 2 C1-39 VD9 VD10 C1-43 ϕ 2	ϕ 2 C1-63 VD11 VD12 C1-76 ϕ 2	ϕ 2 C1-47 VD13 VD31 C11-10 ϕ 2	ϕ 3 C1-58 VD3 VD4 C1-62 ϕ 3	ϕ 3 C11-18 VD32 VD33 C11-22 ϕ 3	ϕ 4 C1-41 VD14 VD15 C1-45 ϕ 4	ϕ 4 C1-65 VD16 VD17 C1-78 ϕ 4	ϕ 4 C1-49 VD18 VD34 C11-12 ϕ 4	SPARE C11-23 —— C11-25 SPARE	RE 24 — -26 ARE	2 PED C1-67 —— C1-69 4 PED	6 PED C1-68 —— C1-70 8 PED
☒	☐	☒	☒	☐	☒	☐	☒	☒	☐	☐	☐	☒	☒
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14
4 I/O :F		VIP :C & E		2I/O:C	4 I/O :A		VIP :D				255	752	752
☒	☐	☒	☒	☒	☒	☐	☒	☒	☐	☐	☒	☒	☒
ϕ 5 C1-55 VD5 VD6 C1-59 ϕ 5	ϕ 5 C11-15 VD35 VD36 C11-19 ϕ 5	ϕ 6 C1-40 VD19 VD20 C1-44 ϕ 6	ϕ 6 C1-64 VD21 VD22 C1-77 ϕ 6	ϕ 6 C1-48 VD23 VD37 C11-11 ϕ 6	ϕ 7 C1-57 VD7 VD8 C1-61 ϕ 7	ϕ 7 C11-17 VD38 VD39 C11-21 ϕ 7	ϕ 8 C1-42 VD24 VD25 C1-46 ϕ 8	ϕ 8 C1-66 VD26 VD27 C1-79 ϕ 8	ϕ 8 C1-50 VD28 VD40 C11-13 ϕ 8	SPARE C1-54 —— C1-75 GPS	PCOI C1-51 —— C1-52 VCOI	EVA C1-71 —— C1-73 EVC	EVB C1-72 —— C1-74 EVD
☒	☐	☒	☒	☐	☒	☐	☒	☐	☐	☐	☒	☒	☒

INPUT FILE I & J (FRONT VIEW)

(NOT TO SCALE)

Check mark the box if the slot/channel is being used. Both the PCOI and VCOI inputs are being used

Signal Designer will import entire input file from excel (signal timer configures the excel file)

20.6.3 DC Isolator Location (Signal Timer Responsibility – Use Excel File)

This is located in slots I13 and I14 and is used for push button detection. The standard phasing is shown in the diagram. The equipment module number is 242.

Equipment goes in the first row below the slot location. The DC isolator equipment number is 242

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14
4 I/O :C		VIP :B & F			4 I/O :D		VIP :A					242	242
☒	☐	☒	☒	☐	☒	☐	☒	☒	☐	☐	☐	☒	☒
ϕ 1 C1-56 VD1 VD2 C1-60 ϕ 1	ϕ 1 C11-16 VD29 VD30 C11-20 ϕ 1	ϕ 2 C1-39 VD9 VD10 C1-43 ϕ 2	ϕ 2 C1-63 VD11 VD12 C1-76 ϕ 2	ϕ 2 C1-47 VD13 VD31 C11-10 ϕ 2	ϕ 3 C1-58 VD3 VD4 C1-62 ϕ 3	ϕ 3 C11-18 VD32 VD33 C11-22 ϕ 3	ϕ 4 C1-41 VD14 VD15 C1-45 ϕ 4	ϕ 4 C1-65 VD16 VD17 C1-78 ϕ 4	ϕ 4 C1-49 VD18 VD34 C11-12 ϕ 4	SPARE C11-23 —— C11-25 SPARE	SPARE C11-24 —— C11-26 SPARE	2 PED C1-67 —— C1-69 4 PED	6 PED C1-68 —— C1-70 8 PED
☒		☒	☒		☒		☒	☒				☒	☒
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14
4 I/O :F		VIP :C & E		2I/O:C	4 I/O :A		VIP :D					752	752
☒	☐	☒	☒	☒	☒	☐	☒	☒	☐	☐	☐	☐	☒
ϕ 5 C1-55 VD5 VD6 C1-59 ϕ 5	ϕ 5 C11-15 VD35 VD36 C11-19 ϕ 5	ϕ 6 C1-40 VD19 VD20 C1-44 ϕ 6	ϕ 6 C1-64 VD21 VD22 C1-77 ϕ 6	ϕ 6 C1-48 VD23 VD37 C11-11 ϕ 6	ϕ 7 C1-57 VD7 VD8 C1-61 ϕ 7	ϕ 7 C11-17 VD38 VD39 C11-21 ϕ 7	ϕ 8 C1-42 VD24 VD25 C1-46 ϕ 8	ϕ 8 C1-66 VD26 VD27 C1-79 ϕ 8	ϕ 8 C1-50 VD28 VD40 C11-13 ϕ 8	SPARE C1-54 —— C1-75 GPS	PCOI C1-51 —— C1-52 VCOI	E C1 —	EVB C1-72 —— C1-74 EVD
☒		☒	☒		☒		☒						☒

INPUT FILE I & J (FRONT VIEW)

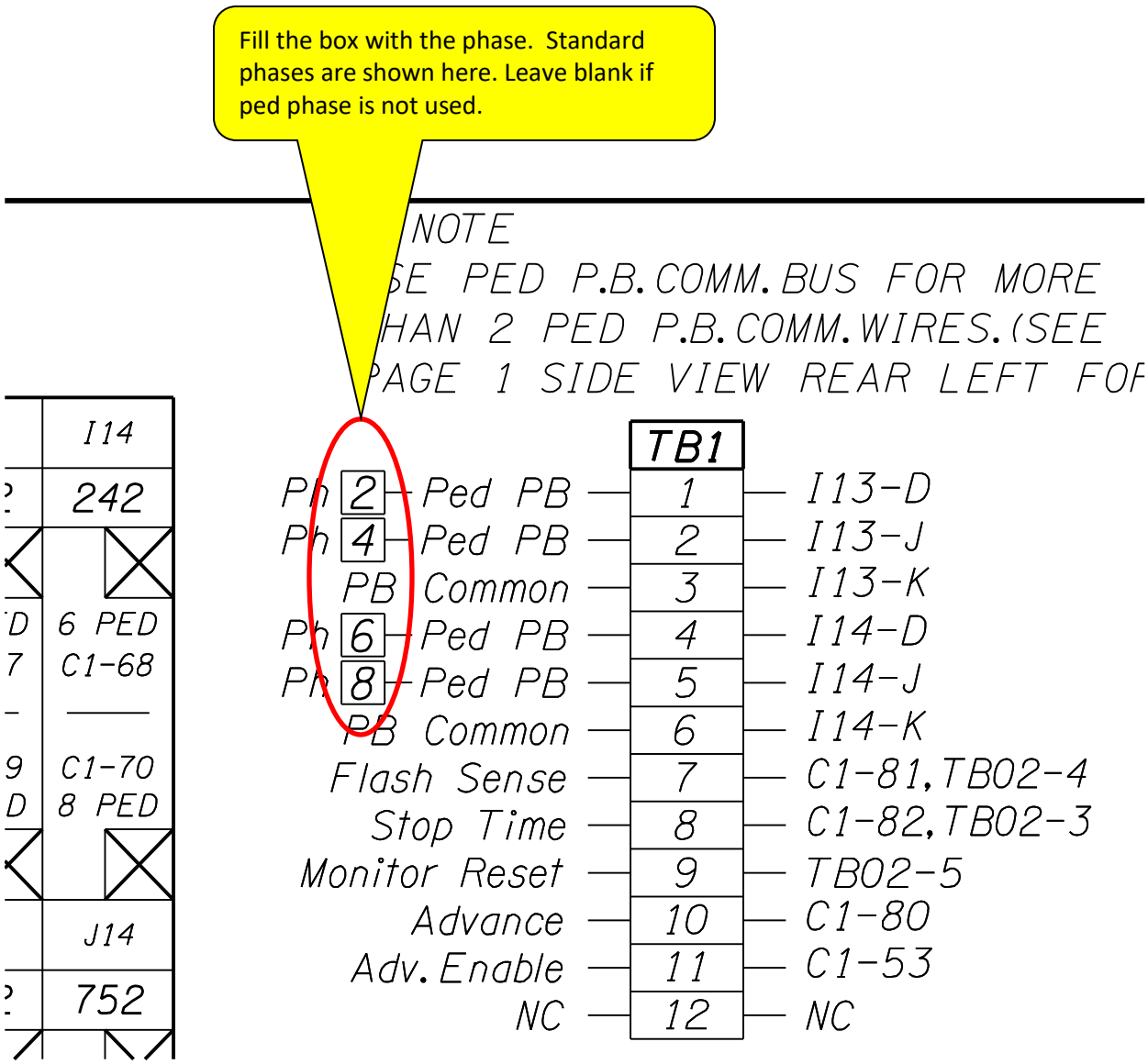
(NOT TO SCALE)

Signal Designer will import entire input file from excel (signal timer configures the excel file)

Check mark the box if the slot/channel is being used. All 4 ped phases are used in this example.

20.6.4 Pedestrian Detector Termination

This shows the terminal block where the pedestrian detectors are wired. Fill in the phase for the pedestrian pushbuttons being used.



20.6.5 Fire Preemption Detectors (Signal Timer Responsibility – Use Excel File)

This is located in slots J13 and J14 and is used to provide the input for fire preemption. The equipment modules for fire preemption detectors are 752 (Opticom phase selector) and 2140 (Tomar Stobecom II O.S.P.).

Equipment goes in the first row below the slot location. The equipment number is either 752 or 2140

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14
4 I/O :C		VIP :B & F			4 I/O :D		VIP :A					242	242
ϕ 1 C1-56 VD1 VD2 C1-60 ϕ 1	ϕ 1 C11-16 VD29 VD30 C11-20 ϕ 1	ϕ 2 C1-39 VD9 VD10 C1-43 ϕ 2	ϕ 2 C1-63 VD11 VD12 C1-76 ϕ 2	ϕ 2 C1-47 VD13 VD31 C11-10 ϕ 2	ϕ 3 C1-58 VD3 VD4 C1-62 ϕ 3	ϕ 3 C11-18 VD32 VD33 C11-22 ϕ 3	ϕ 4 C1-41 VD14 VD15 C1-45 ϕ 4	ϕ 4 C1-65 VD16 VD17 C1-78 ϕ 4	ϕ 4 C1-49 VD18 VD34 C11-12 ϕ 4	SPARE C11-23 C11-25 SPARE	C1 C11-2 SPARE	2 PED C1-67 C1-69 PED	6 PED C1-68 C1-70 8 PED
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14
4 I/O :F		VIP :C & E		2I/O:C	4 I/O :A		VIP :D					752	752
ϕ 5 C1-55 VD5 VD6 C1-59 ϕ 5	ϕ 5 C11-15 VD35 VD36 C11-19 ϕ 5	ϕ 6 C1-40 VD19 VD20 C1-44 ϕ 6	ϕ 6 C1-64 VD21 VD22 C1-77 ϕ 6	ϕ 6 C1-48 VD23 VD37 C11-11 ϕ 6	ϕ 7 C1-57 VD7 VD8 C1-61 ϕ 7	ϕ 7 C11-17 VD38 VD39 C11-21 ϕ 7	ϕ 8 C1-42 VD24 VD25 C1-46 ϕ 8	ϕ 8 C1-66 VD26 VD27 C1-79 ϕ 8	ϕ 8 C1-50 VD28 VD40 C11-13 ϕ 8	SPARE C1-54 C1-75 GPS	PCOI C1-51 C1-52 VCOI	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD

INPUT FILE I & J (FRONT VIEW)

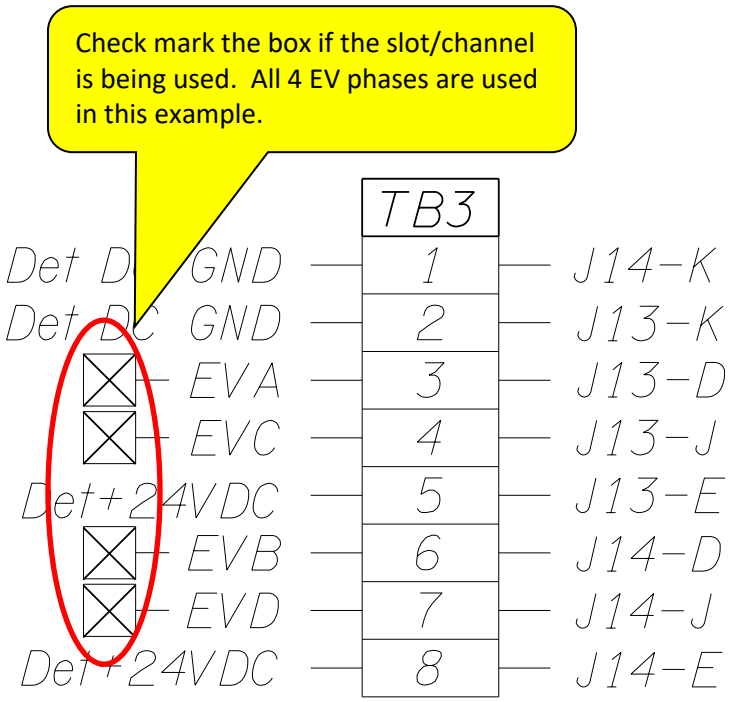
(NOT TO SCALE)

Signal Designer will import entire input file from excel (signal timer configures the excel file)

Check mark the box if the slot/channel is being used. All 4 EV phases are used in this example.

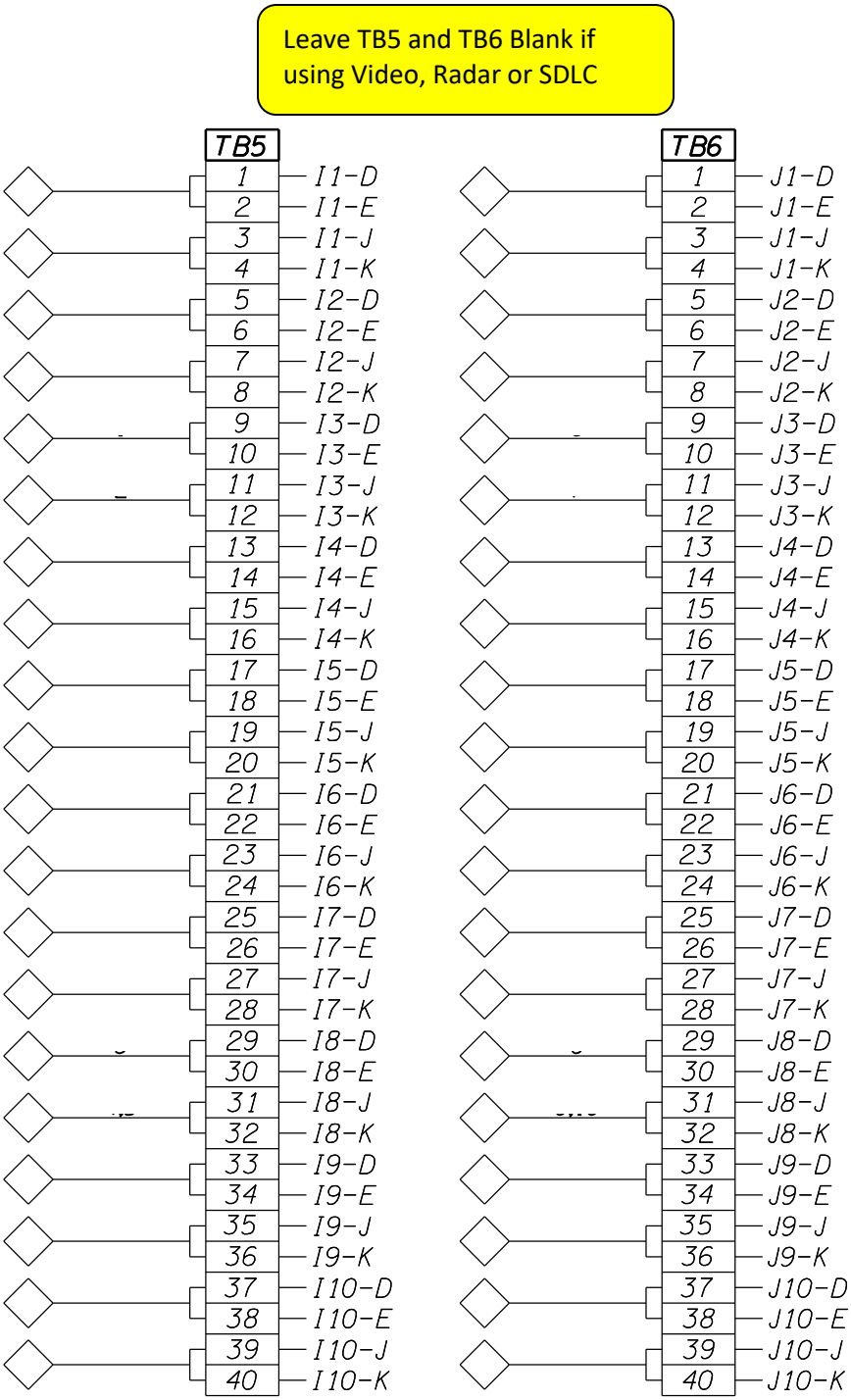
20.6.6 Fire Preemption Detection Termination

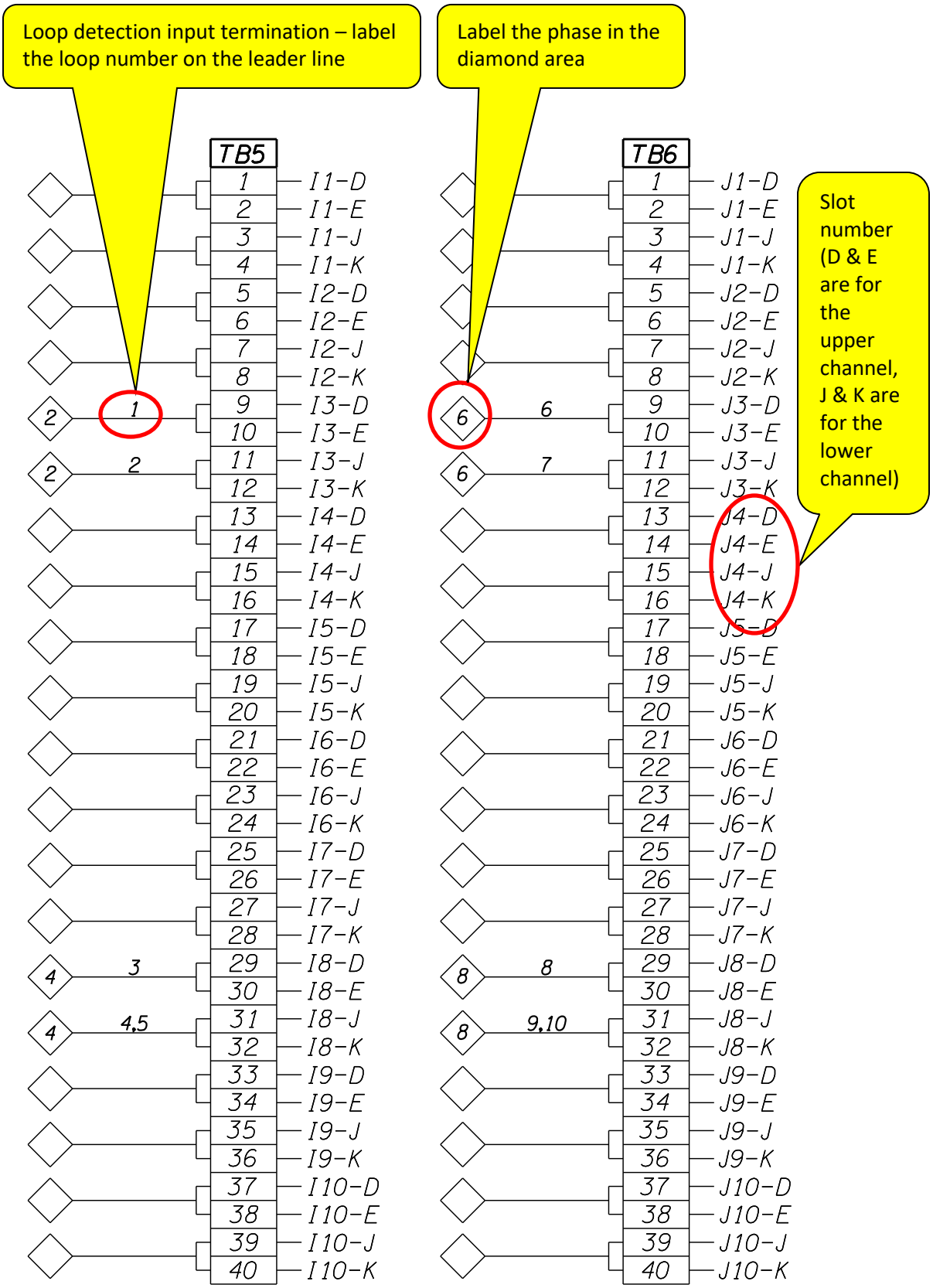
This shows the terminal block where the fire preemption is wired. Mark the check box if the EV channel is being used.



20.6.7 Detector Input Termination

This shows the terminal block where the vehicle detection is wired (TB5 and TB6). In a 332s cabinet, this location should remain blank when using video, radar or SDLC as shown in the first example below (display the proper models as per the microstation base file instructions). Loop detection is the only type of detection that requires entering info and is shown in the second example on the following page.




Loop detection input termination – label the loop number on the leader line
Label the phase in the diamond area
Slot number (D & E are for the upper channel, J & K are for the lower channel)
TB5
1 I1-D
2 I1-E
3 I1-J
4 I1-K
5 I2-D
6 I2-E
7 I2-J
8 I2-K
9 I3-D
10 I3-E
11 I3-J
12 I3-K
13 I4-D
14 I4-E
15 I4-J
16 I4-K
17 I5-D
18 I5-E
19 I5-J
20 I5-K
21 I6-D
22 I6-E
23 I6-J
24 I6-K
25 I7-D
26 I7-E
27 I7-J
28 I7-K
29 I8-D
30 I8-E
31 I8-J
32 I8-K
33 I9-D
34 I9-E
35 I9-J
36 I9-K
37 I10-D
38 I10-E
39 I10-J
40 I10-K
2 1
2 2
4 3
4 4,5
TB6
1 J1-D
2 J1-E
3 J1-J
4 J1-K
5 J2-D
6 J2-E
7 J2-J
8 J2-K
9 J3-D
10 J3-E
11 J3-J
12 J3-K
13 J4-D
14 J4-E
15 J4-J
16 J4-K
17 J5-D
18 J5-E
19 J5-J
20 J5-K
21 J6-D
22 J6-E
23 J6-J
24 J6-K
25 J7-D
26 J7-E
27 J7-J
28 J7-K
29 J8-D
30 J8-E
31 J8-J
32 J8-K
33 J9-D
34 J9-E
35 J9-J
36 J9-K
37 J10-D
38 J10-E
39 J10-J
40 J10-K
6 6
6 7
8 8
8 9,10

20.6.8 Additional Information about the Input File

1. The 332 cabinet without a C11 connector has 28 vehicle inputs using 9 slots and 2 input files that is wired to accommodate:
    - 2 vehicle detection inputs to the controller for each odd numbered phase
    - 5 vehicle detection inputs to the controller for each even numbered phase
    - 4 pedestrian detection inputs (Slot I12 and I13)
    - 4 emergency preemption inputs (Slot J12 and J13)
    - 2 railroad preemption inputs (Slot J11: indirect via 4 C1 pins using a 252 AC Isolator)
    - 0 spares

    Each input file slot has (2) channels associated with it, the upper and the lower. The slot may have one or two controller inputs wired to it. Slots 1, 4, 5, and 8 have one controller input. Slots 2, 3, 6, 7, 9, 12, and 13 have two controller inputs. Slot 10, I11 and 14 have no inputs and are not used (i.e. no C1 pin).

    If a viewcom module is used, it will go in slot I10 and I11.

2. The 332S cabinet with a C11 connector uses has 40 vehicle inputs using 10 slots and 2 input files that is wired to accommodate:
    - 4 vehicle detection inputs to the controller for each odd numbered phase
    - 6 vehicle detection inputs to the controller for each even numbered phase
    - 4 pedestrian detection inputs (Slot I13 and I14)
    - 4 emergency preemption inputs (Slot J13 and J14)
    - 2 railroad preemption inputs (Slot J12: direct via inverting a 255 AC isolator)
    - 1 GPS (J11L)
    - 5 spares (Slot I11U, I11L, J11U, J12U, and J12L)

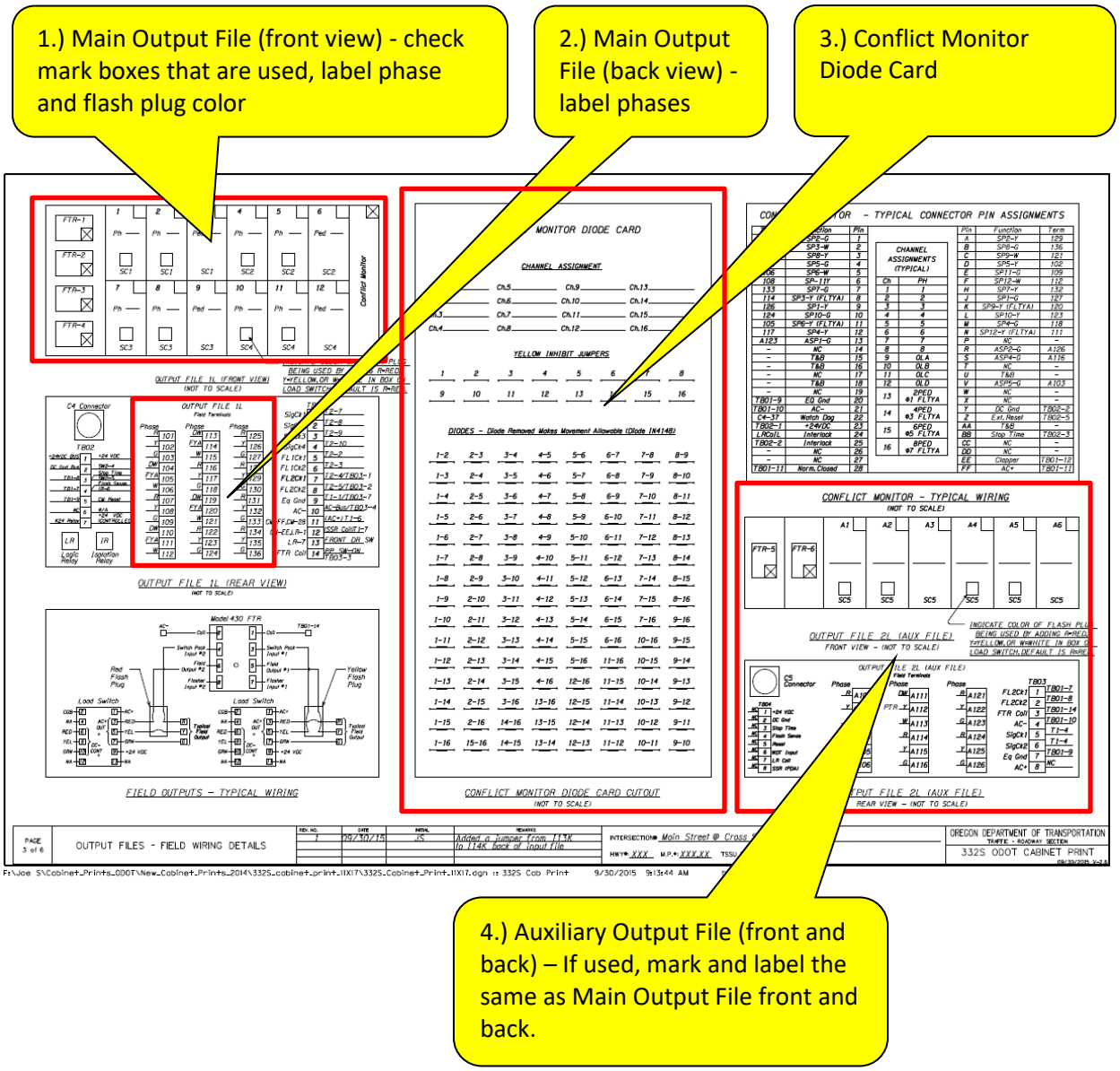
    Each input file slot has (2) channels associated with it, the upper and the lower. All slots have two controller inputs wired to it (assigned to the C1 or C11 connector).

    If a viewcom module is used, it will go in slot I11 and I12. The C11 pins need to be disconnected for the viewcom module to function.

20.7 332S Cabinet Print (Page 3 – Output File)

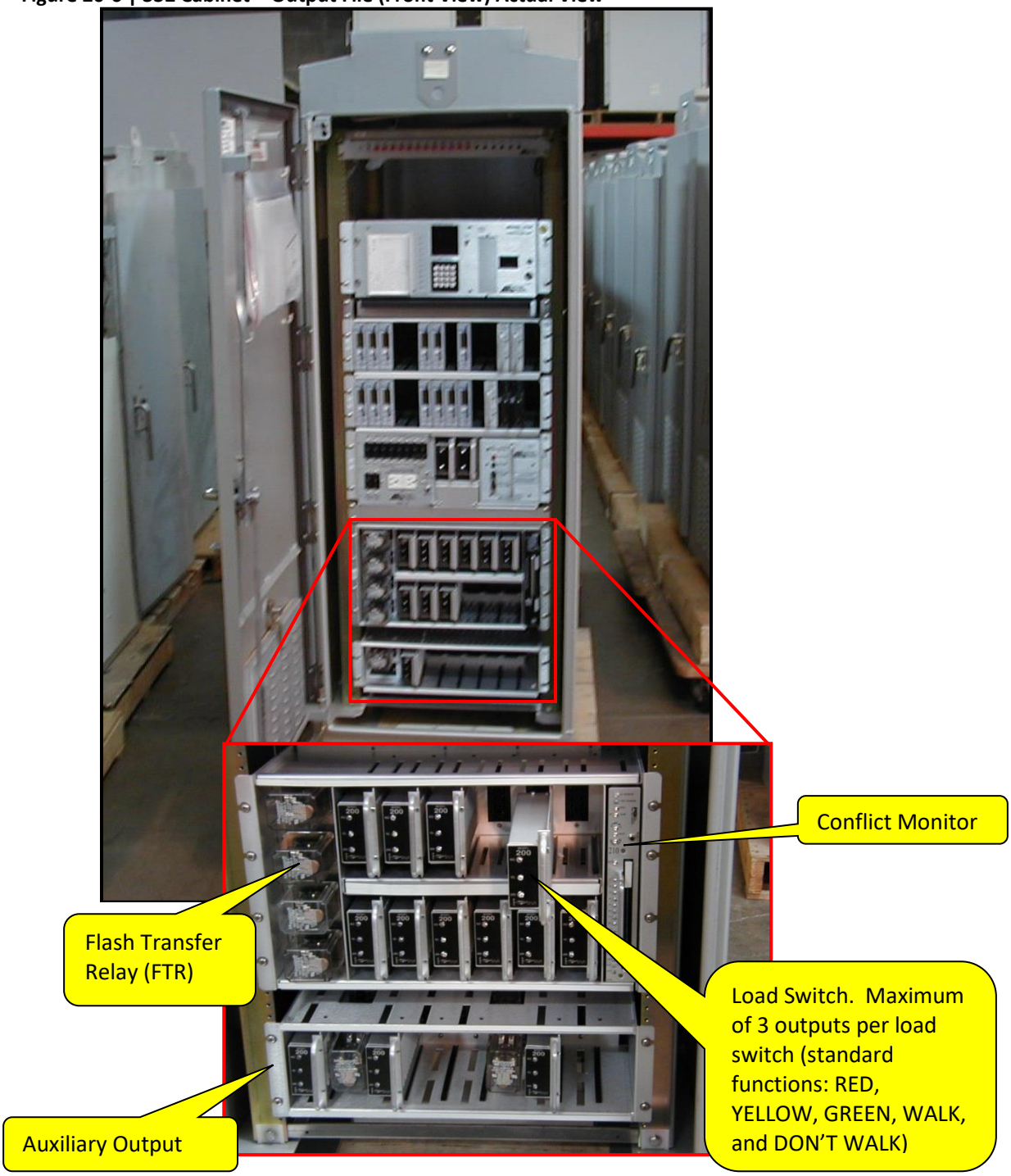
Page 3 of the 332S cabinet print shows the output file and conflict monitor. This sheet requires filling in the information for all the output equipment used. The basic output equipment (i.e. load switches, flash transfer relays, flash plugs, etc.) that needs to be filled in is shown in Figure 20-5. Each bubble note in Figure 20-5 is numbered and described in more detail in the next sections. **Important additional information about the output file is in section 20.7.5.**

Figure 20-5 | 332S Cabinet Print (page 3 – Output File)



For reference, Figure 20-6 shows the actual front view of the output file in a 332 cabinet (which is very similar to the 332S).

Figure 20-6 | 332 Cabinet – Output File (Front View) Actual View

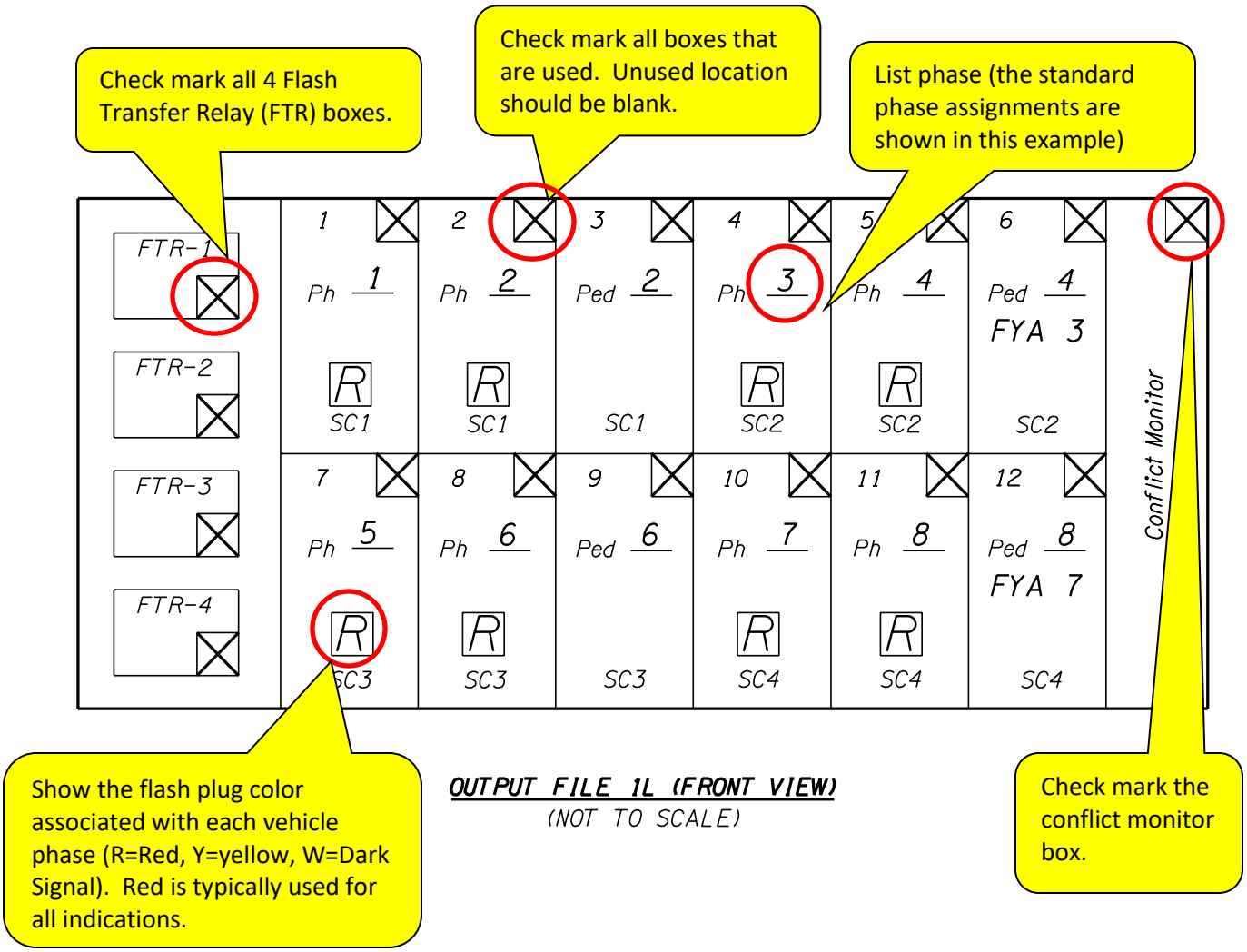


20.7.1 Main Output File (Front View):

This location shows the load switches that are used to power the field indications (vehicle signals: RED, YELLOW, GREEN and pedestrian signals: WALK, FLASHING DON'T WALK). Other types of powered indications, such as PTR signs or advance flashing beacons may be wired to a load switch. Each load switch that corresponds to a vehicle phase will have a flash plug (RED, YELLOW, or WHITE).

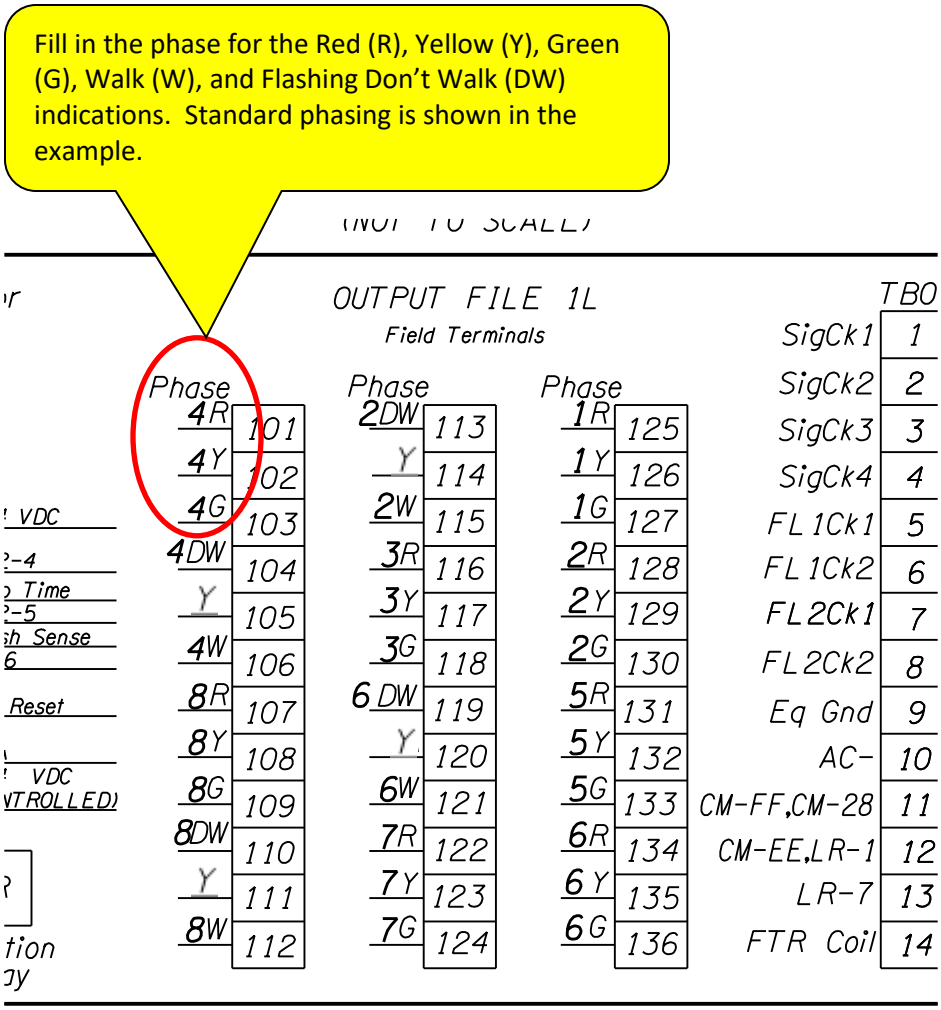
The flash transfer relays (FTR) are used to switch power from the load switches to the flasher units during cabinet flash. All four flash transfer relays should be included.

The conflict monitor checks the green indications, Flashing Yellow Arrow and WALK indications (and a few other items, such as voltage, connection to the controller, etc.) and causes the signal to go into cabinet flash if any conflicting indications come up together.



20.7.2 Main Output File (Back View)

This shows the terminal blocks for the output file. Fill in the phases being used.

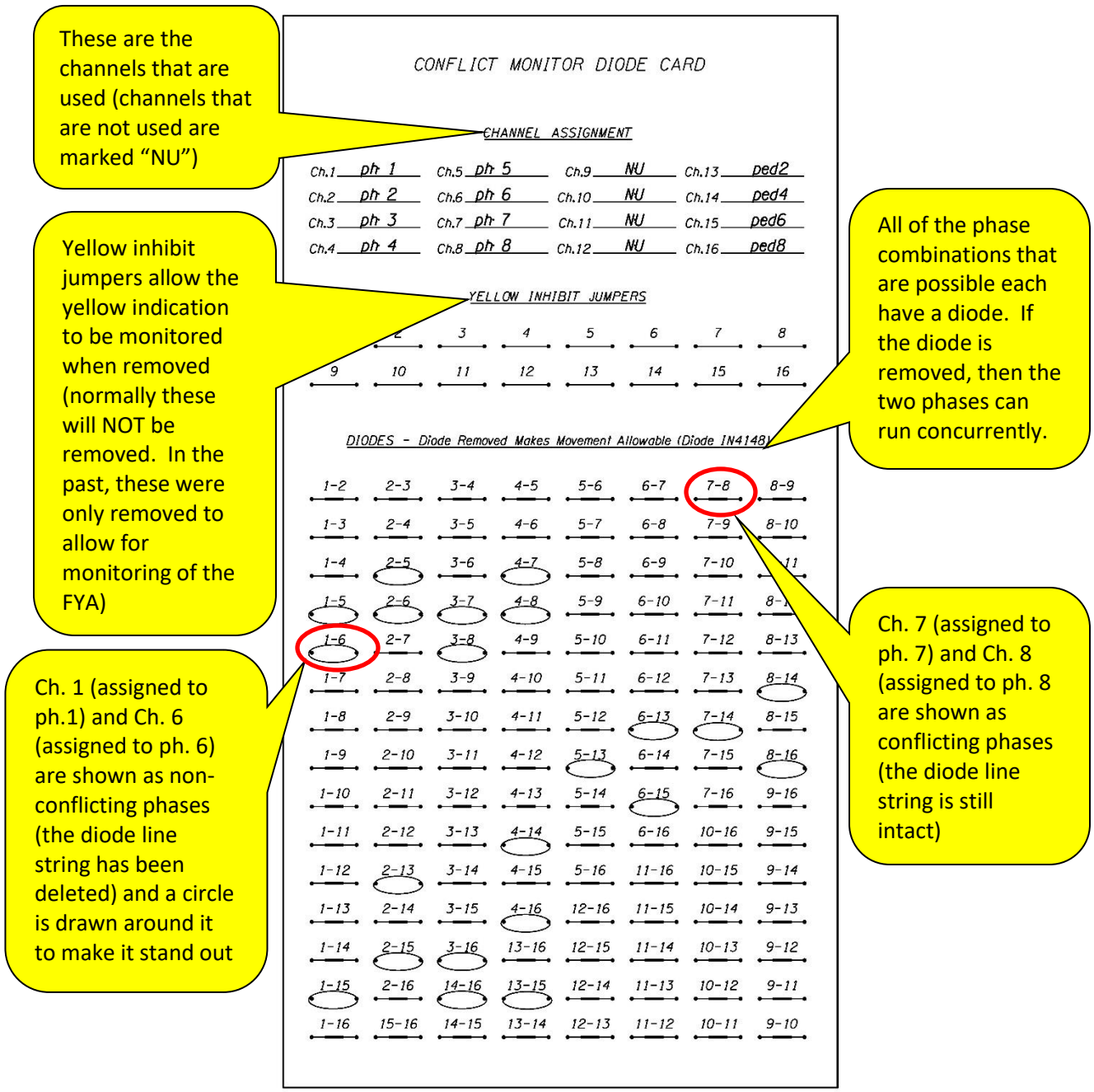


OUTPUT FILE 1L (REAR VIEW)

(NOT TO SCALE)

20.7.3 Conflict Monitor Diode Card

The signal designer will complete the conflict monitor diode card. It will be reviewed and approved by TSSU and/or Traffic Standards. By default, the conflict monitor is configured such that ALL phases are conflicting (all diodes are intact). The diodes for non-conflicting phases will be removed, leaving the diodes for conflicting phases intact. Only the phases that are actually used will determine the monitor configuration (i.e. if phase 3 and 7 are not used, those diodes will remain intact, even though phase 3 and phase 7 are typically non-conflicting phases).



CONFLICT MONITOR DIODE CARD CUTOUT
(NOT TO SCALE)

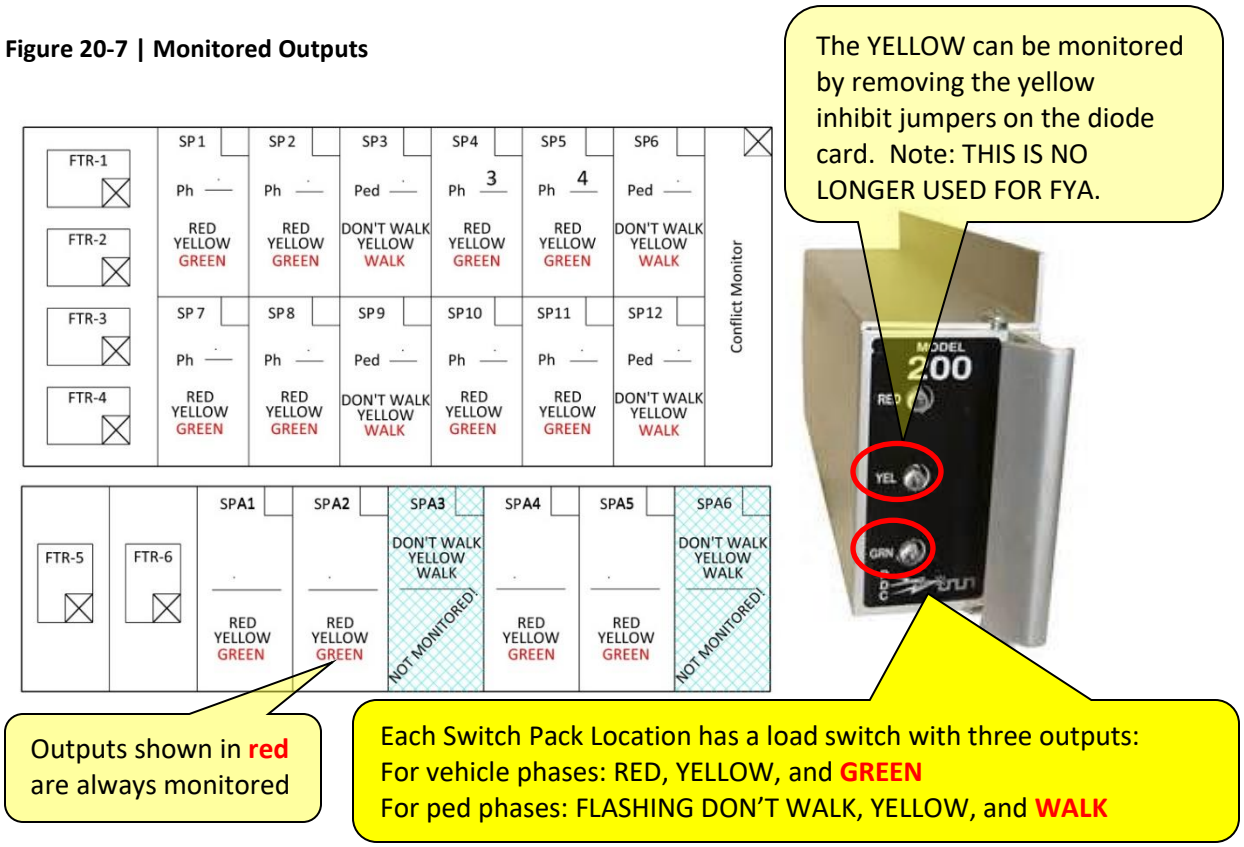
Outputs That Are Monitored

All GREEN, WALK and FLASHING YELLOW ARROW outputs for each phase shall be monitored by the conflict monitor. These are critical indications for each phase because they inform the driver or pedestrian when it is OK to enter or precede through the intersection. Monitoring these outputs for conflict ensures that a driver or pedestrian will never be incorrectly informed when it is OK to enter the intersection.

The GREEN and WALK outputs are always wired to the conflict monitor by the manufacturer as per the Standard Specification for Microcomputer Signal Controller. See Figure 20-7 with the monitored channels shown in red. **ANY OUTPUT ASSIGNED TO ONE OF THESE LOCATIONS WILL BE MONITORED. Do NOT reassign an output that shouldn't be monitored to one of these locations.**

The YELLOW indication can be monitored by removing the Yellow Inhibit Jumpers on the diode card (note: this was used in the past for monitoring Flashing Yellow Arrows), but it does not operate independently of the GREEN indication on the same load switch. For example, if ped phase 2 YELLOW is monitored by removing the yellow inhibit jumpers, it will have the exact same conflicts as ped phase 2 WALK. This can be advantageous for monitoring the Flashing Yellow Arrow, as the opposing pedestrian phase typically has the same conflicts (e.g. Ped phase 2 WALK has the same conflicts as Ph. 1 Flashing Yellow Arrow), but widespread use of not-ped phasing, overlaps, and Type 3LCF signal heads resulted in problems when monitoring the FYA via the YELLOW indication. Therefore, this method is no longer allowed. See Section 20.12.1 for more info.

Figure 20-7 | Monitored Outputs



Not all outputs require conflict monitoring as they are not as critical to eliminating the crash potential associated with being incorrectly informed. For example the YELLOW and RED outputs for each phase inform the driver or pedestrian that they must stop. If a driver is shown one of these indications erroneously, the action the driver is informed to take (stop) should not result in a crash with a conflicting vehicle that has been informed by a GREEN indication.

Outputs that are not monitored include:

- RED outputs
- YELLOW outputs
- FLASHING DON'T WALK outputs
- PTR sign outputs*
- Fire signal confirmation indication outputs* (this does not apply to tattle-tail lights which are not assigned to an output and are directly wired to the RED signal indication)

  *It is important to note that PTR sign output and Fire signal confirmation indication outputs always require an output reassignment (as they do not have a standard output location). Do not reassign these outputs to a load switch location that is monitored (See Figure 20-7. e.g. GREEN or WALK).

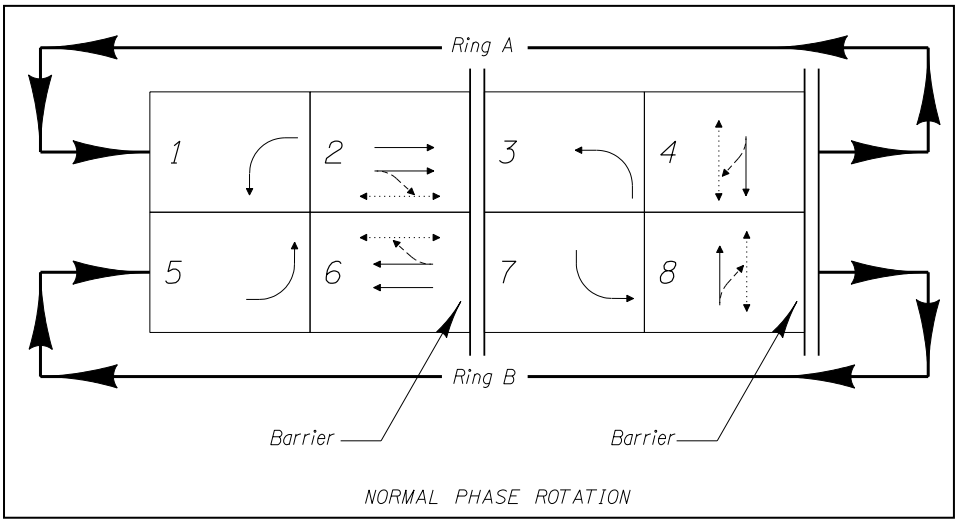
The conflict monitor also monitors other critical aspects of the how the traffic signal is functioning (watchdog, voltages, etc.) as per the Standard Specification for Microcomputer Signal Controller. Unlike the Diode Card, these aspects do NOT require a custom configuration for each intersection.

Rules for Standard Signal Timing Configurations

When using a standard ring and barrier configuration (see Figure 20-8 and Chapter 3 for more information on ring and barrier configuration), the following rules apply:

- An active phase is defined as a movement whose GREEN, WALK, or FLASHING YELLOW ARROW intervals are being timed by the controller.
- Only ONE active phase per ring at a time
- A phase can be active with the phase vertically opposite or diagonal from it as long as it exists on the same side of the barrier. These are called compatible phases (i.e. Phase 1 and Phase 5, Phase 1 and Phase 6)
- Both rings must cross the barrier at the same time

Figure 20-8 | Standard 8 Phase Ring and Barrier Diagram



When using overlap phases the following rules apply:

- An overlap phase may be assigned with any phase or number of phases. These are called the parent phase(s).
- An overlap phase will be permitted by every phase compatible with the assigned parent phase. For example, if Figure 20-8 had an OLA = phase 2, then OLA will also be permitted with ped phase 2, phase 5, phase 6, ped phase 6.
- Any phase can have a pedestrian phase assigned to it, limited by the available outputs from the controller.

When using flashing yellow arrow the following rules apply (for additional background information see Section 20.12.1):

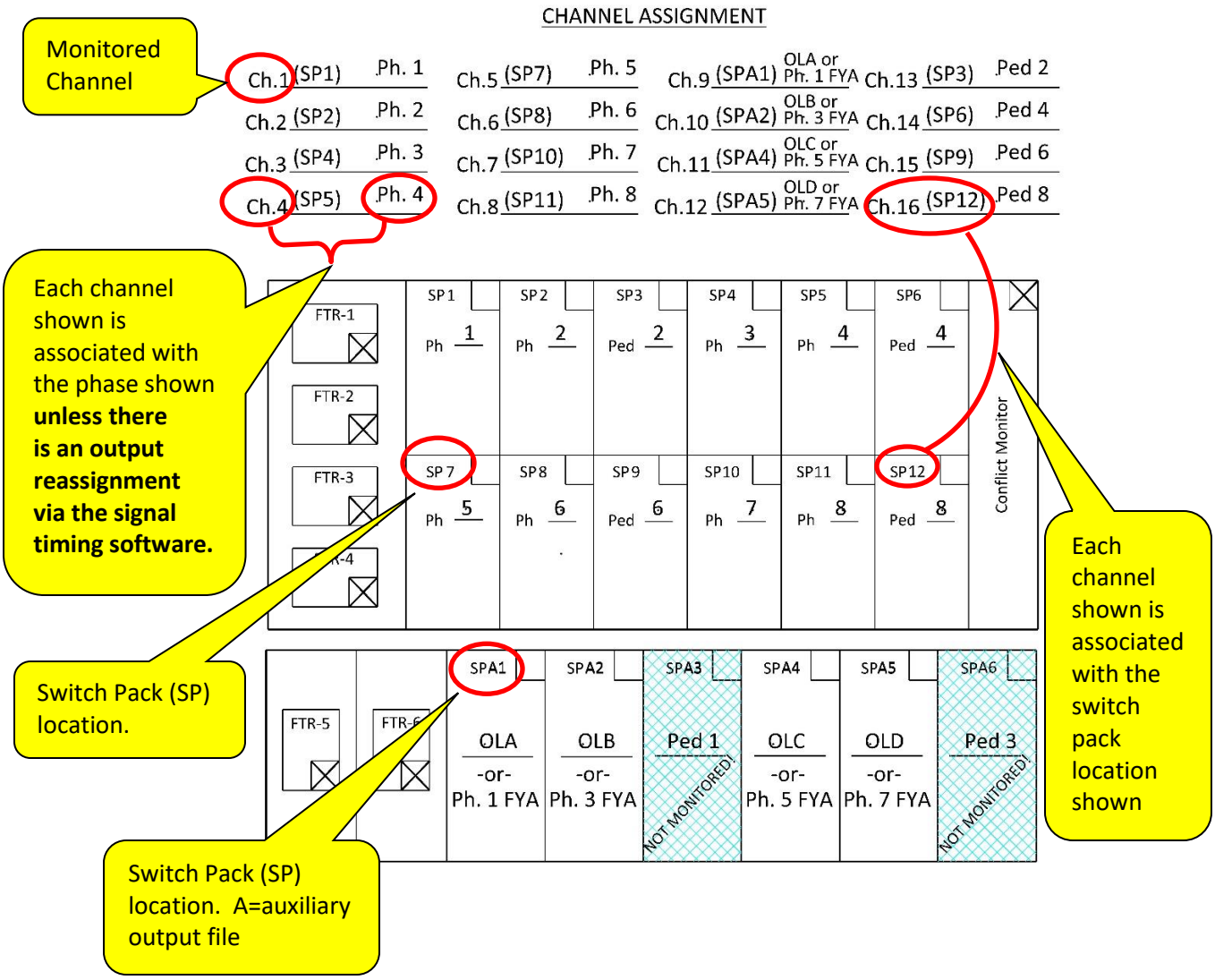
- The flashing yellow arrow signal head type shall be a Type 3LCF
- Phase 1 FYA = Channel 9
    - RED arrow terminated on ph. 1 RED
    - FYA/solid YELLOW arrow terminated on OLA GREEN
    - GREEN arrow terminated on ph. 1 GREEN

- Phase 3 FYA = Channel 10
    - RED arrow terminated on ph. 3 RED
    - FYA/solid YELLOW arrow terminated on OLB GREEN
    - GREEN arrow terminated on ph. 3 GREEN
- Phase 5 FYA = Channel 11
    - RED arrow terminated on ph. 5 RED
    - FYA/solid YELLOW arrow terminated on OLC GREEN
    - GREEN arrow terminated on ph. 5 GREEN
- Phase 7 FYA = Channel 12
    - RED arrow terminated on ph. 7 RED
    - FYA/solid YELLOW arrow terminated on OLD GREEN
    - GREEN arrow terminated on ph. 7 GREEN

Channel Assignment - Standard

On a standard Model 210 conflict monitor, there are 16 channels that can be monitored. Each active phase (GREEN, WALK, or flashing yellow arrow) shall be assigned to a channel on the conflict monitor. The standard channel and phase assignment is shown in Figure 20-9. Switch Packs A3 and A6 are NOT wired to the conflict monitor. Each monitored channel is ALWAYS directly wired to Switch Pack location as shown in Figure 20-9. For example, Channel 1 (regardless of what phase channel 1 is associated with) is ALWAYS wired to Switch Pack 1. Each channel is associated with phase shown in Figure 20-9, unless there are output reassignments (done via the signal software).

Figure 20-9 | Standard Channel Assignment



Channel Assignment – Output Reassignments

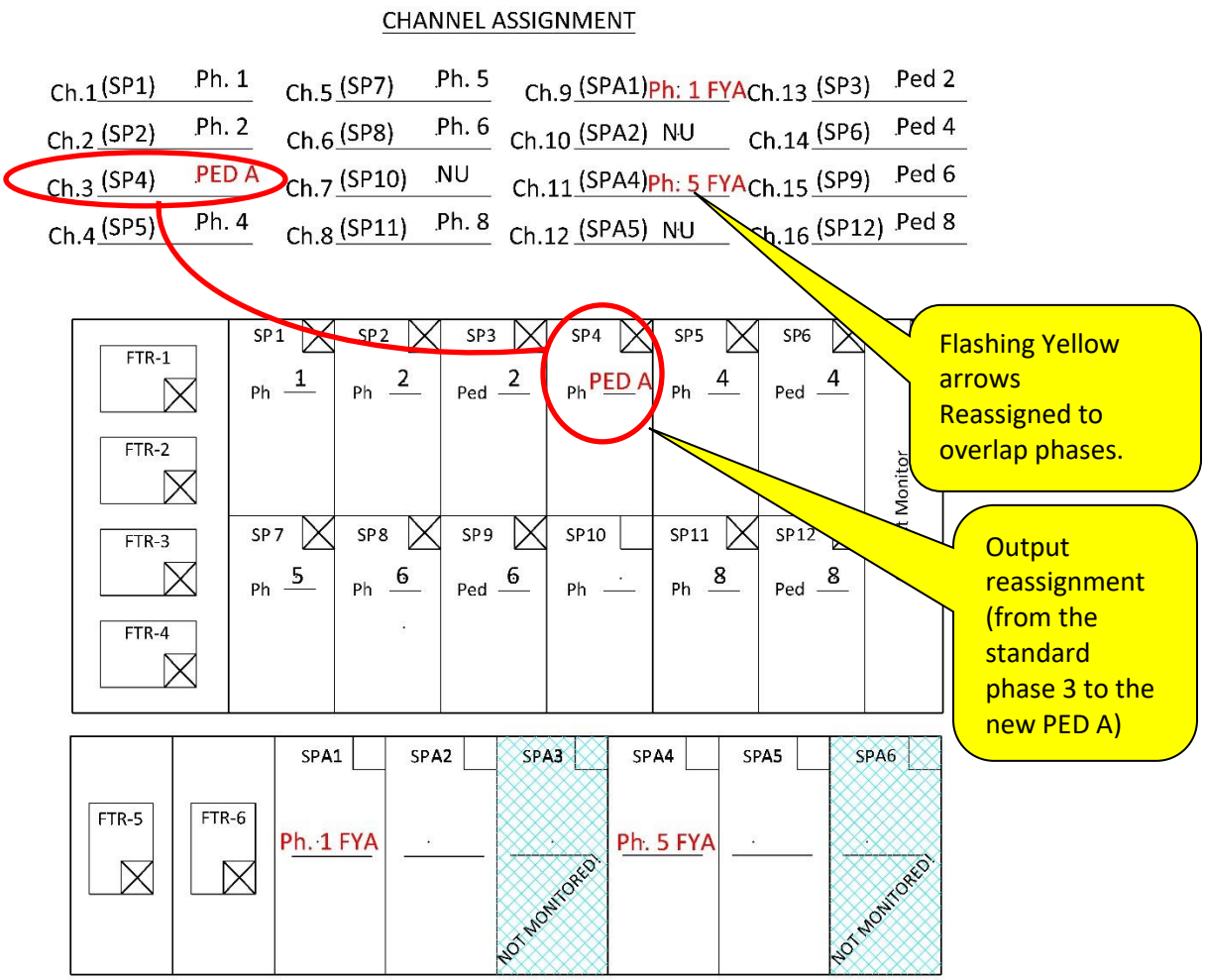
There are cases where it is necessary to reassign the output because a standard designation does not exist in the output file, such as:

- an odd numbered ped phase
- a ped overlap phase
- a flashing yellow arrow

In the past, output reassignments for vehicle overlap phases were commonly done to avoid installing an auxiliary output file. Auxiliary output files are now installed standard in 332S cabinets so this practice is no longer required for new installations.

Output reassignments are done via the signal timing software. **Always verify with the Signal Timer any output reassignments.** Figure 20-10 shows an example where the Channel 3, switch pack location SP4 has been reassigned to Ped A. Flashing yellow arrows have been reassigned to the unused overlap phase switch packs.

Figure 20-10 | Channel Assignment – Output Reassignments



Determining Compatible Phases for the Diode Card

Collect all information about the intersection that will be needed in order to determine the compatible phases, such as:

- Vehicle phases in use
- Pedestrian phases in use
- Parent phase assignments of overlaps
- Exclusive phase assignments
- Output reassignments from signal timing
- Load switches in use
- Existing cabinets: verify cabinet is wired as per standard with TSSU

Step 1: Assign phases to the channels. If a channel is not used, write "NU" next to it.

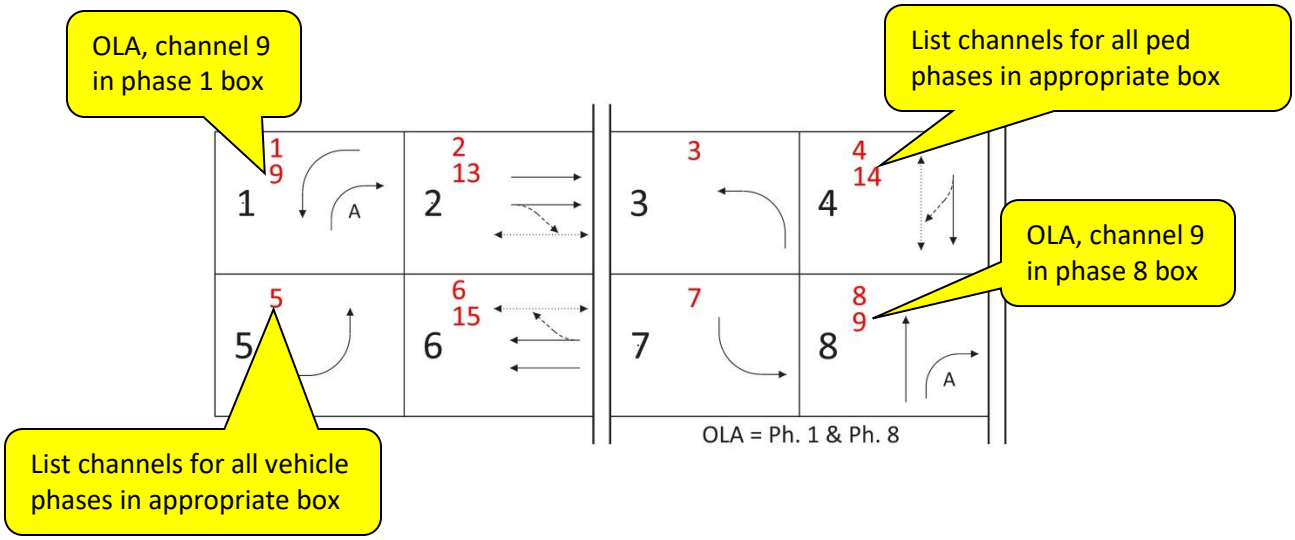
Based on intersection info, assign each phase used to a monitor channel

CHANNEL ASSIGNMENT

Ch.1	(SP1)	Ph. 1	Ch.5	(SP7)	Ph. 5	Ch.9 (SPA1)	OLA	Ch.13 (SP3)	Ped 2
Ch.2	(SP2)	Ph. 2	Ch.6	(SP8)	Ph. 6	Ch.10 (SPA2)	NU	Ch.14 (SP6)	Ped 4
Ch.3	(SP4)	Ph. 3	Ch.7	(SP10)	Ph. 7	Ch.11 (SPA4)	NU	Ch.15 (SP9)	Ped 6
Ch.4	(SP5)	Ph. 4	Ch.8	(SP11)	Ph. 8	Ch.12 (SPA5)	NU	Ch.16 (SP12)	NU

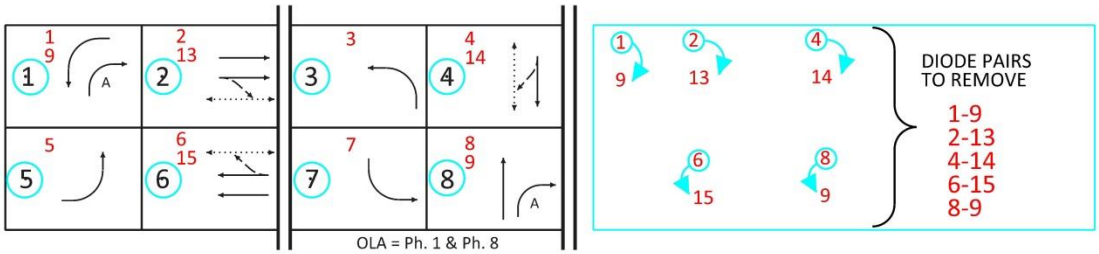
Step 2: Write the monitor channels in the ring and barrier diagram for (pay close attention to outputs that have been reassigned):

- Each vehicle phase used.
- Each pedestrian phase used.
- Each parent phase assigned to an overlap. For example, if OLA = ph. 1 and ph. 8, and OLA is assigned to channel 9, then write 9 in the phase 1 box and 9 in the phase 8 box of the ring and barrier diagram.

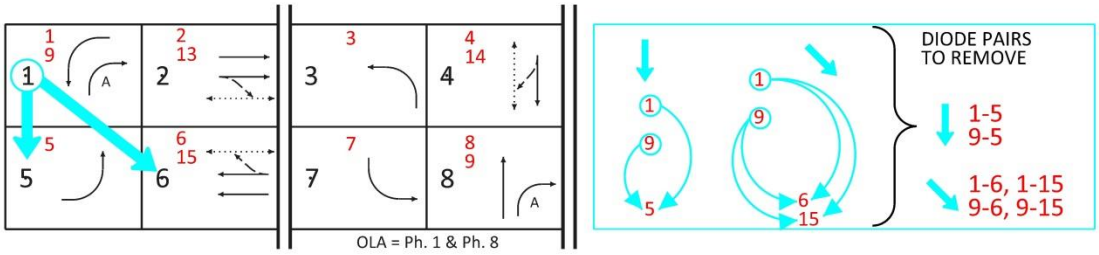


Step 3: Determine the compatible phases (diode pairs that need to be removed). The following procedure will ensure that all correct diodes are removed. There are likely to be a few duplicate diode pairs for phases with overlaps. This is OK, since a diode can only be removed once.

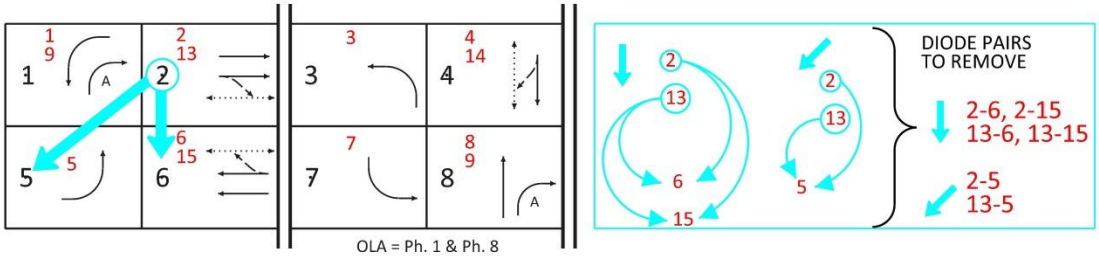
STEP 3A: LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL IN THE SAME BOX

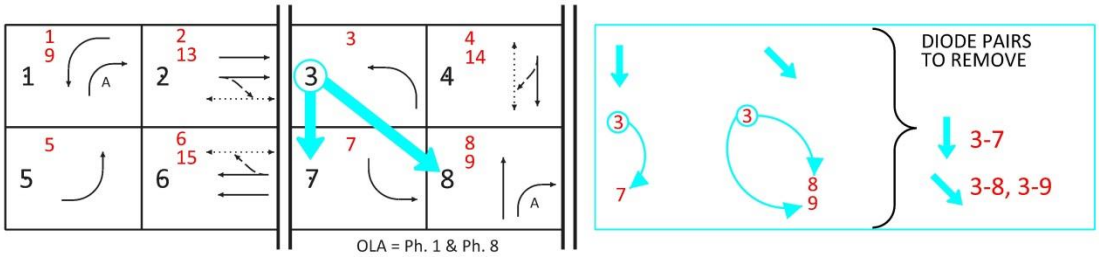


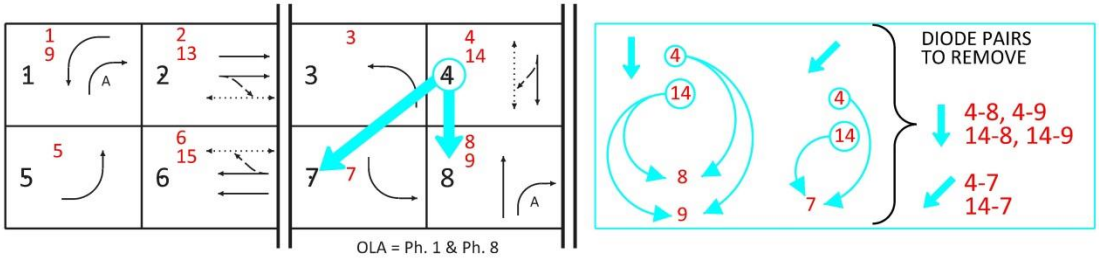
STEP 3B: START IN UPPER LEFT BOX OF THE DIAGRAM. LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL THAT IS VERTICALLY OR DIAGONALLY OPPOSITE THE BOX (EXCEPT ANY EXCLUSIVE PHASES).



STEP 3C: REPEAT STEP 3B FOR EACH BOX ON THE UPPER ROW OF THE DIAGRAM.







When an intersection has a type 3LCF signal head for PPLT **AND** has any overlap phases, the conflict monitor diode configuration shall be determined by using the standard ring and barrier diagram method (shown on the previous page) *PLUS a separate ring and barrier diagram showing only the overlap green movements (vehicle and pedestrian) and the solid yellow left turn arrow of the type 3LCF signal head*. See Figure 20-11.

Figure 20-11 | Determining Compatible Phases – FYA (Type 3LCF signal head) and Overlap Phases

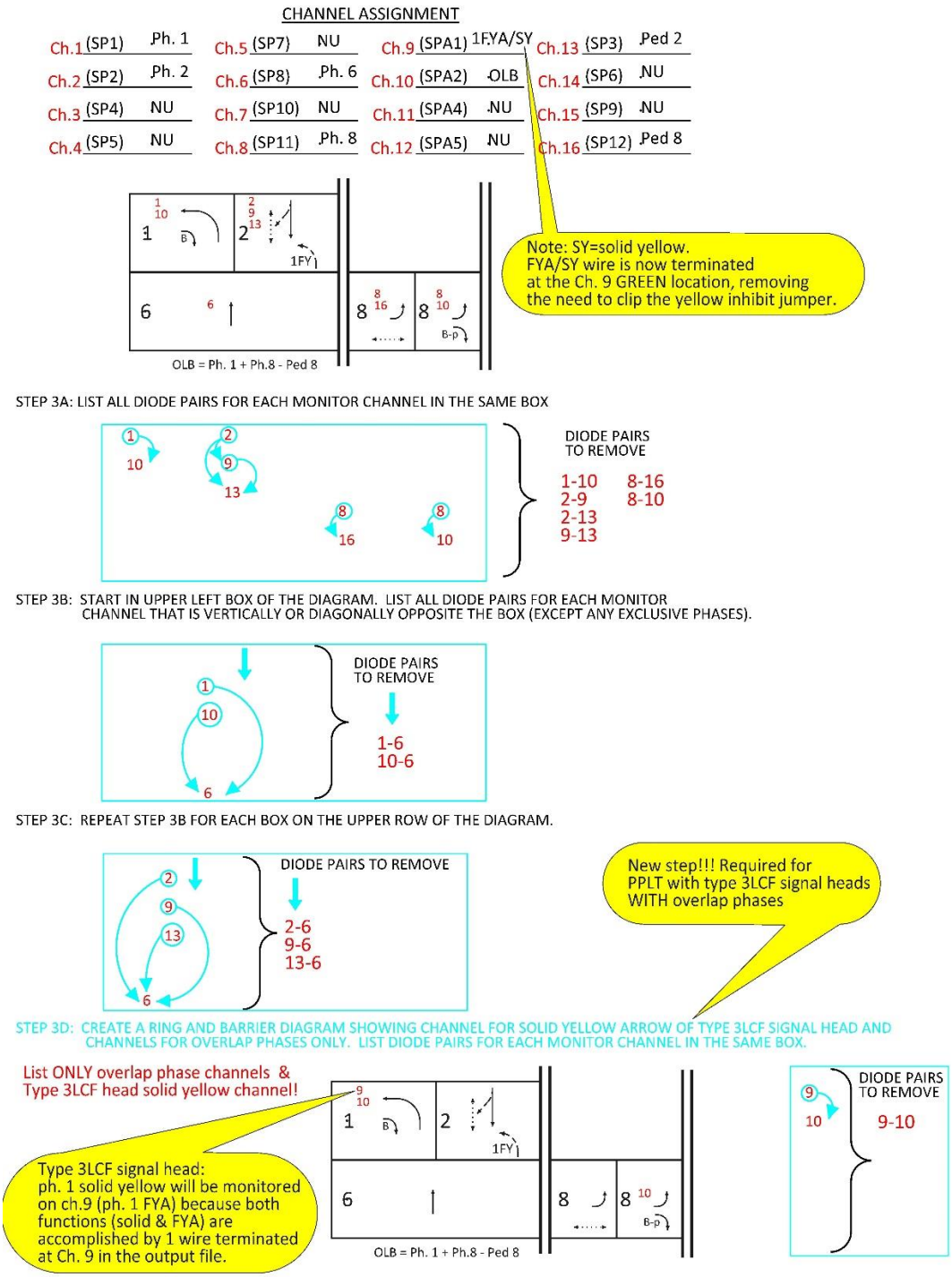


Figure 20-12 thru Figure 20-15 show common examples of determining compatible phases.

Figure 20-12 | Determining Compatible Phases – Example 1: Not-Ped Overlap

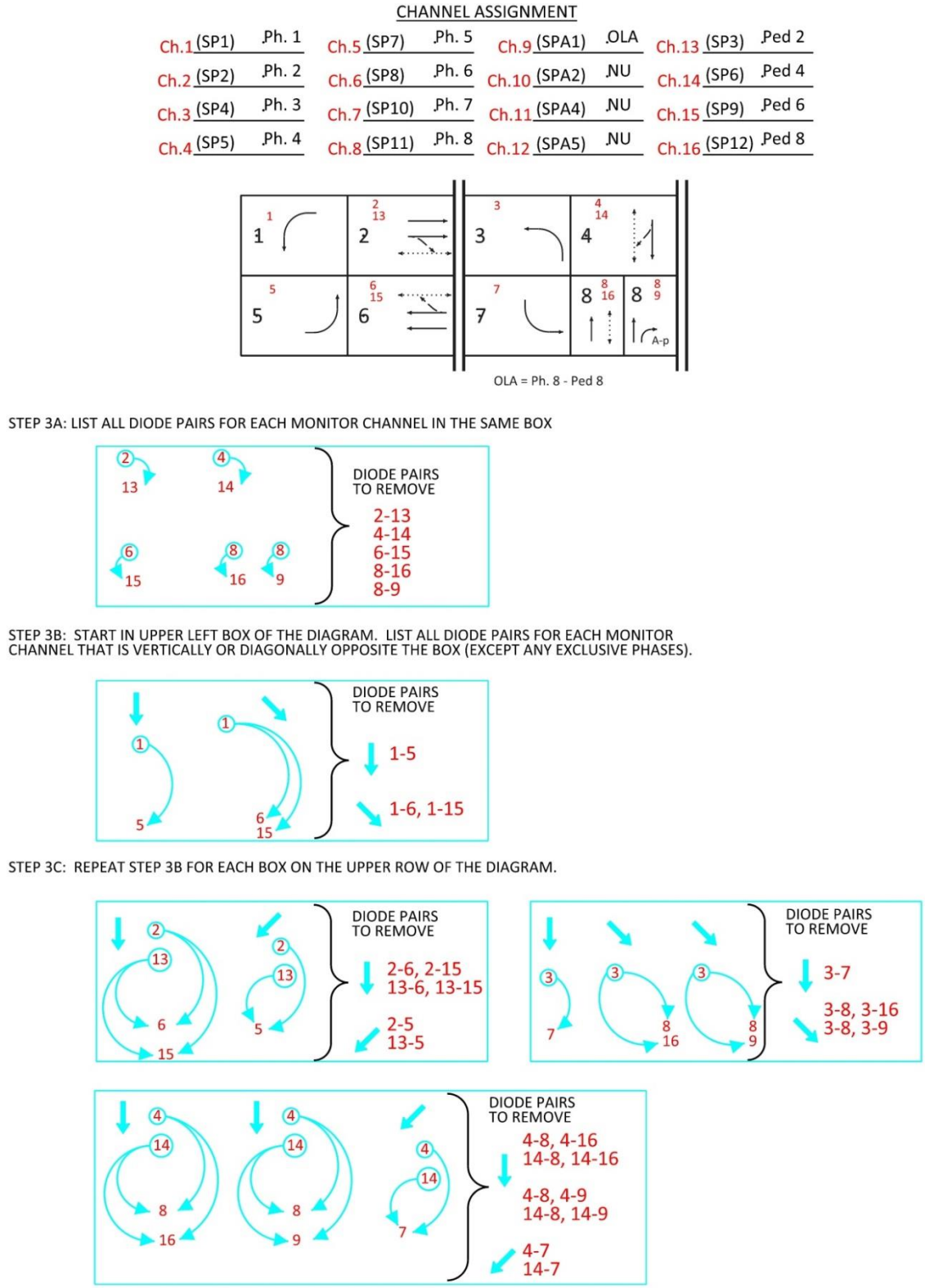
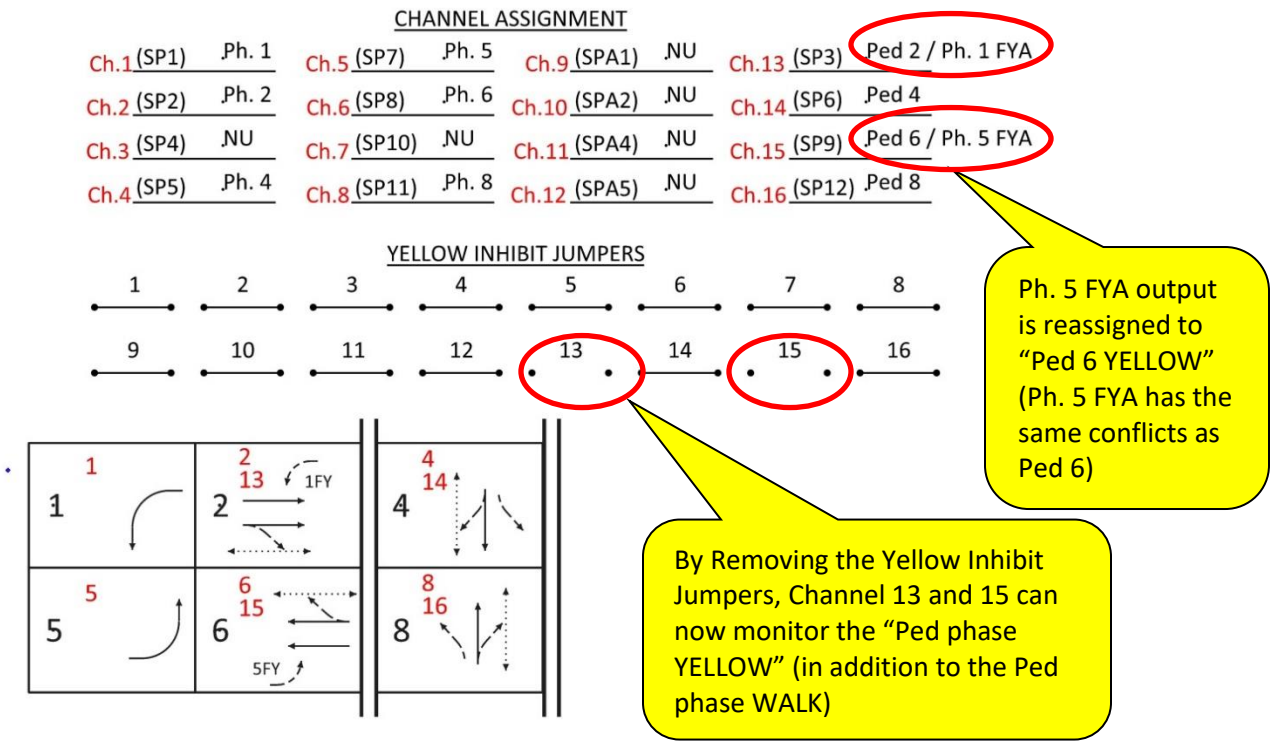
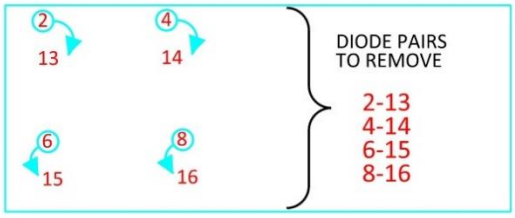


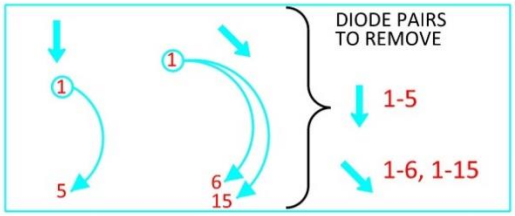
Figure 20-13 | Determining Compatible Phases – Example 2: Flashing Yellow Arrow (OLD METHOD – DO NOT USE PED YELLOW FOR NEW FYA INSTALLATIONS. SEE Figure 20-11 INSTEAD)



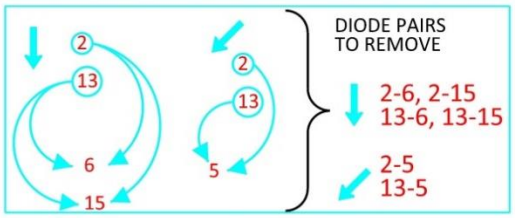
STEP 3A: LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL IN THE SAME BOX



STEP 3B: START IN UPPER LEFT BOX OF THE DIAGRAM. LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL THAT IS VERTICALLY OR DIAGONALLY OPPOSITE THE BOX (EXCEPT ANY EXCLUSIVE PHASES).



STEP 3C: REPEAT STEP 3B FOR EACH BOX ON THE UPPER ROW OF THE DIAGRAM.



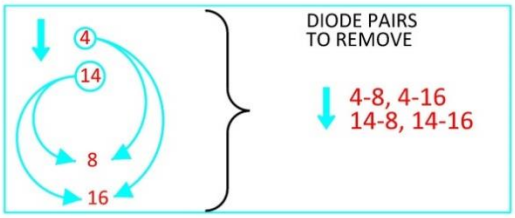
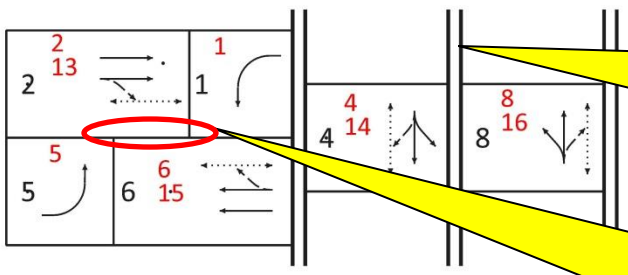


Figure 20-14 | Determining Compatible Phases – Example 3: Exclusive Phases

CHANNEL ASSIGNMENT

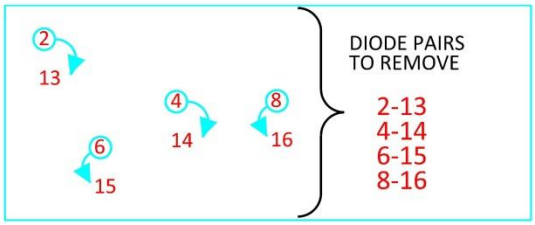
Ch.1	(SP1)	Ph. 1	Ch.5	(SP7)	Ph. 5	Ch.9	(SPA1)	NU	Ch.13	(SP3)	Ped 2
Ch.2	(SP2)	Ph. 2	Ch.6	(SP8)	Ph. 6	Ch.10	(SPA2)	NU	Ch.14	(SP6)	Ped 4
Ch.3	(SP4)	NU	Ch.7	(SP10)	NU	Ch.11	(SPA4)	NU	Ch.15	(SP9)	Ped 6
Ch.4	(SP5)	Ph. 4	Ch.8	(SP11)	Ph. 8	Ch.12	(SPA5)	NU	Ch.16	(SP12)	Ped 8



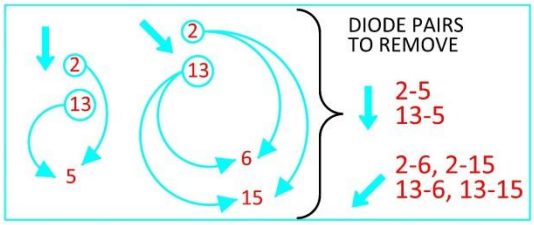
Phase 4 and phase 8 are exclusive phases (There are no compatible phases located vertically or diagonally on the same side of the barrier).

Phase 1 and 5 are NOT compatible as drawn (a diagonal line would not go directly from phase 1 to 5 without passing thru the phase 2 or phase 6 boxes). See Chapter 3 for more info.

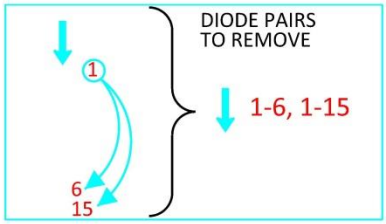
STEP 3A: LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL IN THE SAME BOX



STEP 3B: START IN UPPER LEFT BOX OF THE DIAGRAM. LIST ALL DIODE PAIRS FOR EACH MONITOR CHANNEL THAT IS VERTICALLY OR DIAGONALLY OPPOSITE THE BOX (EXCEPT ANY EXCLUSIVE PHASES).

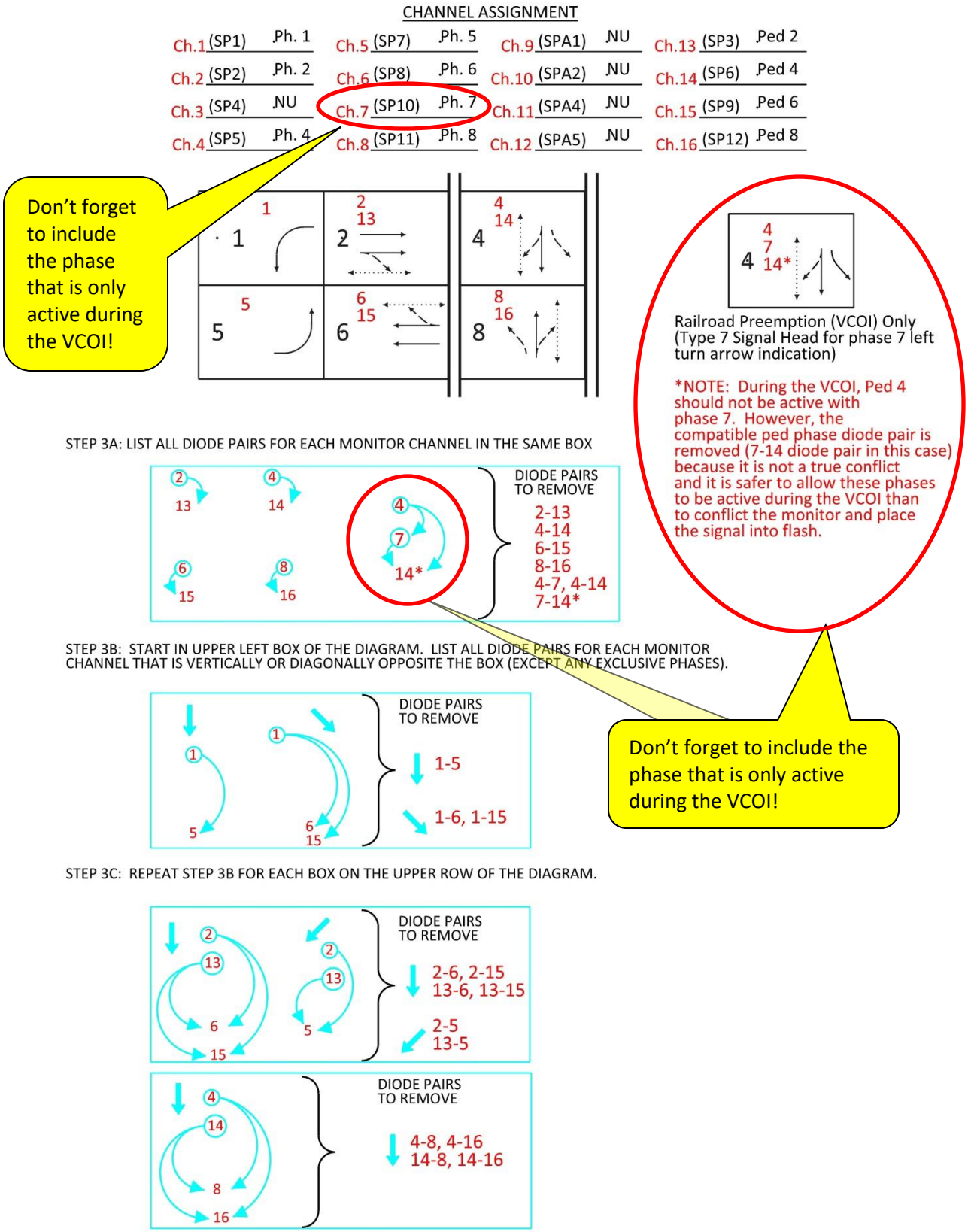


STEP 3C: REPEAT STEP 3B FOR EACH BOX ON THE UPPER ROW OF THE DIAGRAM.



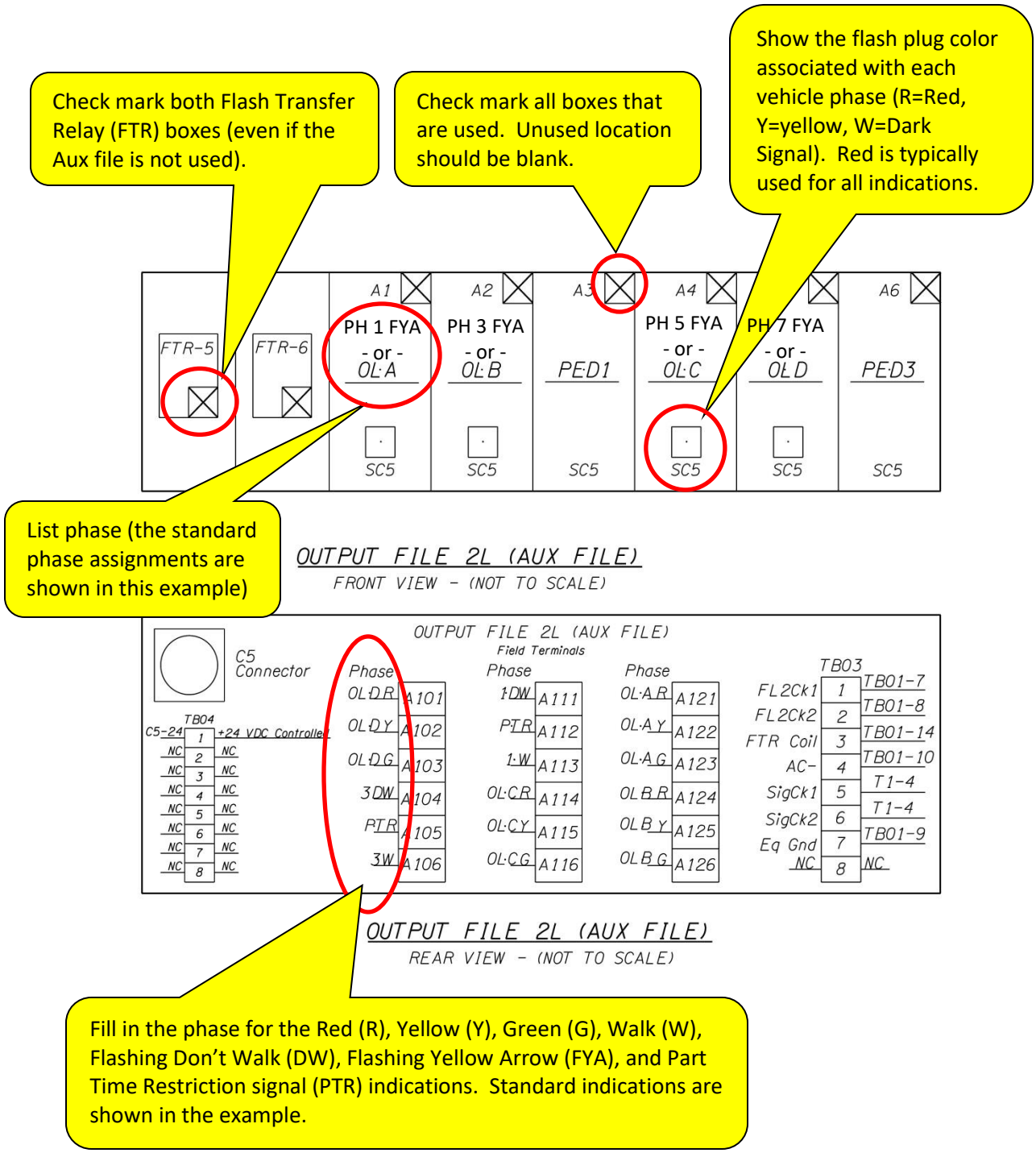
Phase 4 and phase 8 are exclusive phases (no other phases are compatible).

Figure 20-15 | Determining Compatible Phases – Example 4: Railroad Preemption Type 7 Signal Head



20.7.4 Auxiliary Output File (Front and Back View)

This location comes standard in 332S cabinets (optional in 332 cabinets) and provides additional outputs if more are needed. Unused locations should be left blank. It is filled out the same way as the main output file.



20.7.5 Additional Information for the Output File

- The standard 332S (and 332 and 336) cabinets can accommodate 8 vehicle phases and 4 pedestrian phases (a total of 12 load switches). An additional 4 vehicle phase and 2 pedestrian phases (a total of 6 additional load switches) are available if needed in the auxiliary output file of the 332S and 332 cabinet (The auxiliary output file comes standard in the 332S cabinet, and is optional in the 332 cabinet). There is a standard phase layout for the output file. However, most intersection software programs allow the flexibility to assign any phase, pedestrian phase, overlap or special use output to any output location in the output files.

- Sixteen (of the 18 total) load switches are conflict monitored. The load switches in the auxiliary file slot A3 and A6 are not monitored.

- Pedestrian output locations will always be in load switch location 3, 6, 9, and 12 of the main output file and A3 and A6 of an auxiliary output file. The reason for this is that the flash power is not routed to these load switch locations, which allows the pedestrian signal indications to remain dark while the signal is operating in emergency flash mode. Vehicle signal indication should not be reassigned to these slots as they should not remain dark in flashing mode.

- PTR signs should terminate on the phase 1 ped yellow output of the auxiliary output file, switch pack location A3. Note: in the past, PTR signs for rail preemption (the typical installation) were normally terminated on the phase 4 ped yellow output (or any other unused ped yellow output if the phase 4 ped didn't exist) to avoid installation of an auxiliary file.

- The conflict monitor is limited to a total of 16 channels which limits the number of phases that can used at an intersection. The flashing yellow arrow indication (for a protected/permitted left turn phase) is assigned to the channels normally reserved for overlap phases. As such, the number of protected/permitted left turn phases and vehicle overlap phases at an intersection will be limited to a combined total of four. For example, typical maximum combinations an intersection can have:

    - PPLT for phases 1, 3, 5, and 7 with NO overlap phases
    - Four overlap phases with NO PPLT
    - PPLT for phases 1 and 5 with two overlap phases
    - PPLT for phases 3 and 7 with two overlap phases

  Exceptions to combined total of four may be acceptable in the rare circumstance where there is an unused vehicle phase output that an overlap phase can be reassigned to (channels 1 thru 8). The flashing yellow arrow indications should only be wired to channels 9 thru 12 as shown in Figure 20-9.

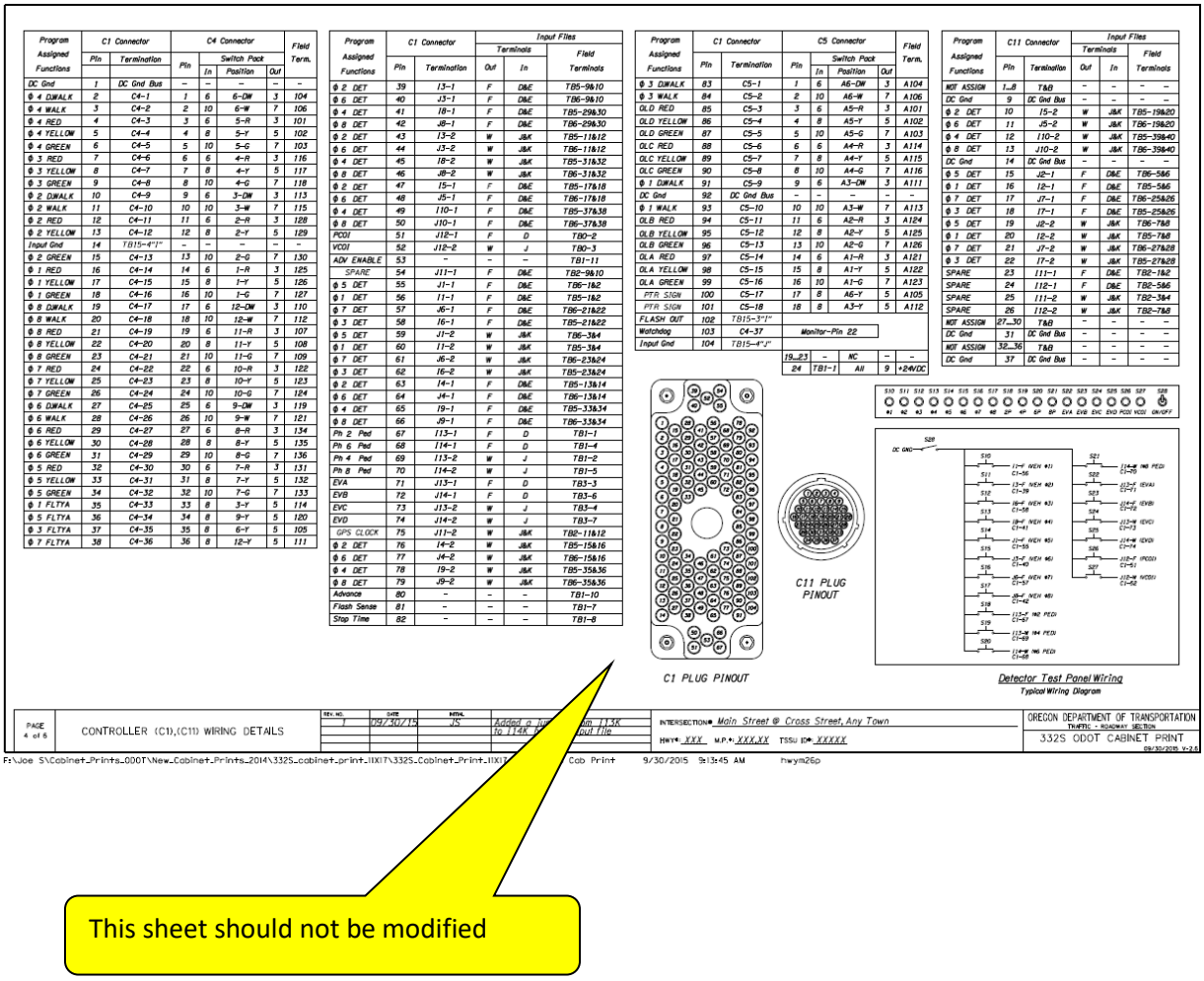
  Assigning flashing yellow arrow to pedestrian yellow outputs will no longer be allowed as it can result in problematic conflict monitoring when used in conjunction with overlaps, not-ped phasing and type 3LCF signal heads. See Section 20.12.1 for additional background/reference info.

- Flash plugs are used with the output file to enable the correct indication to flash while the signal is operating in emergency flash mode (i.e. cabinet flash). RED flash plugs enable the red indication to flash, and YELLOW flash plugs enable the yellow indication to flash. WHITE flash plugs shall be used to bypass the flash power if a standard vehicle phase output (Switch pack locations 1, 2, 4, 5, 7, 8, 10, 11, A1, A2, A4, and A5) has been reassigned to a pedestrian phase so that the pedestrian indications will remain dark while the signal is operating in emergency flash mode. The default standard is to use RED flash plugs for all load switch locations that serve vehicle phases; standard pedestrian phase load switch locations do not use flash plugs and are already wired to bypass the flash power. The major through phase may have YELLOW flash plugs under certain conditions (See the Traffic Signal Policy and Guidelines, Chapter 9 for more information). The Region Traffic Signal Operations Engineer is responsible for making this determination. If something other than RED flash plugs are required, it shall be noted on the switch pack location as “Y” (for yellow) or “W” (for no-flash).

20.8 332S Cabinet Print (Page 4 – C1 Pin Assignments & Test Switch)

Page 4 of the cabinet print shows the C1 pin assignments and test switch details. This sheet generally doesn't require any modification. See Figure 20-16.

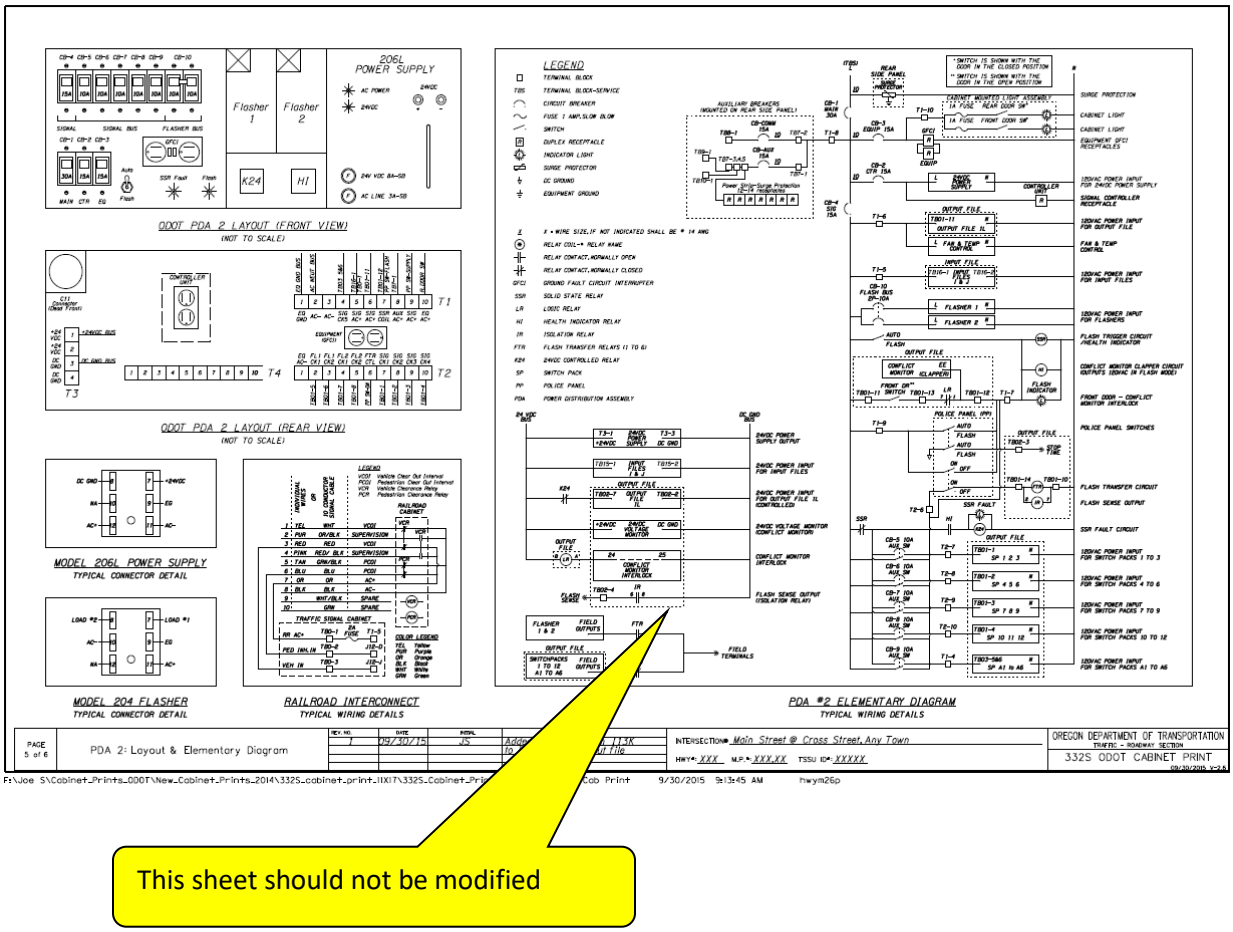
Figure 20-16 | 332S Cabinet Print (page 4 – C1 pin assignments & test switch)



20.9 332S Cabinet Print (Page 5 – Electrical Diagrams)

Page 5 of the cabinet print shows the electrical diagram details. This sheet generally doesn't require any modification. See Figure 20-17.

Figure 20-17 | 332S Cabinet Print (page 5 – electrical diagrams)



This sheet should not be modified

20.10 332S Cabinet Print (Page 6 – Intersection Drawing)

Page 6 of the cabinet print shows the intersection drawing. The intent of the intersection drawing is to provide a simplified illustration of critical signal equipment and operations to allow the field tech to quickly determine the orientation and location of equipment during routine maintenance and troubleshooting. It may seem redundant to provide an intersection drawing as part of the cabinet print given the contract plan sheet(s) contain the same (plus additional) info, but it is very valuable to highlight only the relevant maintenance information on a single sheet (or two sheets if necessary) for efficient fieldwork. THIS SHEET NO LONGER SHOWS DETECTION INFO. THIS INFORMATION IS NOW SHOWN ON SHEET 7.

The intersection drawing is created from the design file and is copied into the cabinet print file. This is to allow for easy future modification and archiving of the cabinet print file without having to reference other files.

The intersection drawing should include the following. See Figure 20-18 to Figure 20-20:

- Plan view of intersection, oriented correctly for a person standing at the front of the controller cabinet (i.e. "you are here" map orientation. Note this is probably different than the plan sheet orientation)
- North arrow
- Street Names
- Operation items:
    - Lanes and lane use arrows
    - Phasing, labeled in each lane
    - Crosswalks, labeled in each crosswalk
    - Phase rotation diagram
    - Fire preemption diagram
- Equipment:
    - Signal poles with mast arms/span wires
    - Pedestals
    - Pushbutton posts
    - Other poles that contain signal equipment controlled by the cabinet (i.e. a remote fire preemption unit, advance flashing beacons, etc.)
    - Signal heads and pedestrian heads
    - Emergency preemption devices, labeled per device
    - Controller cabinet, labeled
    - Communications gear located on TB8, TB9, or TB10
- Railroad items (see Figure 20-19):
    - Railroad controller cabinet, labeled
    - Railroad tracks, labeled
    - Railroad preemption site specific constraints (from the rail matrix text)
    - PTR signs, labeled per device
- Reference to all relevant contract plan sheets related to the intersection
- List of intersections that are interconnected

The intersection drawing should be simple, uncluttered and easy to read. To achieve this, do NOT include the following:

- Detection information
- Right-of-way lines
- Conduit
- Utilities
- Stationing
- Bubble notes & legend

The scale of all features shown on the intersection drawing is flexible to maximize readability while still containing all the information needed. TSSU and Region Electricians may request modifications to what is included or not included on the intersection drawing depending on the intersection complexity, uniqueness, or staff preference. In general, modifications are allowed, but are reviewed and informally approved by Traffic-Roadway Unit.

Figure 20-18 | 332S Cabinet Print (page 6 – Intersection Drawing) Example 1

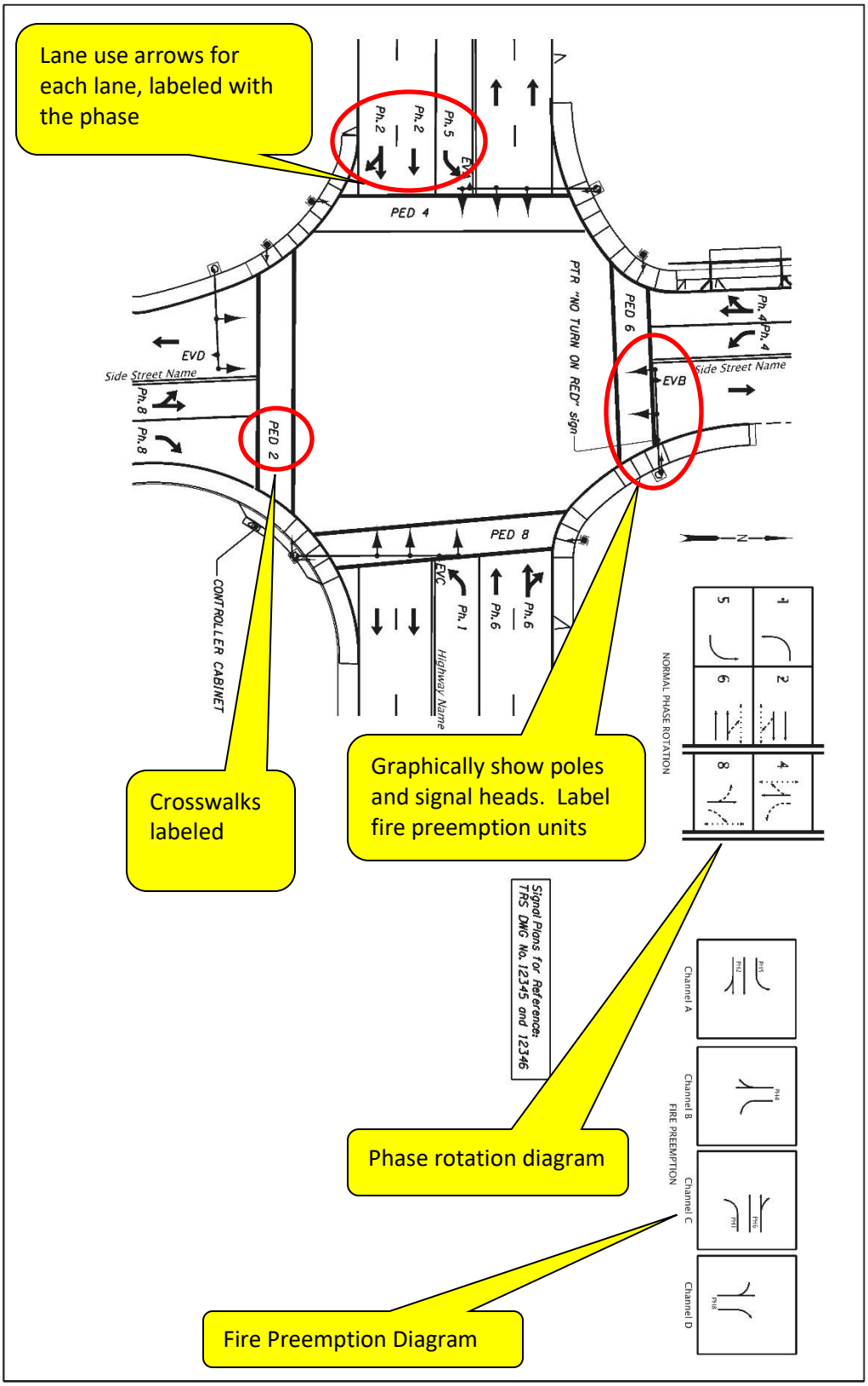


Figure 20-19 | 332S Cabinet Print (page 6 – Intersection Drawing) Example 2

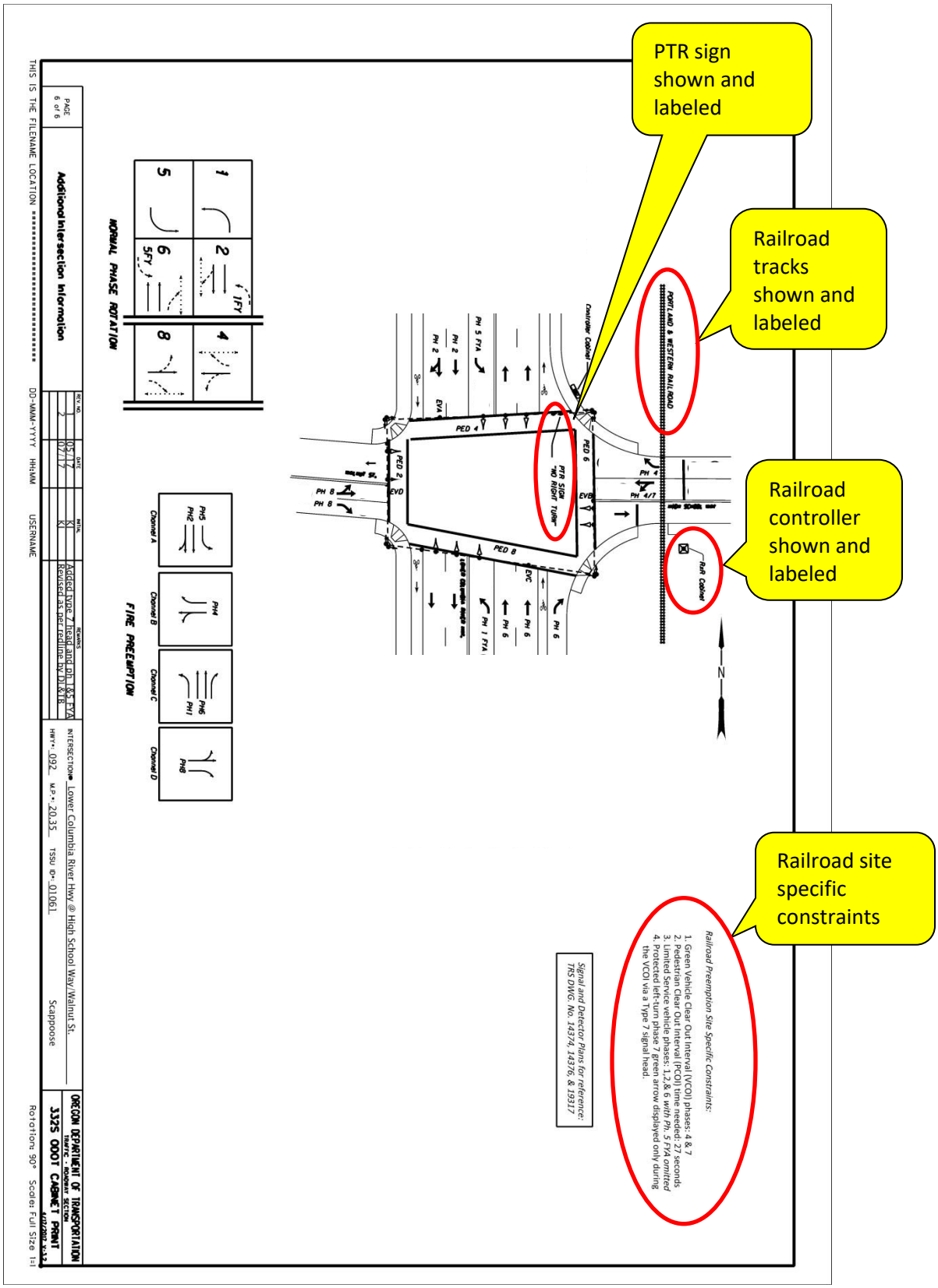
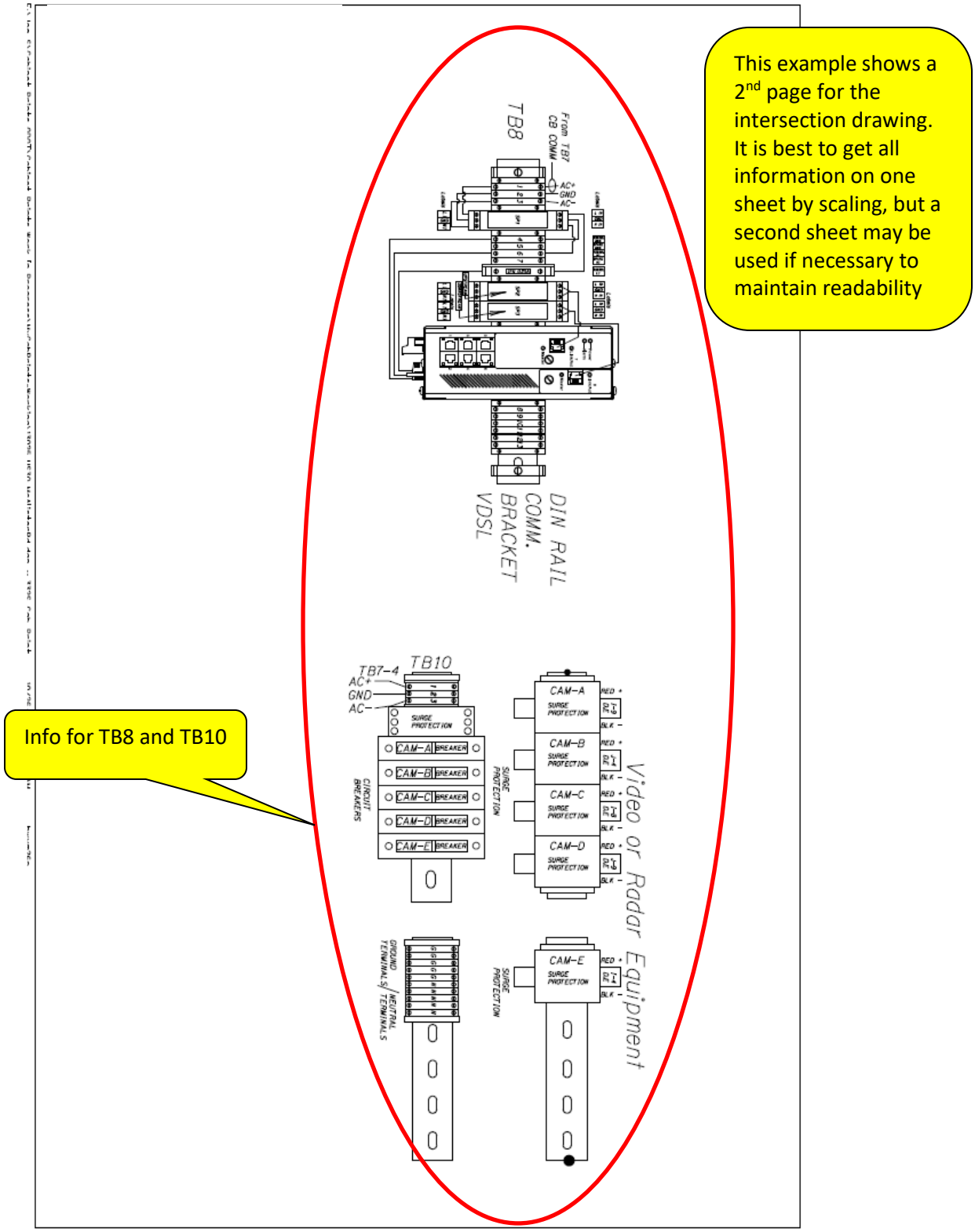


Figure 20-20 | 332S Cabinet Print (page 6 – Intersection Drawing) Example 3



20.11 332S Cabinet Print (Page 7 – Detection Drawing)

Page 7 of the cabinet print shows the detection drawing. The intent of the detection drawing is to provide a general illustration of detection units, coverage areas, and/or zones and software detection configuration information to allow efficient maintenance and troubleshooting. Showing the detection info on a separate sheet from the intersection drawing helps with readability and field workflow.

The detection drawing is created from the design file and is copied into the cabinet print file. This is to allow for easy future modification and archiving of the cabinet print file without having to reference other files.

The detection drawing should include the following. See Figure 20-21 to Figure 20-22:

- Plan view of intersection, oriented correctly for a person standing at the front of the controller cabinet (i.e. "you are here" map orientation. Note this is probably different than the plan sheet orientation)
- North arrow
- Street Names
- Note on detection zones (one for if zones are shown, one for if they are not)
- Function legend
- Operation items:
  - Lanes and lane use arrows
  - Near-side radar coverage area (cone shape), labeled
  - Detection zones, not labeled – ONLY IF REQUESTED BY THE SIGNAL TIMER!
  - Import excel file of detector configuration from signal timer
- Equipment:
  - Signal poles with mast arms/span wires or pedestals where detector units are mounted
  - Detector Units, labeled
  - Controller cabinet, labeled
  - Loops with loop numbers (for advance loops only indicate the distance from stop line)
- Railroad items:
  - Railroad tracks

The detection drawing should be simple, uncluttered and easy to read. To achieve this, do NOT include the following:

- Information shown on the intersection drawing
- Right-of-way lines
- Conduit
- Utilities
- Stationing
- Bubble notes & legend

The scale of all features shown on the intersection drawing is flexible to maximize readability while still containing all the information needed. TSSU and Region Electricians may request modifications to what is included or not included on the detection drawing depending on the intersection complexity, uniqueness, or staff preference. In general, modifications are allowed, but are reviewed and informally approved by Traffic-Roadway Unit.

Figure 20-21 | 332S Cabinet Print (page 7 – Detection Drawing) Example 1

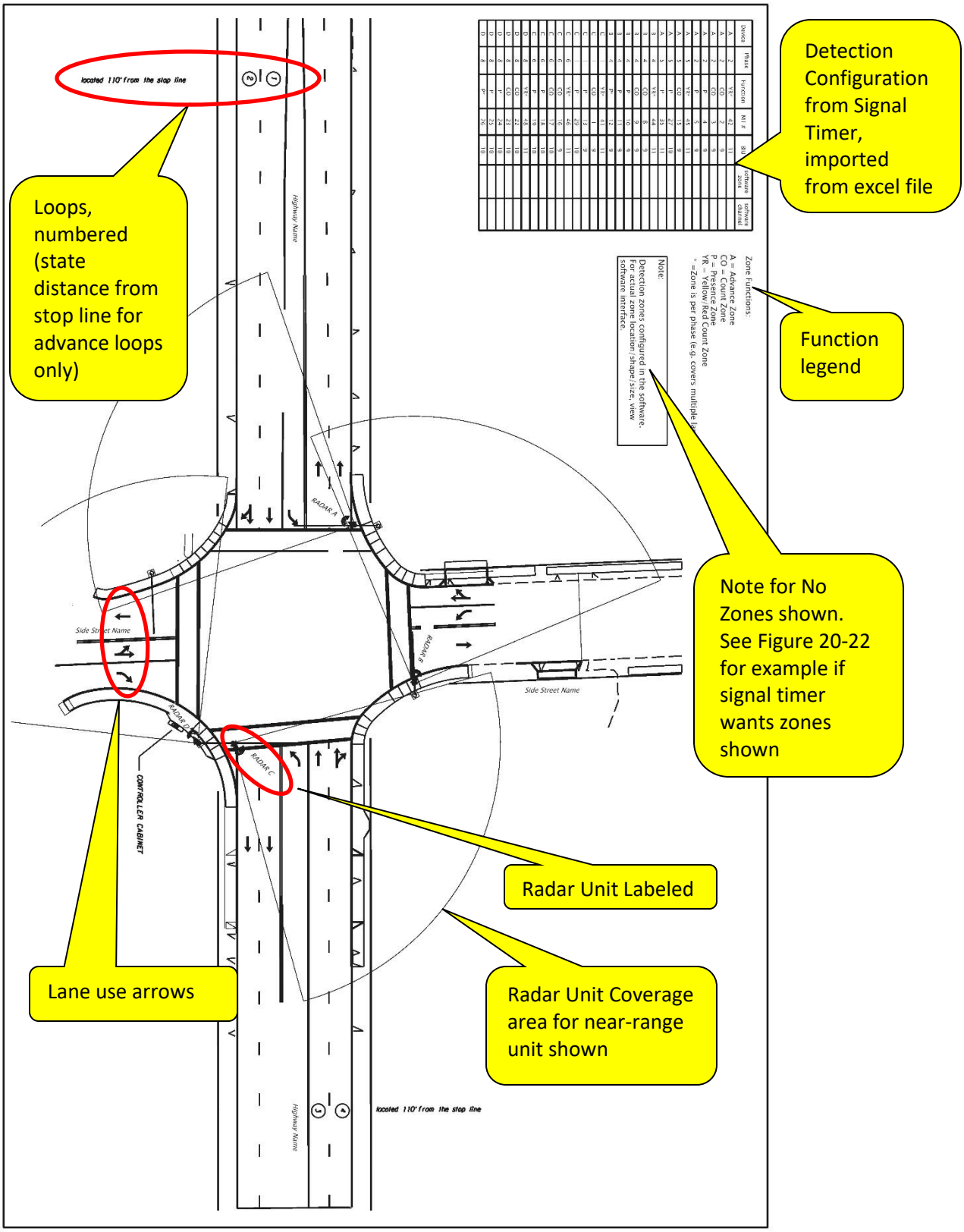
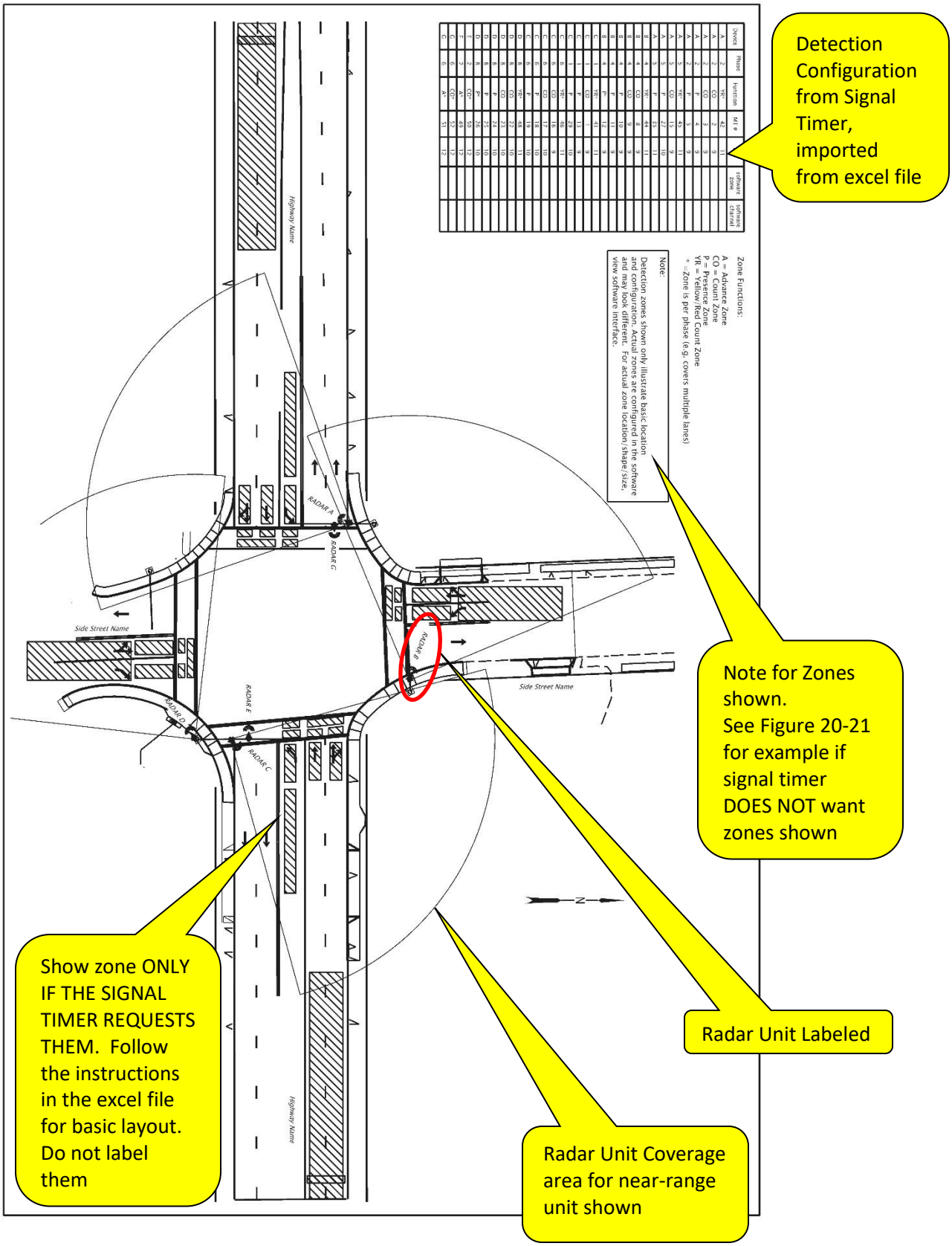


Figure 20-22 | 332S Cabinet Print (page 7 – Detection Drawing) Example 2



20.12 Background/Reference Information

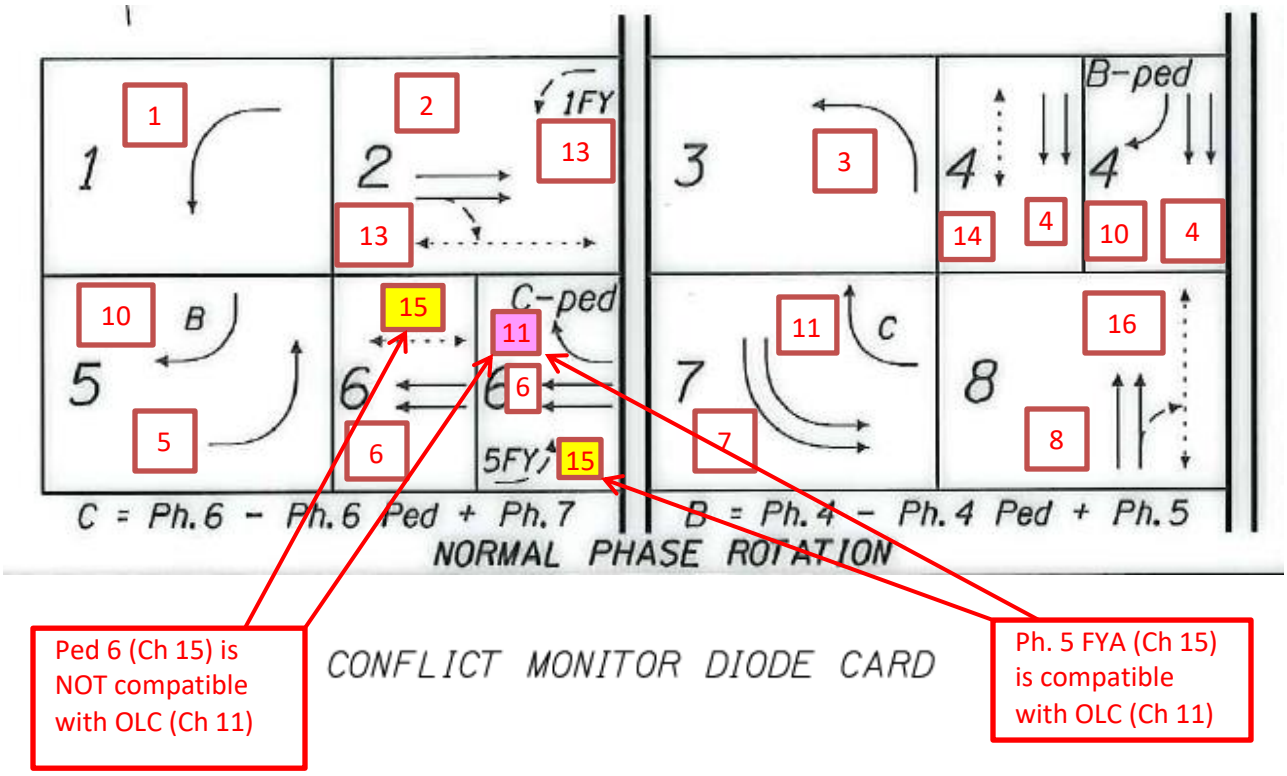
This section contains more in-depth information to aid in understanding guidance presented in this chapter.

20.12.1 Flashing Yellow Arrow and Conflict Monitoring

Two problems with using pedestrian yellow outputs for FYA were identified when troubleshooting several signals that went into cabinet flash after installing not-ped overlap phases and/or Type 3LCF signal heads. The results of this investigation led to changing the FYA output and conflict monitoring standard from ped YELLOW with yellow inhibit jumpers to overlap GREEN (ch. 9 thru 12).

Problem 1: Using a Ped Yellow output for the FYA will not work if the FYA has different conflicts than the ped WALK. For example, Figure 20-23 shows that OLC is not compatible with ped 6 which would require conflict monitor diode 11-15 to remain intact. However, OLC is compatible with ph. 5 FYA which would require conflict monitor diode 11-15 to be removed. If diode 11-15 remains intact, the signal will go into cabinet flash when OLC and phase 5 FYA are served together, resulting in signal phasing that will fail every cycle. If diode 11-5 is removed, the signal will NOT go into cabinet flash if OLC and ped 6 are served together, resulting in unsafe operation.

Figure 20-23 | Problem 1: FYA and WALK phase have different conflicts



CHANNEL ASSIGNMENT

Ch.1 Ph. 1	Ch.5 Ph. 5	Ch.9	Ch.13 Ped2/1FYA
Ch.2 Ph. 2	Ch.6 Ph. 6	Ch.10 OLB	Ch.14 Ped4
Ch.3 Ph. 3	Ch.7 Ph. 7	Ch.11 OLC	Ch.15 Ped6/5FYA
Ch.4 Ph. 4	Ch.8 Ph. 8	Ch.12	Ch.16 Ped8

YELLOW INHIBIT JUMPERS

1	2	3	4	5	6	7	8
9	10	11	12	13	~~14~~	15	~~16~~

Problem 2: Using a Ped Yellow output for the FYA will not work with a Type 3LCF signal head and overlap phase. The type 3LCF signal head uses only one wire terminated at the yellow indication which will provide both the solid yellow and the flashing yellow function. The solid yellow will be monitored because the FYA is required to be monitored and both functions are driven by the same wire/output in the controller cabinet. The solid yellow has different conflicts than the FYA which will cause the signal to go into cabinet flash when the complementary overlap phase stays green while the protected left turn phase is solid yellow. For example, Figure 20-24 shows the conflict monitor channel assignment and Figure 20-25 shows where this phasing sequence creates a conflict monitoring problem with the solid yellow and overlap phase.

Figure 20-24 | Problem 2: FYA and solid yellow have different conflicts – Conflict monitor channel assignment

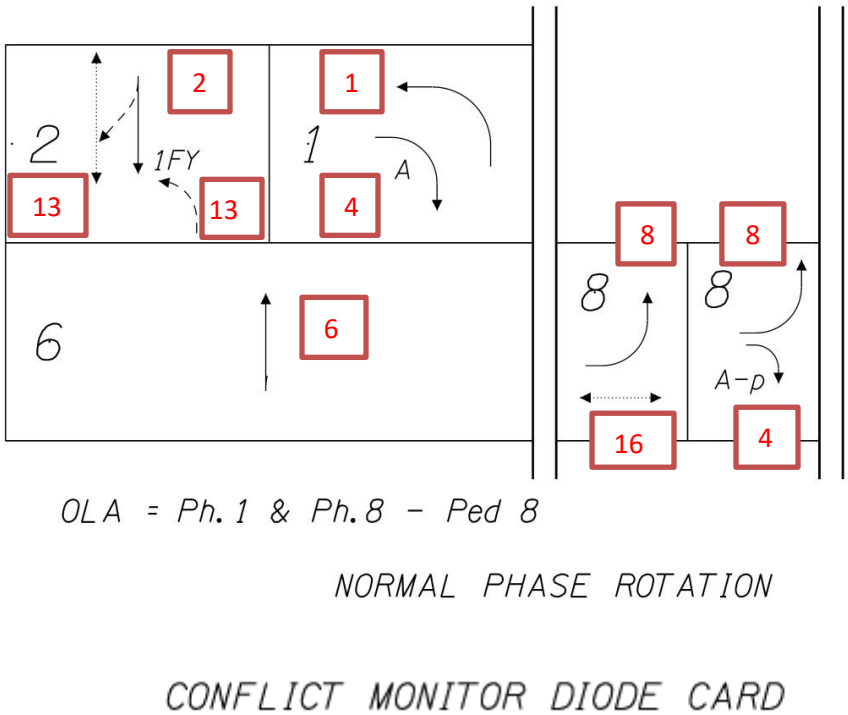


Figure 20-25 | Problem 2: FYA and solid yellow have different conflicts – phasing sequence

For a 3-wire system, solid yellow is monitored with the FYA

For a 3-wire system, solid yellow is monitored with the FYA

Phase	Indication color, sequence going from left to right								
1	-	-	-	-	G 1	Y 13	R	R	-
1 FYA	FYA 13	FYA 13	Y 13	R	-	-	-	-	FYA 13
2	G	G	Y	R	R	R	R	R	G
Ped 2	W	FDW	DW	DW	DW	DW	DW	DW	W
6	G	G	G	G	G	Y	R	R	G
8	R	R	R	R	R	R	G	Y	R
Ped 8	DW	DW	DW	DW	DW	DW	DW	DW	DW
OLA	R	R	R	R	G 4	G 4	G 4	Y	R

In this column, diode 4-13 would need to be removed (compatible phases). However, OLA (ch 4) and ped 2 (ch 13) are conflicting phases requiring diode 4-13 to remain intact.

If diode 4-13 is removed, the signal will NOT go into cabinet flash if OLA (ch 4) and ped 2 (ch 13) are served together, resulting in unsafe operation. If diode 4-13 remains intact, the signal will go into cabinet flash when OLA remains green when phase 1 is followed by phase 8.

Various solutions to these two problems, listed below, were thoroughly vetted by Traffic-Roadway Section, TSSU, Region Traffic and Local Agency staff:

- **<u>Do not monitor the flashing yellow arrow:</u>** Several local agencies do not monitor the flashing yellow arrow because the software controlling the flashing yellow arrow sequence has a high level of reliability and there are a limited number of conflicts that can be monitored using the standard conflict monitoring equipment. On the same principle, ODOT does not monitor the flashing don't walk portion of the pedestrian phase (only the walk phase is monitored). However, ODOT has a long standing history of requiring monitoring of the flashing yellow arrow as it provides the same function as a circular green indication for a permissive left turn and we monitor all green

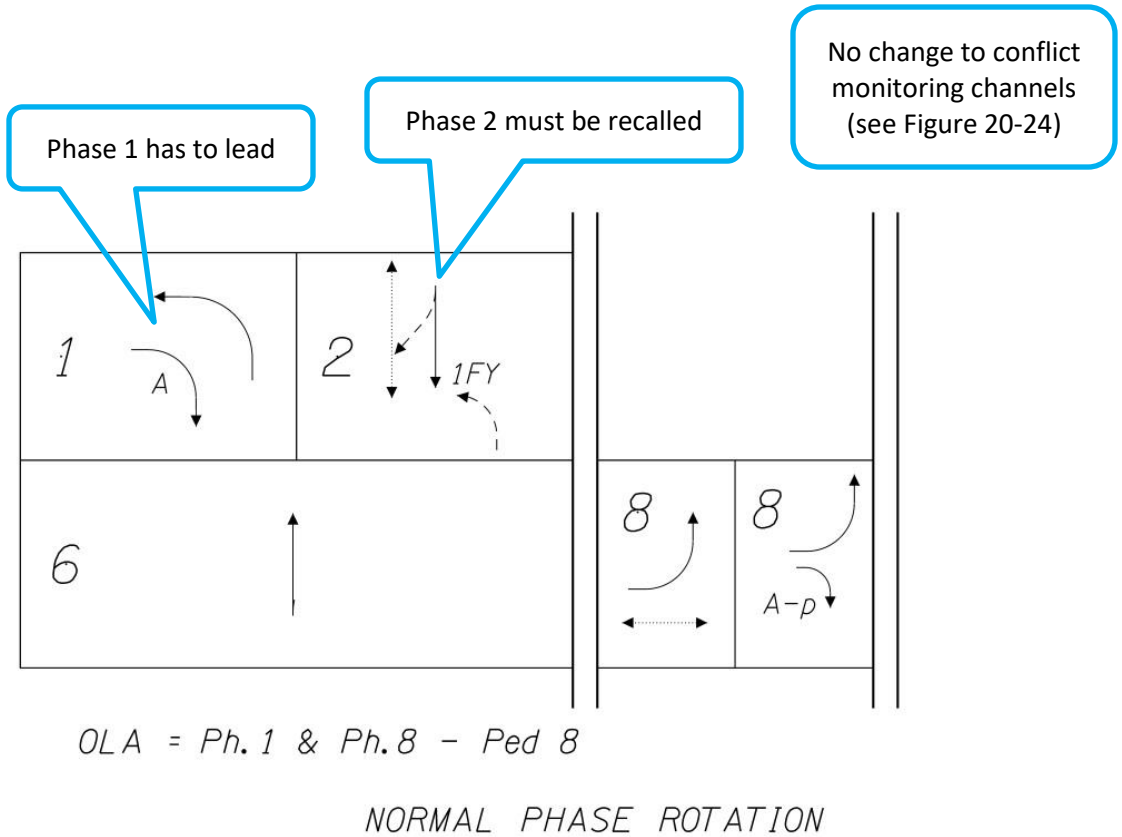
indications. At this point in time, this option was dismissed due to the importance of ensuring the flashing yellow arrow does not run concurrent to any conflicting phase.

- **Restrict signal phasing options:** Allow the overlap phase and remove the FYA or allow the FYA and remove the overlap phase. One of the original benefits of the standard conflict monitoring using pedestrian yellow outputs for FYA was to "free-up" the overlap channels (ch 9 thru 12) for use. In the past, when overlap phases used Type 2 programmed signal heads or closed conflicting pedestrian crossings, those "available" channels could be used without a conflict monitoring problem. This changed when overlap phases started to use Type 3R signal heads and not-ped phasing, basically making those previously "available" overlap channels unusable if pedestrian yellow outputs were being used for FYA. Restricting the desired operation at the intersection was also met with widely varying opinions about what phases are truly needed. This option was dismissed because agreement could not be reached that prioritizing the conflict monitoring standard (ped yellow FYA monitoring) over desired operations (when operational analysis indicates certain phases are not needed for acceptable V/C and queue lengths) was a viable solution and an original benefit of using ped yellow monitoring was negated.

- **Problem 2 only – use a Type 6L signal head (separate wire and termination for solid yellow and flashing yellow):** This option allows the solid yellow indication to be unmonitored. This option was dismissed because ODOT is moving away from using Type 6L signal heads for new PPLT installations. The type 3LCF signal head has many advantages over the type 6L signal head, such as reduced structural loading, less wiring, reducing the number of signal head types for maintenance to stock, and far easier ability to retro-fit existing installations.

- **Problem 2 only - Restrict signal phasing to ensure overlap phase green and solid yellow are never served together:** By restricting the sequencing of the left turn phase (lead/lag) and recalling other phases, the solid yellow and overlap green will always terminate at the same time. See **Figure 20-26** for example. This option was dismissed due to being overly complicated to determine the correct sequencing and because changing from a left turn phase from leading to lagging shouldn't require a change to the conflict monitor.

Figure 20-26 | Problem 2 potential solution: Restricted signal phasing sequence



Phase	Indication color, sequence going from left to right									
1	G [1]	Y [13]	R	-	-	-	-	-	-	G [1]
1 FYA	-	-	-	FYA [13]	Y [13]	R	R	R	R	-
2	R	R	G	G	Y	R	R	R	R	R
Ped 2	DW	DW	W [13]	FDW	DW	DW	DW	DW	DW	DW
6	G	G	G	G	Y	R	R	R	R	G
8	R	R	R	R	R	G	G	G	Y	R
Ped 8	DW	DW	DW	DW	DW	W	FDW	DW	DW	DW
OLA	G [4]	Y	R	R	R	R	R	G [4]	G [4]	G [4]

Phase 1 solid yellow will never be on with OLA GREEN because phase 1 is always followed by phase 2, which will terminate OLA GREEN and phase 1 GREEN at the same time.

Phase 1 solid yellow will never be on with OLA GREEN

21 CONSTRUCTION SUPPORT

Once the project has been let, the signal designer will need to provide assistance to the office administering the contract during the advertisement and construction phases. This typically consists of:

- Clarifying/interpreting information shown in the plans and specifications
- Adding, modifying or deleting information in the plans and specifications as necessary
- Providing a cost estimate for your expected amount of construction support
- Reviewing submittals
- Attending meetings as requested
- Periodic inspection of work as requested

Construction Support should be the highest priority for the Signal Designer.

21.1 Authority over the Contract Work

Once the project is let (during the advertisement phase and the construction phase) the Engineer has full authority over the work contained in the contract documents. The Engineer is defined in the specifications as the Chief Engineer of the Agency acting directly or through authorized representative (Section 00110.20). The specifications also define the Project Manager as the Engineer's representative who directly supervises the engineering and administration of a contract (Section 00110.20) and the states the duties and authorities of the project manager (Section 00150.01). One of the duties of the project manager is to address any clarification, interpretation, corrections, etc. of the contract documents. This is to ensure that clear, concise information/direction is given to the bidders or the contractor. Contract clarification or interpretation obtained from persons other than the project manager (i.e. the signal designer) are not binding on the agency and unnecessarily complicate administration of the contract.

The Engineer (Project Manager) has authority of the contract work. Always work directly with the project manager's office when providing construction support. DO NOT WORK DIRECTLY WITH THE BIDDER OR CONTRACTOR!

21.2 Addenda

Changes or corrections to the plans, special provisions or bid items may be required during the advertisement phase. These changes are made by addenda.

If the addendum includes modifying a plan sheet, the plan sheet will either need to be digitally signed again or a revised stamped and sealed mylar plan sheet is required. Revision triangles are required on ALL revised plan sheets as shown in the Contract Plans Development Guide, NO EXCEPTIONS.

In addition, Traffic Standards Section for review and design approval of the revised plan sheet is required as per Chapter 2. The T.R.S number does not change from the original plan sheet.

21.3 Pre-Construction Conference

After the contract has been awarded and prior to starting work, the contractor must meet with the Project Manager for a Pre-construction conference (pre-con). The pre-construction meeting will typically cover the following topic that can impact signal design:

- Utility relocation and potential conflicts
- Identifying known problem areas, identifying procedures to resolve those problems, and establishing a process to resolve future problems in a timely manner
- Calling attention to unique design requirements in the plans and specs
- Project schedule
- Temporary traffic control and staging
- Identification of key personnel and channels of communication

The signal designer should attend the pre-con conference if possible, especially if there are known problem areas, unique design requirements, and/or the contractor or inspector have limited traffic signal construction experience. Obtaining a copy of the agenda can maximize your efficiency as it is not necessary to stay for the entire pre-con, which can be lengthy and cover a wide array of contract topics.

21.4 Material Submittals and Shop Drawing Review

The signal designer may receive different types submittals to review, but the three main required construction submittals are pole drawings, Blue & Green Sheets, and Field Verification Forms.

21.4.1 Pole and Foundation Submittals

When you receive pole submittals, review the basic traffic features: mast arm orientation, luminaire arm orientation, and any other appurtenances that you have specified on the plans.

After reviewing the submittals, mark them as REVIEWED including your signature and the date. Keep one copy of the pole submittal for yourself and send the rest of the shop drawings with a copy of the signal plan, to the Traffic Structures Engineer for review of the pole design and foundation design.

21.4.2 Blue Sheets and Green Sheets

The Traffic Signal Standards Section maintains two lists of materials and equipment that show a list of prequalified equipment for use on signal projects. These lists are commonly referred to as the “Blue and Green Sheets”. They are updated frequently and posted on the Traffic Signal Standards Website under “Product evaluation and approval” at:

http://www.oregon.gov/ODOT/Engineering/Pages/Signals.aspx

The "Blue Sheets" contain a list of items that are normally qualified by the Project Manager according to the Non-Field Tested Materials Guide.

The "Green Sheets" contain a list of items that are normally accepted for environmental and functional testing by the Traffic Signal Services Unit (i.e. the controller cabinet and equipment contained within).

The contractor is responsible for downloading, appropriately filling-out, and submitting copies of blue and green sheets to the Project Manager prior to starting work. The second page of the blue and green sheets contains detailed instructions for how to use and process each document.

Typically the signal designer is not involved in reviewing, using, processing, or approving the green and blue sheets. However, you may be asked to help the inspector review them, usually to make sure that the contractor has included all of the necessary components as required by the plans and specifications. If this occurs, read through and follow the instructions listed on the second page of the submittal.

Always read and follow the instructions on the second page of the Blue and Green Sheets.

21.4.1 Field Verification Forms (for Signal Poles and Signal Pole Foundations)

There are two field verification forms, one for Signal Poles and one for Signal Pole Foundations. These two forms are required for each large pole on the project (not required for pedestals or pushbutton posts). Both forms contains information that is intended to verify the exact location of the pole foundation, the vertical clearance for all equipment mounted on the mast arm will meet the 18' min. to 19' max, and the anchor rod projection is installed per specification. You can download copies of the two forms, as well as get additional information about their use (flow chart and roles & responsibilities) at the Traffic Structures website under "signal supports, field verification forms":

http://www.oregon.gov/ODOT/Engineering/Pages/Structures.aspx

These forms are filled out by the Project Manager's office prior to installation of the signal pole foundations based on the information provided in the signal plan sheets and design files. However, you may be asked to help fill them out or review the content.

21.5 Cabinet Print

The cabinet print is submitted to the Traffic Signal Services Unit (TSSU) and the Region Traffic Operations Engineer during the construction phase (ideally near the pre-construction conference project milestone), prior to the signal being constructed. See Chapter 20 for more information on the cabinet print.

21.6 Requests for Information

The Project Manager's Office will contact the Engineer of Record when there is a need for interpretation of the plans or the specifications. As mentioned in Section 21.1, all requests for information should come from the Project Manager's Office. If a request from someone other than the Project Manager Office is received, do NOT answer any project specific questions and direct them to the Project Manager's Office for proper processing of the issue. This may seem overly bureaucratic and unhelpful, but the importance of this process cannot be understated; it is vital that agency communication is directed through a single official source to avoid conflicting, confusing, or inappropriate release of information that may result in time delays, unnecessary expense, or construction claims.
The construction lead will submit any contractor questions, contractor proposals, errors in the plans/specifications, etc. to the Engineer of Record for review and comment. The Engineer of Record will determine a proper response back according to the following:

- If clarification of the plans is all that is needed, the Engineer of Record will provide this information to the PM with no further action needed from the EOR.

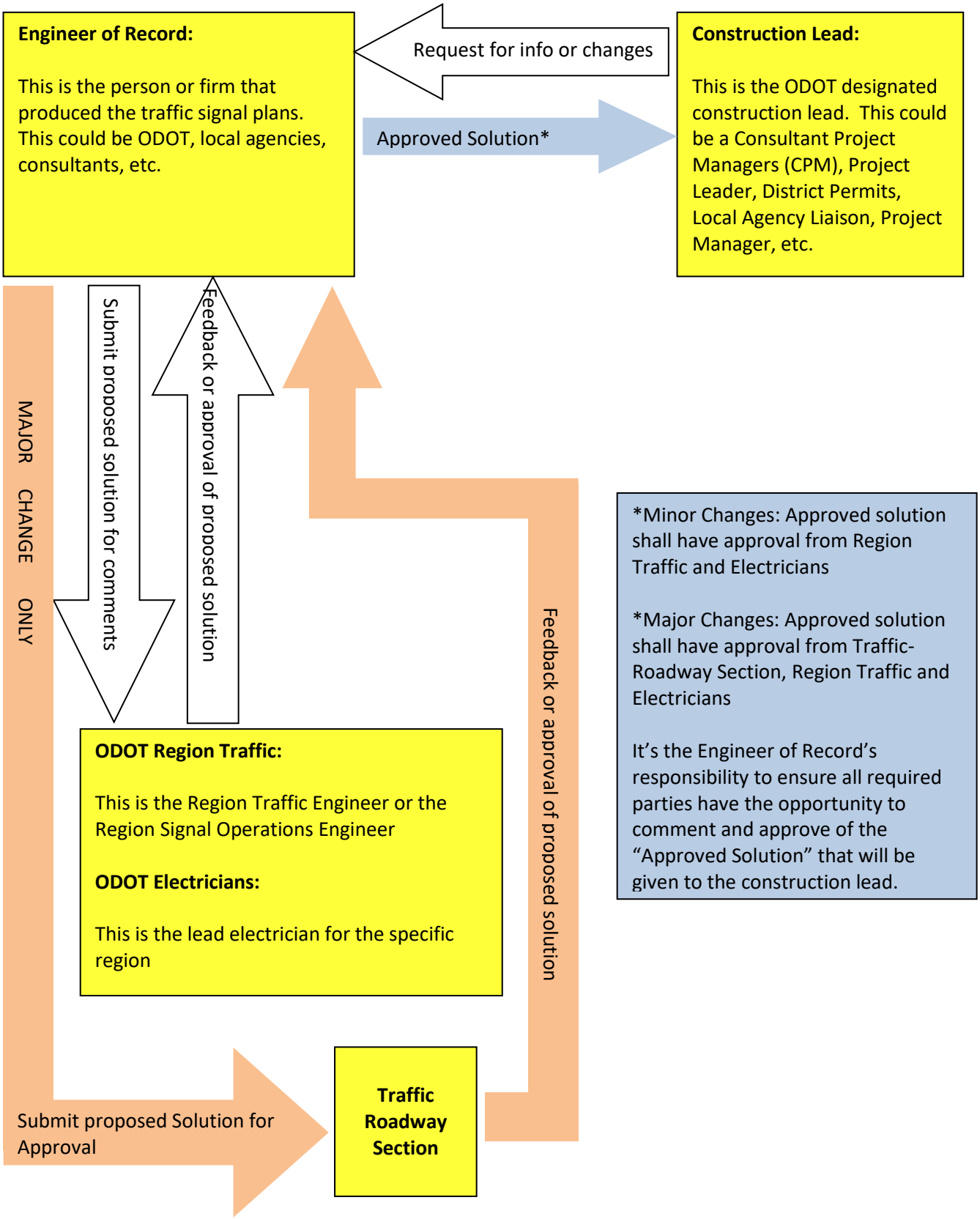
- If a minor change to plans and/or specifications is needed, the Engineer of Record will submit a proposed solution to Region Traffic and the Region Electricians for review and approval. A minor change would be anything that falls under current standard practice. The EOR will give the approved solution to the construction lead (see section 21.7) who will then direct the contractor.

- If a major change to plans and/or specifications is needed, the Engineer of Record will submit a proposed solution to the Traffic Roadway Section, Region Traffic and the Region Electricians for review and approval. A major change would involve any deviation from standards. The EOR will give the approved solution to the construction lead (see section 21.7) who will then direct the contractor.

The Engineer of Record is responsible for providing a solution to issues that arise during construction! The Construction Lead is responsible for making sure that solution is carried out.

The following flow chart, Figure 21-1, outlines this basic process for handling requests for information and resolving issues during construction.

Figure 21-1 | Changes During Construction Flow Chart



21.7 Contract Change Orders

Changes or corrections to the plans, special provisions or bid items may be required during the construction phase. These changes are made by contract change orders (CCO).

If a CCO includes modification to a plan sheet, there are two options for resolution:

- Provide written or verbal direction to the PM of the required change. This change will then be documented in the CCO paperwork and on the plan sheet as-built when the project is completed. If the change is major or includes a deviation from standards, verbal or written approval (such as e-mail) is required by the Traffic Standard Section.

- Produce either a digitally signed revised plan sheet or a revised stamped and sealed mylar for inclusion into the CCO. This option is recommended if the revision is complex enough that written or verbal directions to the construction lead would be insufficient to properly understand and implement the change. Revision triangles are required on ALL revised plan sheets as shown in the Contract Plans Development Guide, NO EXCEPTIONS. The revised plan sheet does NOT need to be submitted to the Traffic Signal Standards Section for review and design approval if the proposed change is minor and doesn't deviate from standards (i.e. adjustment or deletion of an optional lane use sign). If the change is major (i.e. deviates from the requirements stated in the operational approval) or involves a deviation from standards, the revised plan sheet shall be submitted to the Traffic Signal Standards Unit for review and Design Approval as per chapter 2. The T.R.S number does not change from the original plan sheet.

CCO plan sheet revisions are given the highest priority for Traffic Signal Standards Section review.

Verbal approval by the Traffic Standards Section for changes that deviate from standard is acceptable for moving forward during construction.

21.8 Certified Traffic Signal Inspection Certification

ODOT Traffic Standards Section provides training and certification each year for inspection of ODOT traffic signal installations. While this training is specific to inspection and NOT a requirement signal designers, it is highly recommended as it will give a better understanding of the materials and construction process related to traffic signals. Class topics include:

- Material Qualifications (Blue and Green Sheets)
- Review of the current "Field Inspectors Manual for Signal Construction"
- Exposure to basic signal design
- Standard Drawings
- Reading of plans and specifications

The training is taught in two different formats; a 2-day full class and a 1-day re-certification class for those that are more familiar with the subject topics and just need a refresher course

highlighting the recent changes. An exam is given at the end of each class and certification is given to those that pass. Certification is good for three years.

For more information on these classes, access to the current version of the "Inspector's Manual for Signal Construction", and to register for up-coming classes, visit the ODOT Inspector Certification Program website:

- http://www.oregon.gov/ODOT/Construction/Pages/Traffic-Signal-Manual.aspx
- http://www.oregon.gov/ODOT/Construction/Pages/Inspector-Certification-Program.aspx

21.9 Construction Issues

This section takes excerpts from actual construction change orders and project manager narratives, grouped into basic categories. Some of these issues could have been resolved prior to construction during the design phase by a site visit to field verify conditions or by coordinating with other disciplines. Some result from ambiguity, incomplete, or conflicting information in the contract documents. Others are the result of unexpected conditions that were uncovered during the construction process and would have been hard to predict ahead of time. While not all contract change orders can be avoided, the goal is to minimize the number of CCOs needed to build the contract by producing complete, concise, and field verified contract plans.

The Traffic Signal Standards Unit reviews contract change order and project manager narratives as they are posted on the ODOT server.

It is always more cost effective for the contractor to bid and build what's shown in the original contract documents than to issue a change order during construction for the same work.

21.9.1 Detection

April 2013

THIS CONTRACT IS HEREBY MODIFIED AS FOLLOWS (DESCRIPTION AND LOCATION OF WORK COVERED BY THIS ORDER):

This Contract Change Order will provide a method of payment to install Loops #23 and #24 at Boones Ferry Road and to be connected to existing feeder cables. However, field investigation showed the loop feeder cables did not exist.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$1,347.96
	DECREASE		

November 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

Region 1 determined that a proposed future project will reconfigure the ramp meter detector loops at the US26 EB straight on ramp and therefore, the loop replacement work shown on the project plans was deleted in this contract. ODOT Region 1 requested this change. The price for cutting loops in the sub-sub-contract for Bid Item 117, for Ramp Meter Modification: EB ON-Ramp at 185th, was $6,360 for 14 loops, which equals $454.28 per loop. At the 185th ramp to EB US26 six loops were not removed and replaced. Six loops at $454.28 each plus 17% mark-up is $3,189. Splicing the loops to the loop feeder cable would take about 1/2 day at $72/hour plus $15/hour for equipment and materials is an additional $348 for time and materials. The total associated with this work, and appropriate for credit to ODOT, is $3,537.

The attached email dialogue documents agreement from sub-contractor O'Neill Electric Inc. to credit ODOT $3,537.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE		($3,537.00)
	DECREASE	X	

Extra Work Order, August 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

There are several locations where there are old steel street loop boxes that will be impacted by the pavement grinding. The old steel street boxes will be replaced by new PVC loop pockets. There are also several locations that will require new conduit that was not shown in the contract plans. This EWO will compensate the contractor for the added electrical work as directed by the engineer.

PAY ITEM	REASON CODE	WORK TYPE	DESIGN (E OR I)	PM (E OR I)	DESCRIPTION	ESTIMATED AMOUNT
803	26	F	I	I	0900 EW 26-0 FA Compensate Contractor For Added Electrical Work.	$4,660.00

PM Narrative May 2012

SECTION I – SPECIFIC FEEDBACK FOR PROJECT DESIGNER(S) and/or PROJECT DELIVERY TEAM

Provide constructive feedback to the project Designer(s) and/or Project Delivery Team identifying project components and aspects that worked well, and which could/should be used on other projects. Identify project components or aspects which were problematic along with suggested solutions to avoid repeating on future projects. For Design-Build projects, include feedback to the DB Project Manager or Project Leader regarding contract language which was problematic, along with suggested solutions. Also identify contract language which worked well.

These type of paving projects usually do not get adequate amount of time for quality control. Perhaps for future projects, it would be good to check the existing loops and connections, quality of J-Boxes and Wiring. In most cases, the plans call for adjust boxes, extend wires, etc..., the directions in the plans for the installations are usually not specific enough, leading to conflicts, delays, and extra costs.

21.9.2 Conduits

January 2013

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

During the ~~the~~ installation of the new illumination conduit, the contractor encountered rock that was not shown in the geotechnical report. The contractor's HDD equipment has experienced several breakdowns due to the rocky sub-surface conditions. This CCO compensates the contractor for the added costs of drilling through the rock.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$58,752.00
	DECREASE		

May 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

This work was required due to damaged condition of the existing conduits that were to be utilized by the project for site lighting. The conduits were damaged on a previous city project and not repaired. Our project called for these conduits to be utilized in the new lighting system.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$5,447.20
	DECREASE		

October 2011

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The Work to be done under this Contract consists of constructing traffic signal modifications at eleven intersections along SW Tualatin-Sherwood Road and Nyberg Street. The modifications include installing video detection and pan-tilt-zoom cameras along with fiber optic cable and associated communications hardware. During construction, the exististing conduit that was to be used for equipment and communication cables, was found to be at capacity. It was also determined additional cameras at Boones Ferry Rd needed to be installed. This CCO addresses installing conduit and junction boxes to be used for the video detection and fiber optic cables along with installing additional video detection cameras.

Flagging was not anticipated but during construction flagging was determined to be necessary.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$49,631.90
	DECREASE		

21.9.3 Utility Conflicts

February 2013

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

During the Utility pre-construction meeting, the ODOT Electrical Crew Manager voiced concerns about the location of the existing interconnect conduit and junction boxes located in the median ditch. The existing conduit appeared to be in conflict with the plan design to regrade the median and excavate the shoulders. The Engineer verified that a locate was not performed during design and the interconnect will be in conflict and require relocation during construction. The current design only addressed the removal and new installation of the interconnect wire from Ringuette to Redwood Hwy. This change order compensates the contractor for the additional work needed to remove a portion of the existing conduit and install approximately 1000' of new conduit and required junction boxes for installing the new wire.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$10,888.00
	DECREASE		

PM Narrative, September 2012

8. Part 900 – Permanent Traffic Control & Illumination Systems

Included in the scope of this project was installing a new traffic signal on NE Columbia Blvd. and the 82nd street off ramp. One pole was relocated due to a fiber optic cable bank in the same alignment.

Extra Work Order, July 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

Several of the illumination pole sites have potential utility/structure conflicts that were not clearly shown in the plans. This EWO will compensate the contractor for potholing as directed by the engineer.

PAY ITEM	REASON CODE	WORK TYPE	DESIGN (E OR I)	PM (E OR I)	DESCRIPTION	ESTIMATED AMOUNT
801	26	F	I	I	0900 EW 26 ~~0~~ F A~~0~~ Illumination Potholing As Directed	$3,400.00

Force Order, April 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other that State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and / or attached documents, including estimates of costs for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The $3,000 cost is for WOEC to provide electrical power for illumination on this project. This amount will come from the Construction Engineering budget as it was not included in the Anticipated Items.

21.9.4 Poles & Foundations

PM Narrative, October 2012

Section I: Specific Feedback for Project Designer(s) and/or Project Delivery Team

Provide constructive feedback to the project Designer(s) and/or Project Delivery Team identifying project components and aspects that worked well, and which could/should be used on other projects. Identify project components or aspects which were problematic along with suggested solutions to avoid repeating on future projects. For Design-Build projects, include feedback to the DB Project Manager or Project Leader regarding contract language which was problematic, along with suggested solutions. Also identify contract language which worked well.

There was no Specific Feedback on this project ☐

The traffic signal pole vendor and resulting issues in obtaining final approval of their submittals was the driving force behind project delays. The Prime Contractor and electrical Sub-contractor were advised by the Project Manager that delays to the Project may occur if the signal pole supplier was NOT a pre-approved ODOT supplier. This may have been averted to some degree if the following language had been added in the Special Provisions: "Only 'pre-approved' material suppliers will be considered for Signal and/or Luminaire Pole manufacture, purchases or installations for Oregon Department of Transportation Projects". Exceptions would require special approval of the State Structural Materials Engineer before proceeding.

August 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

While drilling Signal Pole Foundation (Pole #1) water was first encountered at a depth of 6.5 feet (Required Footing depth = 10.5'). As drilling continued, infiltrating water began to collapse the shaft wall. The contractor was directed to place a temporary steel casing in the shaft thereby protecting the shaft from collapsing further. The pour was postponed until the next day due to the water. Plans were made to rent a Vacujet, pump the shaft free of water immediately prior to concrete pour and to pull the casing slowly enough to seal the water as the concrete was poured to 6.5 feet from the bottom. Although none of the remaining three foundations encountered enough water to require sleeving, the extra costs for Pole Foundation #1 are being compensated because it is considered a 'Changed Condition' as the Geotechnical report stated the water table to be at 12 feet or deeper.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$2,215.00
	DECREASE		

PM Narrative, November 2012

SECTION I – SPECIFIC FEEDBACK FOR PROJECT DESIGNER(S) and/or PROJECT DELIVERY TEAM

Provide constructive feedback to the project Designer(s) and/or Project Delivery Team identifying project components and aspects that worked well, and which could/should be used on other projects. Identify project components or aspects which were problematic along with suggested solutions to avoid repeating on future projects. For Design-Build projects, include feedback to the DB Project Manager or Project Leader regarding contract language which was problematic, along with suggested solutions. Also identify contract language which worked well.

The two issues that caused the most problems on this project were: #1 the existing signal heads were wired incorrectly. This problem would be hard to catch unless an electrician had opened up the junction boxes and looked for problems. # 2 the signal pole was not tall enough. The 4x4 sign that was called for on this pole arm is not the norm for standard signal poles. Therefore, the use of a non-standard pole should have been considered.

Additionally, the pole was placed in the clear zone. If roadway design had been involved, they may have noticed the clear zone issue.

21.9.5 Unique Situations

Historic Bridge Issue, October 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The signal plans show surface mounted conduit on the face of the span 4 arched curtain walls on both the upstream and downstream sides of the structure to provide power to the northbound and southbound Highway 99 traffic signals. The plans also show retaining the signal controller on the Hwy 99 face of Pier 1 along with the pedestal mounted pedestrian push button. This change will run the power through a larger 3" conduit under the center of the structure, thus eliminating the outside surface mounted conduit giving the signal installation a much cleaner look. It would also move the signal controller to the downstream face of Pier 1 next to the service cabinet and meter base. Other changes include moving the power to the under deck lighting shown on drawing #81882, note 5 to the service cabinet. The pedestrian signal push button would be moved to the Pier 1 wall face. These changes will provide a much cleaner installation on this historic bridge.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$11,642.77
	DECREASE		

21.9.6 Temporary Signals

February 2013

THIS CONTRACT IS HEREBY MODIFIED AS FOLLOWS (DESCRIPTION AND LOCATION OF WORK COVERED BY THIS ORDER):

This contract change order pays for some of the initial costs the Contractor has incurred to install a temporary traffic signal installation on this project. A contract change order to address Contractor's cost reduction proposal for use of the temporary traffic signal system instead of 24 hour flagging will be written when all costs and savings associated with the temporary signal installation can be evaluated. The initial costs paid for in this contract change order will be included in the cost reduction proposal. Removal costs will be tracked by Force Account and paid by CCO at a later date.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$52,542.09
	DECREASE		

21.9.7 Signs

December 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

Work to be Done:

4006A: Install "Truck Route' Sign on the Mast Arm at the intersection of Lombard and St. Louis
4006B: Install additional Interconnect on N Lombard to N John

Reason for Work:

4006A: The sign was mounted in a center island that was removed. The directional sign had to stay in that area and the mast arm of the signal was the best location.
4006B: In order to provide a completed system this interconnct had to be extended.

Cost Justification:

4006A: Directional sign and Safety issue
4006B: To provide a successful project

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$3,575.45
	DECREASE		

April 2013

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

The City of Wilsonville's Engineer, Steve Adams, requested this Contract Change Order to provide a method of payment to compensate the contractor to remove the newly installed "No Right Turn on Red" signs as shown on Plan Sheets, 15717, 15719, and 15727.

Attachment "A" Email from Scott Mansur DKS Engineer. During design it was unclear if adequate intersection sight distance would be available for cars making safe right turn maneuver from exit ramp onto Wilsonville Road (with the adjacent walls). After final construction review the sight distance has been determined there is adequate sight distance at both locations meeting AASHTO sight distance requirements.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$790.90
	DECREASE		

21.9.8 Pushbuttons

October 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

THE CONTRACTOR SUBMITTED AUDIBLE PEDESTRIAN BUTTONS FROM THE QPL WHICH WOULD HAVE WORKED. HOWEVER THE CITY OF EUGENE SAID THESE WERE NOT ACCEPTABLE BECAUSE THEY DID NOT MATCH WHAT THEY HAD ALREADY AND THEY COULD NOT WORK ON THESE. THEY CITY OF EUGENE HAS AN IGA TO WORK ON THE ODOT SIGNALS, SO WE HAD TO MAKE THIS CHANGE TO CONFORM TO CITY OF EUGENE STANDARDS.

THE NEW BUTTONS INCLUDED ADDITIONAL LABOR AND MATERIALS TO MAKE THEM WORK. THE CONTRACTOR SUBMITTED DETAILED PRICING WHICH WAS REVIEWED AND FOUND TO BE REASONABLE. COMPLETE RECORDS ARE IN THE PM FILE IN SPRINGFIELD.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$5,929.36
	DECREASE		

21.9.9 Wiring

PM Narrative, June 2012

4003 A-B	23	**$9,223.20**	**$9,223.20**
Description	On September 22, 2011, the contractor submitted a RFI requesting direction on how to proceed with wiring the new turn signals installed at the East Pine St/Peninger Rd intersection. The new signals had been installed the previous night and it was discovered that there was not sufficient wiring to properly connect the new signal. The existing signals consisted of three heads while the newly installed signals consisted of four heads. The plans did not call for the contractor to add additional signal cable. During the design phase, it was assumed (no as-built plans were available) that because the existing signals were set up with a flashing left turn arrow, a fifth cable, which is normally required for the flashing yellow, was available. Upon further inquiry, the EOR determined that the County had retrofitted the signal at some point in the past and wired them with the flashing left turn arrow using only four cables, which is not the current standard. The PM requested a phone conference on September 22, 2011, to discuss the issue with the contractor, Jackson County, the EOR, and the LAL. At the meeting, options were discussed and an acceptable resolution was agreed upon. New signal cables would be run overhead on messenger cables from the new signals to Poles 10A and Pole 11. It was understood that at pole 10A, the contractor would need to run the new signal cable down the inside of the pole, out through a new condalet, into a new 2" PVC conduit and into an existing junction box about fifteen feet away. The contractor requested an additional 20 work days to complete the remaining work including the final striping, which could not be completed until the signals were fully operational. The request was for 10 days to procure the material, and 10 days to complete the signal work including scheduling and completion of the striping. This was deemed reasonable. Thus, 28 calendar days were added to the contract.		

August 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval; Estimate effect on project time; Significant discussions; References to supporting and/or attached documents, including cost estimates for "Extra Work Orders" and "Force Orders"; Why contractor refuses to sign). List all previously approved overruns.

The Contract work to install Flashers at the Mid-Block Crossing was completed per plan and activated prior to the completion date of June 29,2012. It was later determined that one of the Flashers was not functioning independently in Alternating Rapid Flash. Investigation revealed that two (2) #14 type THHN wires were ommitted in the Flashing Beacon Plan (Sht.16155) and that these wires would need to be installed to acquire the desired flashing pattern. A price to provide and install two hundred (200) feet of #14 THHN Stranded copper wire, two (2) terminal blocks and labor to terminate in the control cabinet then test, was submitted in the amount of $596.00. After reviewing the invoice for materials and labor, it was determined the price was reasonable and that one (1) additional contract day would be granted and no Liquidated damages will be assessed.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$596.00
	DECREASE		

21.9.10 Service Cabinet

May 2012

ADDITIONAL INFORMATION THAT IS NOT INCLUDED ON ORDER (Additional Description; Who requested; Why necessary; Why cost is not a contractor responsibility; Parties other than State or FHWA that have agreed to share the costs; Emergency work prior to approval

The Contractor requested this Contract Change Order to relocate the service cabinet and cable because the current conduit location was in the excavation area on the west side of the Wilsonville northbound on ramp.

By lowering the existing conduit in the excavation area, additional communication cable would be required. The additional cable was anticipated to be bundled in the existing Junction Boxes'; no bundles of cable were found in existing Junction Boxes.

Increased cable length was required.

ESTIMATED NET COST EFFECT OF THIS AGREEMENT ON THE CONTRACT:	INCREASE	X	$15,283.09
	DECREASE		

21.9.11 Junction Boxes

September 2011

4004b - Three loop detector junction boxes need to have concrete aprons installed to protect them against potential off roadway traffic. One junction box is in a fill area and needs to be raised to correct grade.

4004b	011	1000.CC 30 Ø CDA Modifications To Loop Detector Junction Boxes	1.00	LS	$2,765.00	$2,765.00

22 STATE FORCE WORK

Signal modifications that are performed by state forces, not a contractor, are classified as state force work. Often, these modifications are small in scope, inexpensive, and/or need to be done quickly which is why the work is not contracted out in a traditional project development process. Depending on the type of signal modification, additional ODOT crews may need to be involved (signing crew, striping crew, etc.).

22.1 Is Operational Approval Needed?

This type of work still requires operational approval (depending on the proposed modification), as per chapter 3. State force work is comprised of **modifications** to existing signal installations (the following list contains common state force work items, but is not all inclusive):

- Adding or deleting regulatory signing attached to signal equipment
- Adding or deleting signal heads
- Modifying signal head type
- Adding, deleting or modifying signal phasing
- Adding or deleting detection
- Adding or deleting crosswalks/pedestrian phases
- Adding or deleting emergency preemption
- Changing intersection lane use

State force work does NOT include standard MAINTENANCE work such as replacing signal equipment in-kind (due to end-of-service life or malfunction) and replacing detection in-kind.

22.2 Are Plan Sheets and Design Approval Required?

Plan sheets are required for all state force work. While creating plan sheets can be time consuming and seem like an unreasonable task for minor work performed by state forces that really don't need a plan sheet to understand or install the proposed changes, a plan sheet provides the mechanism for documentation, archival, and accurate installation information used by future personnel.

Design Approval as per Chapter 3 is required for all state force work. Due to the nature of state force work (small scope of work and the informal payment/inspection inherent in state forces performing the work), the Design Approval process can be typically be completed much faster than plans developed for contract.

22.3 Plan Sheet

The plan sheets for state force work should follow the guidelines used for standard contract plan development with the following exceptions:

22.3.1 Title Block

The title block should state “STATE FORCE WORK” in the project information area to clearly identify that the modifications are not contract work. See Figure 22-1.

Figure 22-1 | State Force Work Title Block

22.3.2 Detailing Work and Referencing Prior Plan Sheets

The plan sheet should only detail the work to be done and just show the symbology for the other signal equipment that is not impacted by the work. Also, placing a reference to prior plan sheets can be helpful so that accessing the additional information on the signal equipment that is just shown symbolically is easier. See Figure 22-2 for example note referencing prior plan sheets. This simplifies the plan sheet and makes it much easier to see what work needs to be done. See Figure 22-3 for an example of properly detailed work and symbology for all other existing equipment.

Figure 22-2 | Referencing Prior Plan Sheets

See TMS DWG No. 10243 & 2048 for reference

Avoid detailing any equipment that is not impacted by the work to be done (i.e. placing a large amount of "retain and protect" bubble notes). This tends to add little value and instead clutters the drawing making it easier to miss what work needs to be done. See Figure 22-4 for an example of excessive use of "retain and protect" bubble notes.

Figure 22-3 | Only Detailing Work to be Done (Preferred Method)

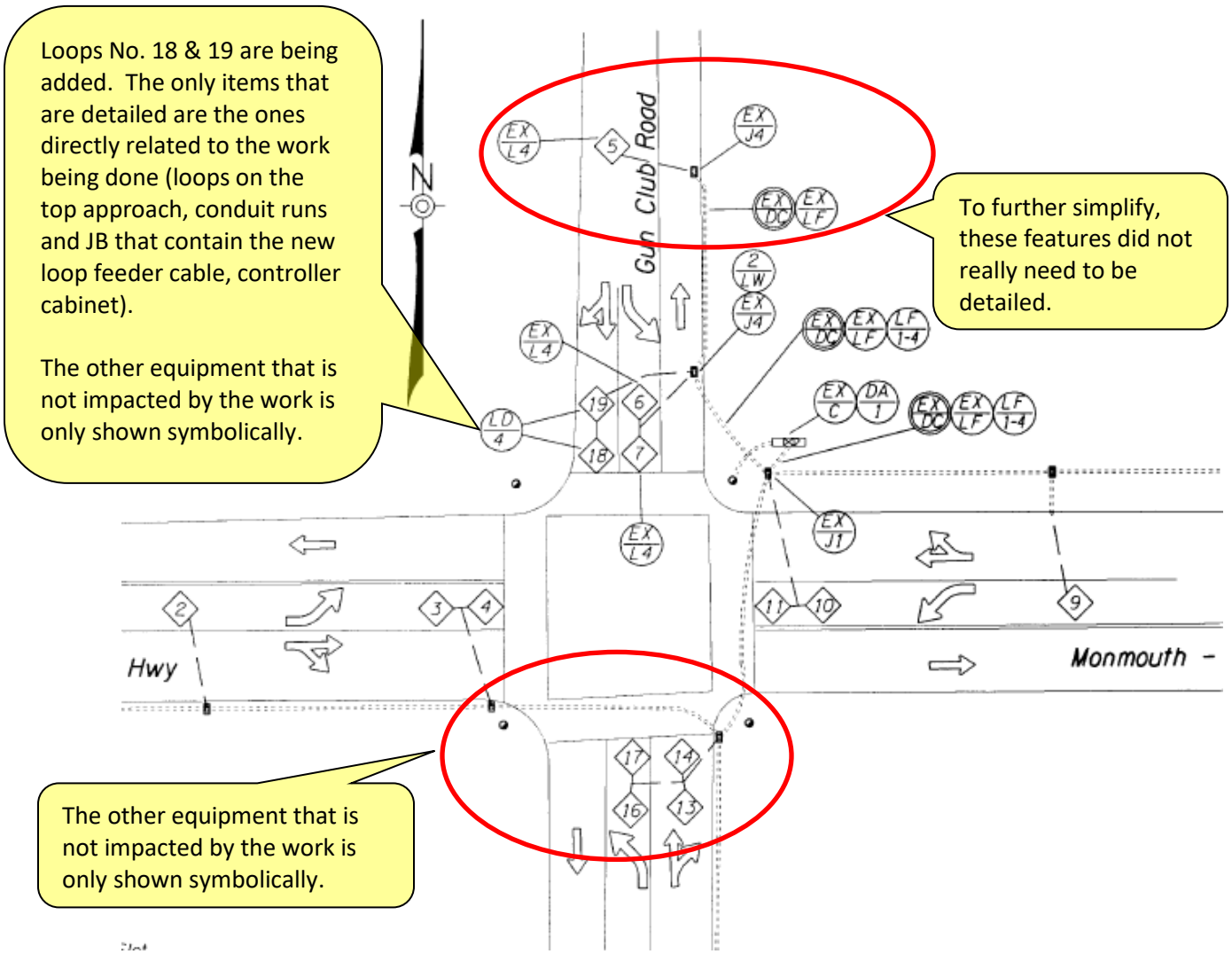
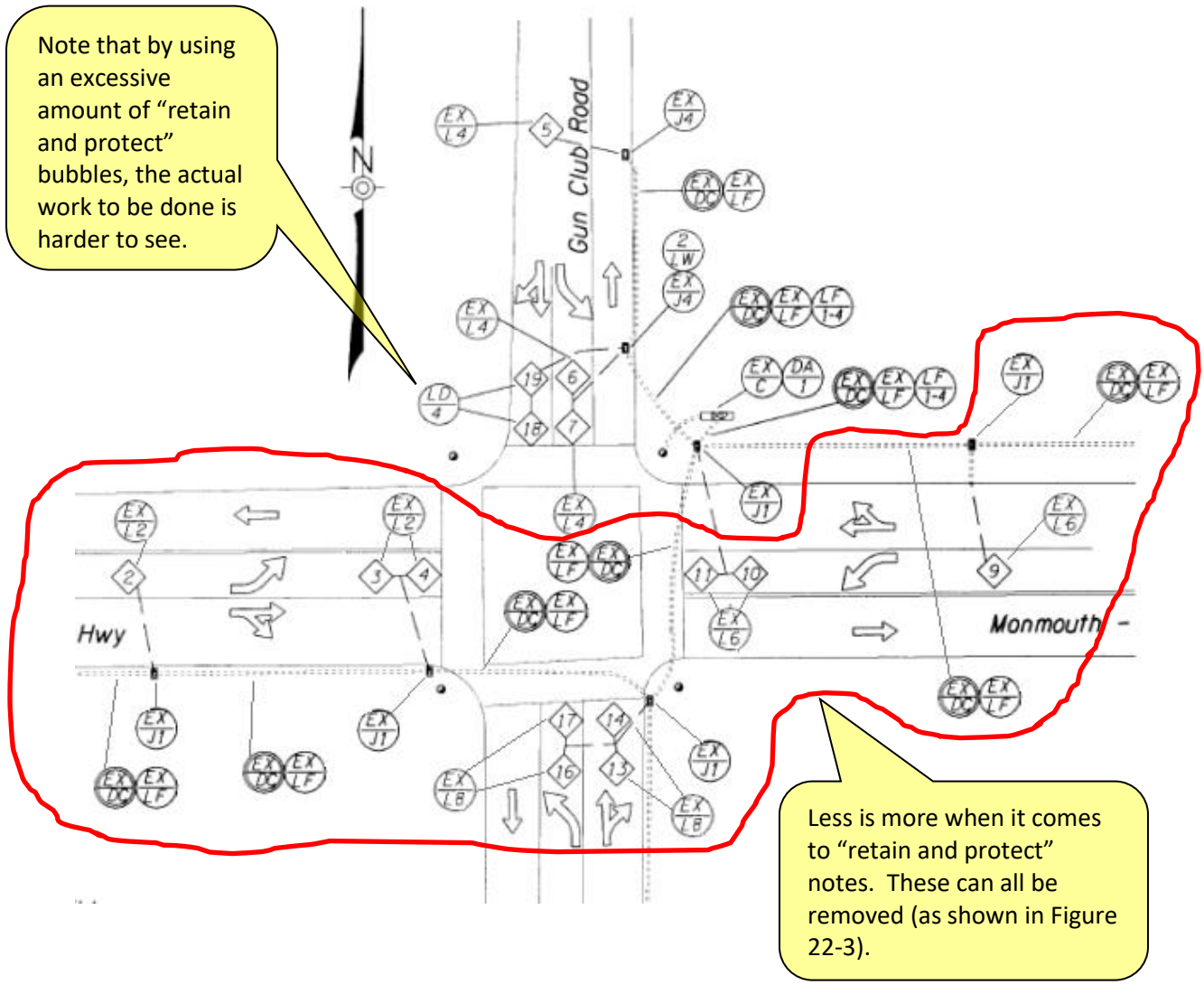


Figure 22-4 | Detailing Equipment Not Impacted by the Work (Avoid this Method)



22.4 Are Specifications, Standard Drawings and Cost Estimate Required?

Standard Specifications and modifications as shown in the special provision boiler plates for the technical aspects installation (materials, certain construction methods) should be understood and followed by those performing the state force work. Other parts of the specifications pertaining to contract administration and payment simply do not apply to work done in-house. Because there is no need for a formal contract for in-house work, there is no need to formally produce specifications to accompany the plan sheets. It is assumed that that those performing the work are staying current with their agency's standards and procedures.

Similar to the specifications, those performing the work should understand and follow the most current version of the standard drawings. The standard drawings that are applicable to the state force work should be listed in the title block (just like for contract work), but do not necessarily need to be provided with the work as those performing the work most likely have their own copies and are well informed of the current standards.

Depending on where the funding for the state force work is coming from (e.g. electrical budget, Region safety or operational budget, claim against other, etc.), a cost estimate may or may not be performed by the signal designer. If a cost estimate is requested for budget planning purposes, it is best to gather the data from those performing the work because the standard cost estimating tools used for contract work will not be accurate due to factors that are inclusive to the bid item (such as profit margin).

23 MOVEABLE BRIDGES

23.1 General

Traffic control for moveable bridges is covered in section 4J of the Manual on Uniform Traffic Control Devices. Additional information specific to Oregon is presented in this chapter.

23.2 Design Responsibility

The Bridge Section has historically been responsible for the design, maintenance and operation of all traffic control devices that are activated by the moveable bridge control system (which includes the signal indications and flashing beacon warning devices). As such, the Signal Designer has had little involvement in the past with the traffic control devices used for moveable bridges. However, due to several recent moveable bridge projects, it became clear that more information about the traffic control devices used and more coordination between the Traffic Section and the Bridge Section was needed. The Bridge, Signal, and Sign Designer should work closely together to ensure that the design for each discipline is detailed or referenced appropriately.

The Bridge Plans Sheets should detail the following items:

- Control system that activates the traffic signals and flashing beacons (cabinets, power source, termination of wires, etc.)
- Location of Gate arms
- Audible devices for warning traffic
- Non-standard poles, foundations, or mounting for signal heads, signs, and flashing beacons
- Electrical conduit routed on/through the bridge structure (including expansion fittings)
- Junction Boxes located on the bridge structure

The Signal Plan Sheets should detail the following items:

- Location of the traffic signals
- Location of the STOP line
- Use of and location of the flashing beacon warning devices
- PTR signs (site specific for the I-5 NB and SB Columbia River Bridge only)
- Wiring from the traffic signals and flashing beacons to the control system (wire terminations are detailed on the bridge plans)
- Electrical conduit not routed on/through the bridge structure
- Connection details for conduit going onto (or off) of the bridge structure (Junction box, expansion fitting, etc.)
- Standard poles, foundations, and mounting for signal heads, signs & flashing beacons

The Signing Plan Sheets should detail the following items:

- Ground mounted signs that do not have a flashing beacon

23.3 Operational Approval

The decision to install a moveable bridge resides with the Bridge Section. Moveable bridges are typically not the most economical type of bridge to build or maintain, making it unlikely that a new moveable bridge will be built today. If a new moveable bridge is installed, the MUTCD Section 4J.01 requires both signals and gates (allowing a few exceptions under certain conditions). Therefore, State Traffic-Roadway Operational Approval is NOT required. Bridge Section is also responsible for the how the activated devices are operated during a bridge opening. **The Yellow Change Interval duration shall follow the requirements stated in the Traffic Signal Policy and Guidelines.**

23.4 Design Approval

Design Approval of the signal plan sheets is required. The Drawing Title for the plan sheets should be "Signal Plan".

23.5 Existing Moveable Bridges on the State Highway System

There are 11 existing moveable bridges on the state highway system that will require repair or replacement in future years. It is likely that complete bridge replacement projects will decrease the number of existing moveable bridges as time goes on.
Table 1 below shows the location of the 11 existing bridges and the type of lift.

Table 1 | List of Moveable Bridges in Oregon

Bridge Name		Region	Route	ODOT Highway No.	Milepoint	Type of Bridge
1	Columbia River (Interstate) NB	1	I-5	1	308.38	Vertical Lift
2	Columbia River (Interstate) SB	1	I-5	1	308.38	Vertical Lift
3	New Youngs Bay	2	US 101	9	4.91	Vertical Lift
4	Old Youngs Bay	2	US 101B	105	6.89	Bascule: Double Leaf
5	Lewis and Clark River	2	US 101B	105	4.78	Bascule: Single Leaf
6	Siuslaw River	2	US 101	9	190.98	Bascule: Double Leaf
7	Umpqua River & McIntosh Slough	3	US 101	9	211.11	Swing
8	Coos River (Chandler)	3	OR 241	241	3.73	Vertical Lift
9	Isthmus Slough (Eastside)	3	OR 241	241	0.42	Bascule: Double Leaf
10	South Slough (Charleston)	3	OR 540	240	8.33	Bascule: Double Leaf
11	Coquille River (Bullards)	3	US 101	9	259.65	Vertical Lift

23.5.1 Non-Compliant Existing Traffic Control Devices (TCD)

There are several moveable bridges with traffic control devices that were commonly used in the past, but are no longer compliant with the current standards as described in this chapter. These devices, listed below, should be removed or replaced with compliant devices when possible:

- Signal heads mounted horizontally. See Figure 23-1.
- Use of a single Type 2 signal head to stop traffic. See Figure 23-1.
- Use of only bridge warning gates with no traffic signals (i.e. Coos River – Chandler Moveable Bridge). Note: all 11 existing moveable bridges require both signals and gates as per the MUTCD. See Figure 23-2.
- Mounting a STOP sign to the bridge warning gate. See Figure 23-3.
- Use of an advance single signal head to warn traffic (custom Type: Flashing Yellow, Green, Flashing Yellow indications or Type 2). See Figure 23-4 and Figure 23-5.
- Use of signs no longer in the MUTCD or the Oregon Sign Policy and Guidelines (DRAW BRIDGE AHEAD sign, DRAWBRIDGE ½ MILE sign). See Figure 23-6 and Figure 23-7.

Figure 23-1 | Non-Compliant Existing TCD: Single Signal Head to Stop Traffic Mounted Horizontally

Figure 23-2 | Non-Compliant Existing TCD: Use of Only Bridge Warning Gates with No Traffic Signals

Figure 23-3 | Non-Compliant Existing TCD: Mounting a STOP sign to the warning gate

Figure 23-4 | Non-Compliant Existing TCD: Single Advance Signal Head, Example 1

Figure 23-5 | Non-Compliant Existing TCD: Single Advance Signal Head, Example 2

Figure 23-6 | Non-Compliant Existing TCD: Outdated Signs, Example 1

Figure 23-7 | Non-Compliant Existing TCD: Outdated Signs, Example 2

23.6 Bridge Warning Gate and STOP Line Placement

The bridge warning gate location is the control point that influences the location of all the other associated traffic control devices, starting with the STOP line location. The signal heads and advance signing are then located based on the STOP line location. The Bridge Designer is responsible for determining the location of the warning gate. See the MUTCD Section 4J.02 for guidance on warning gate placement.

If feasible, the location of the STOP line should be at least 8 feet from the gate arm. The bridge structure and alignment should also be considered when determining the best placement of the STOP line to maximize sight distance to the signal heads.

Historically, the bridge warning gate has been installed near the signal indications or even downstream from the signal indications (rather than near the STOP line). See Figure 23-8. Modifying the placement of the existing warning gate, STOP line and/or the signal heads may not always be practical due to the structural and electrical systems already in place and the scope of the project. These existing systems have been in operation for many years and unless there an operational or safety concern with the location of the bridge warning gate, signal heads and/or stop line (i.e. non-compliance of the gate, vehicles stopping at the wrong location, broken gate arms, poor sight distance, crash history, near-misses, etc.), the location of these devices does not require modification.

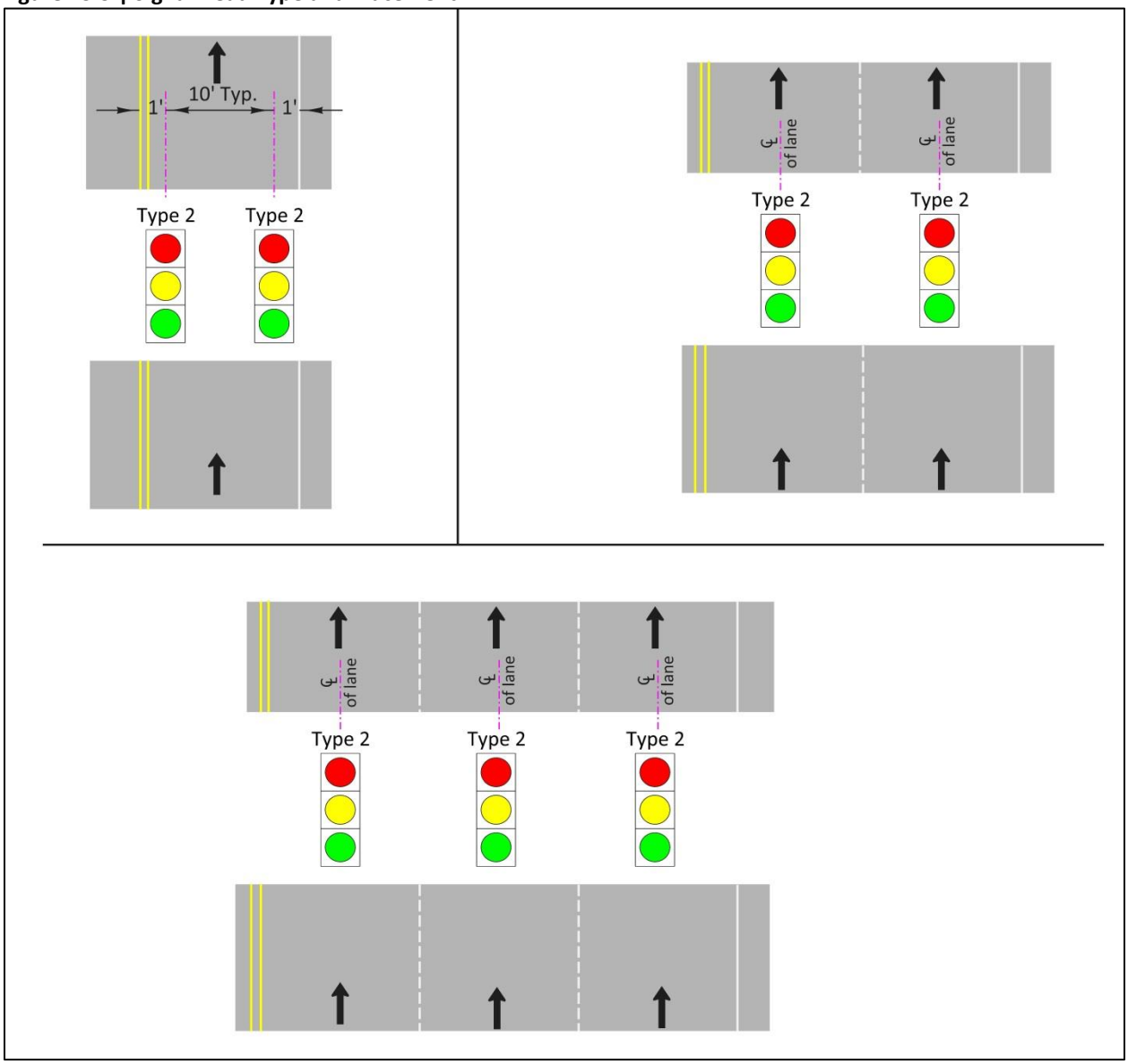
Figure 23-8 | Example of Existing Warning Gate Arm Located Downstream from Signal Indications

23.7 Signal Head Type and Placement

Basic requirements for signal head type and placement:

- A minimum of two Type 2 Signal heads mounted vertically overhead shall be used to stop traffic
- Heads shall be at least 8 feet apart, desirable 10 feet apart
- Heads shall not be less than 45 feet from the STOP line, desirable 80 to 100 feet
- Supplemental heads may be used if necessary to improve sight distance to the signal indications
- A signal head per lane shall be used when there are 2 or more approach lanes

Figure 23-9 | Signal Head Type and Placement



23.8 Mounting Signal Heads and Signs

The bridge structure and alignment will determine how the signal heads and signs will be mounted. Signal heads shall be mounted vertically. Some locations will be able to accommodate standard traffic signal mast arm poles (with a custom foundation incorporated into the bridge structure) and standard sign and signal pedestal supports. See Figure 23-10. Other locations will require the signal heads and/or signs to be custom mounted on the bridge structure or on a custom support. See Figure 23-11. The Bridge Designer is responsible for any custom mounting or support details.

Figure 23-10 | Standard Traffic Signal Mast Arm Pole Incorporated into the Bridge Deck

Figure 23-11 | Signal Heads and Sign Custom Mounted on Bridge Structure

23.9 Traffic Control Device Sequence

The following sections 23.9.1 through 23.9.3 show the standard sequence of signs and flashing beacons in advance of the moveable bridge based on the required sight distance to the signal heads. **Section 23.9.4 is specific to the I-5 NB Columbia River Crossing and Section 23.9.5 is specific to the SB Columbia River Crossing.**

Sign location dimensions shown in sections 23.9.1 through 23.9.3 are based on AASHTO and MUTCD guidance; they may be adjusted as necessary according to site specific constraints, such as:

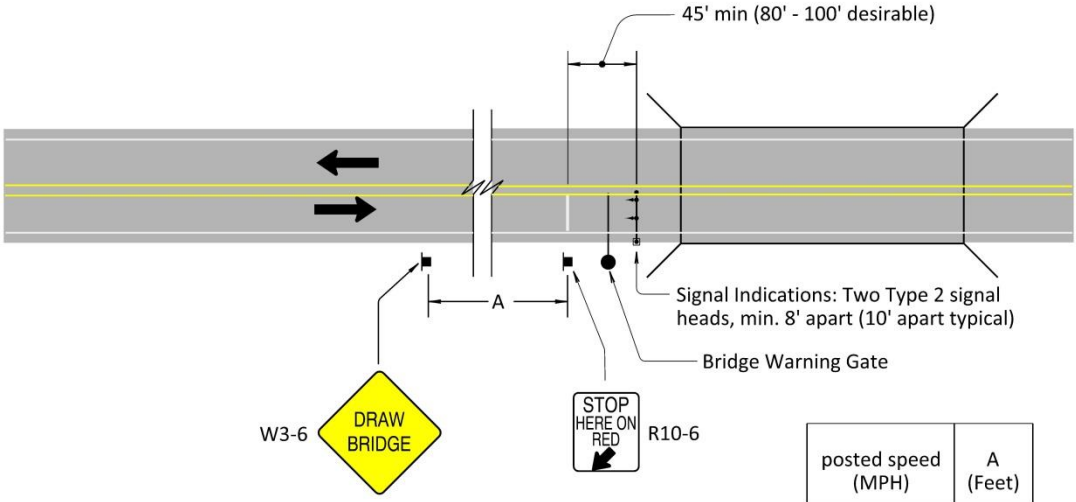
- maximizing sight distance
- Allowable locations on the bridge structure to mount traffic control devices and electrical features
- Obtaining appropriate spacing between other required signs, especially those with flashing beacons (i.e. NARROW BRIDGE sign, bridge height/weight restriction signs, curve warning signs, bikes/peds on bridge when flashing sign).
- Expected queue lengths during bridge openings
- Location of nearby approaches/accesses

23.9.1 No Sight Distance Restrictions to Signal Heads

Figure 23-12 shows the standard traffic control device sequence when the sight distance to the signal indications meets or exceeds the distances stated in MUTCD Table 4D-2. All signs are typically ground mounted. A supplemental signal head may be used to achieve the sight distance requirement.

The Sign Designer is responsible for the two ground mounted signs.

Figure 23-12 | Sign Placement – No Sight Distance Restrictions to Signal Heads



posted speed (MPH)	A (Feet)
30 & under	100
35	100
40	125
45	175
50	250
55	325
60	400
65	475

W3-6 placement values (from stop line) based on MUTCD Table 2C-4 condition B, deceleration to 0 MPH.

23.9.2 Sight Distance Restrictions to Signal Heads

Figure 23-13 shows the standard traffic control device sequence when the sight distance to the signal heads does not meet the distance specified in the MUTCD Table 4D-2 (and a supplemental signal head still does not meet the distances specified). This standard sequence may also be warranted regardless of sight distance if the bridge has high traffic volumes, frequent bridge openings, rural location, high speeds, high percentage of heavy vehicles, or high percentage of unfamiliar drivers. Signs are typically ground mounted, but overhead mounting should be considered as per section 2A.17 of the MUTCD. If overhead mounting is used, the OR15-14 sign with two Type 1Y flashing beacons shall be used instead of the W3-4 sign with W16-13p rider. The two flashing beacons shall flash in a wig-wag pattern.

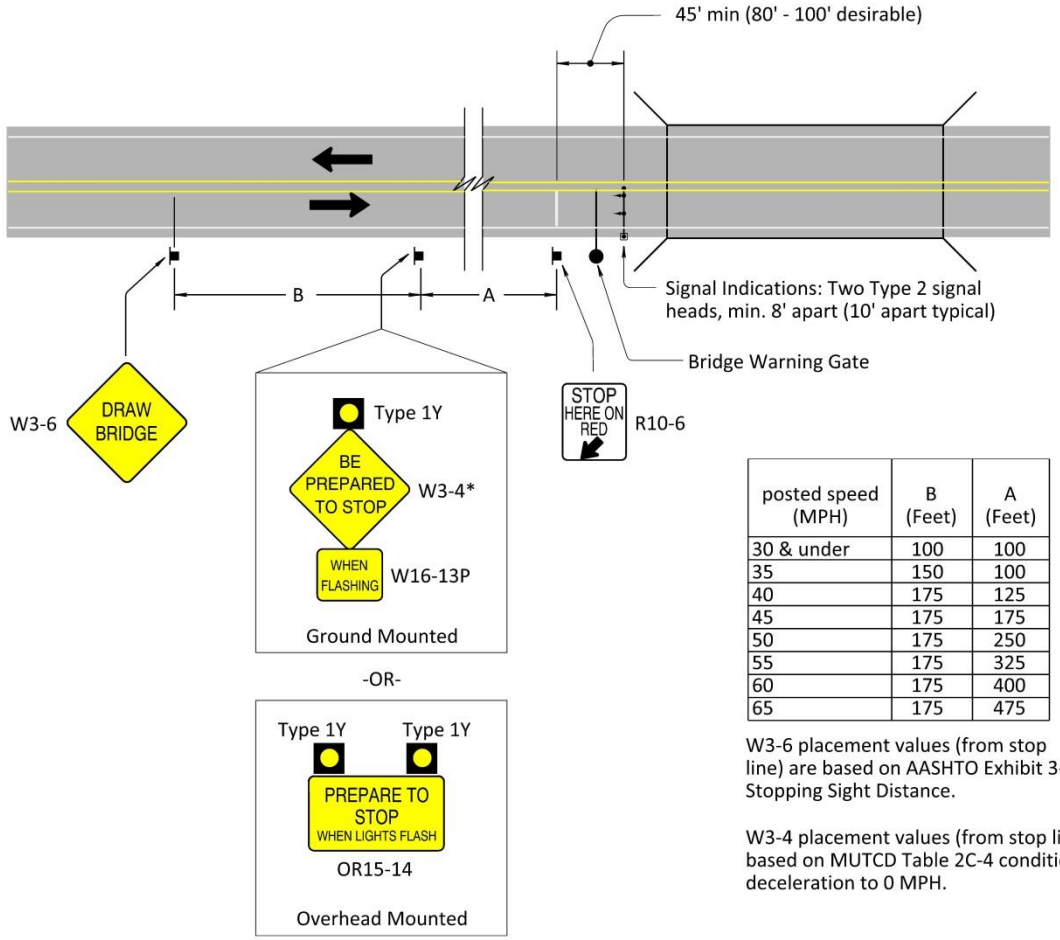
Sign Designer is responsible for:

- The DRAW BRIDGE sign (W3-6)
- The STOP HERE ON RED sign (R10-6)

Signal Designer is responsible for:

- The sign assemblies with Type 1Y flashing beacons

Figure 23-13 | Sign Placement – Sight Distance Restrictions to Signal Heads



posted speed (MPH)	B (Feet)	A (Feet)
30 & under	100	100
35	150	100
40	175	125
45	175	175
50	175	250
55	175	325
60	175	400
65	175	475

W3-6 placement values (from stop line) are based on AASHTO Exhibit 3-1 Stopping Sight Distance.

W3-4 placement values (from stop line) based on MUTCD Table 2C-4 condition B, deceleration to 0 MPH.

23.9.3 Sight Distance Restrictions to Signal Heads (Special Application Only)

Figure 23-14 shows the traffic control device sequence for special applications when the sight distance to the signal heads does not meet the distance specified in the MUTCD Table 4D-2 (and a supplemental signal head still does not meet the distances specified). Signs are typically ground mounted. The following sequence may only be used in the following circumstances:

- when the AADT is low (3000 or less) with a high percentage of familiar drivers
- moveable bridge operation is infrequent
- urban locations where sign placement location is limited

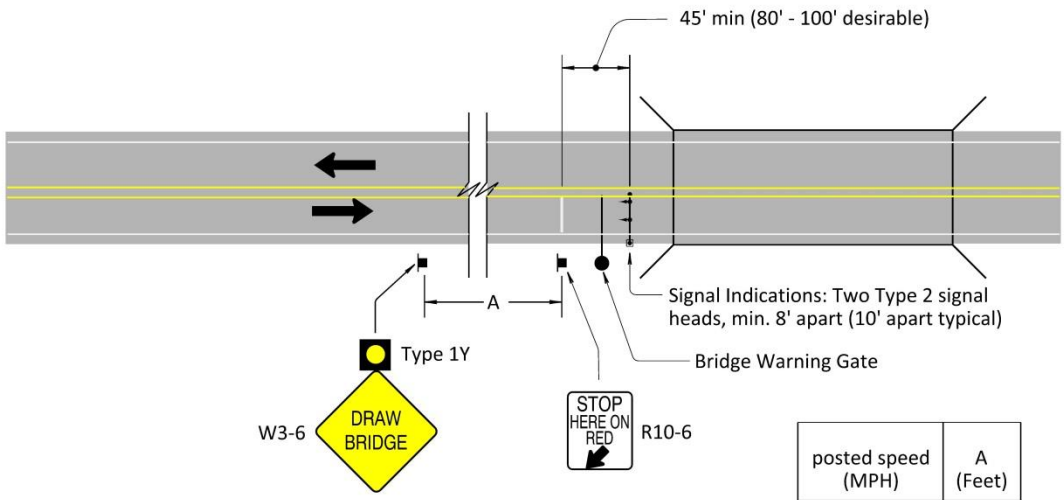
The Sign Designer is responsible for:

- STOP HERE ON RED sign (R10-6)

The Signal Designer is responsible for:

- The DRAW BRIDGE sign (W3-6) with the Type 1Y flashing beacon

Figure 23-14 | Sign Placement – Sight Distance Restrictions to Signal Heads (Special Application Only)



posted speed (MPH)	A (Feet)
30 & under	100
35	100
40	125
45	175
50	250
55	325
60	400
65	475

W3-6 placement values (from stop line) based on MUTCD Table 2C-4 condition B, deceleration to 0 MPH.

23.9.4 Unique Traffic Control Devices: Columbia River (Interstate) NB

Being a major interstate bridge, the traffic control devices used and the placement are unique from the other 10 existing bridges. All traffic control devices are custom mounted to the structure, except one device mounted on a sign bridge. This moveable bridge has been slated for replacement; however, it is uncertain when that project will move forward. If the existing traffic control devices need to be replaced, they should be replaced in-kind:

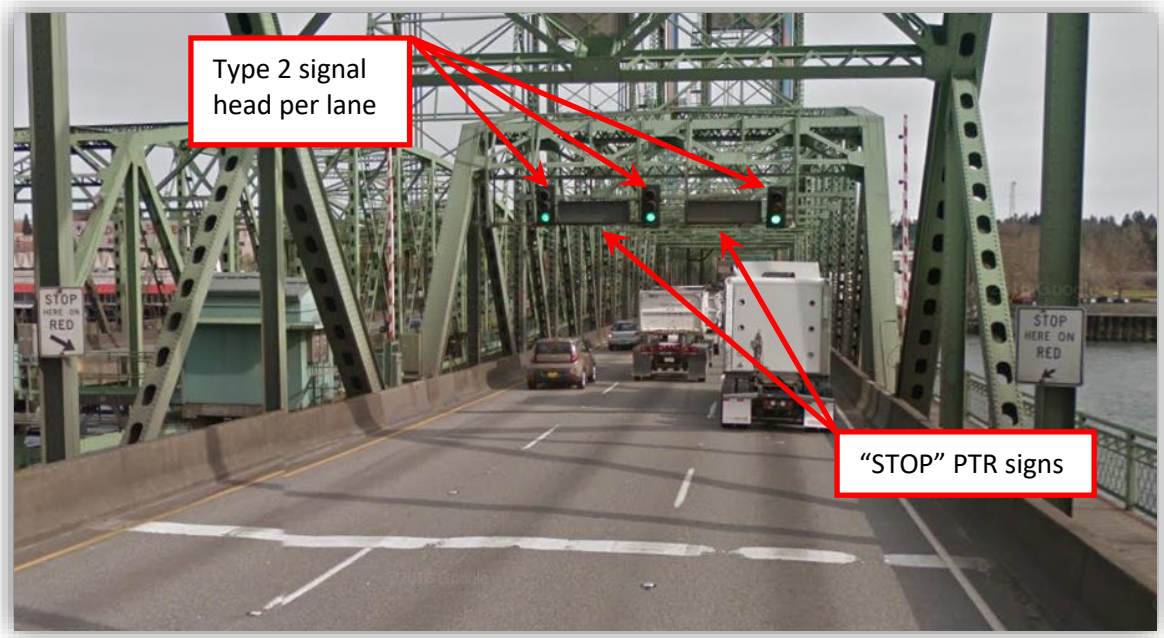
- 1st warning device: approx. 600 feet south of MLK overcrossing, Two Type 1Y flashing beacons mounted next to the custom "DRAWBRIDGE PREPARE TO STOP WHEN LIGHTS FLASH" sign. See Figure 23-15.
- 2nd warning device: Two Type 1Y flashing beacons mounted next to the custom "DRAWBRIDGE PREPARE TO STOP WHEN LIGHTS FLASH" sign. See Figure 23-16.
- 3rd warning device: Two Type 1Y flashing beacons mounted next to the "STOP AHEAD" PTR sign. See Figure 23-17.
- Signals: Three Type 2 Signals Heads (one per each approach lane) and two "STOP" PTR signs. See Figure 23-18.

Figure 23-15 | Columbia River NB: 1st Warning Device

Figure 23-16 | Columbia River NB: 2st Warning Device

Figure 23-17 | Columbia River NB: 3st Warning Device

Figure 23-18 | Columbia River NB: Signals



23.9.5 Unique Traffic Control Devices: Columbia River (Interstate) SB

Being a major interstate bridge, the traffic control devices used and the placement are unique from the other 10 existing bridges. All traffic control devices are custom mounted and located on WashDOT facilities which will require coordination during design. This moveable bridge has been slated for replacement; however, it is uncertain when that project will move forward. If the existing traffic control devices need to be replaced, they should be replaced in-kind:

- Warning device: One Type 1Y flashing beacon mounted next to the custom PTR sign. See Figure 23-19.
- Signals: Three Type 2 Signals Heads (one per each approach lane) and two "STOP" PTR signs. See Figure 23-20.

Figure 23-19 | Columbia River SB: Warning Device

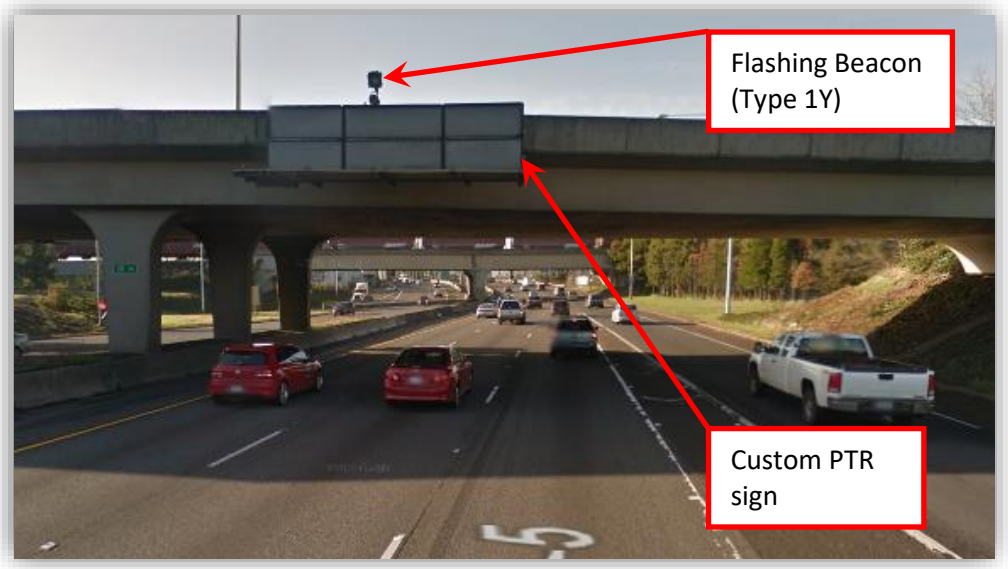


Figure 23-20 | Columbia River SB: Signals

24 QUICK REFERENCE

24.1 General

The quick references are comprised of information, tables, and charts that are contained within the manual. They are placed in this chapter without the accompanied explanation text for experienced signal designers to have quick reference to common design standards.

24.2 Basic Wiring Guidelines

An AC positive ("hot") wire and an AC negative ("Neutral") wire is required to complete the circuit for each piece of equipment (from the equipment to the power source).

Basic Wiring Guidelines (Individual Conductors) 120V Wiring shall be sized for a maximum 3% voltage drop			
120 Volt AC	Signal System Neutral: Poles over 4" in diameter	One #8 THWN (-)	Used to complete the circuit for indications in Vehicle or Pedestrian Signals mounted on large signal poles.
	Signal System Neutral: Pedestals 4" in diameter	One #12 THWN (-)	Used to complete the circuit for indications in Vehicle or Pedestrian Signals mounted on small pedestals.
	Vehicle Signals	Three #14 THWN (+)	Typically one wire for each indication color: Red, Yellow, & Green. Certain signal head types require a different number wires. (note: see Signal System Neutral)
	Pedestrian Signals	Two #14 THWN (+)	One wire for each indication: walk & flashing don't walk. (note: See Signal System Neutral)
	Luminaires	Two #10 XHHW* (120V = + & -) (240V = + & +)	From Service Cabinet to each luminaire (no daisy chaining). Never routed through the controller cabinet.
	Photoelectric Cells	Three #12 THWN* (+ & -)	From the Service Cabinet, for the luminaire circuit. Never routed through the controller cabinet.
	Part-Time Restriction Signs	Two #12 THWN* (+ & -)	For each sign.
	Power Supply	Two #6 XHHW* (+ & -)	From Service Cabinet to Controller Cabinet.
Low Voltage DC	Pedestrian Push Buttons	One #14 THWN (+)	For each pedestrian phase.
	Push Button Common	One #14 THWN (-)	Used to complete the circuit for Pedestrian Push Button.
	Interconnect	One 6 twisted pair cable (n/a)	Unspliced from Controller cabinet to Controller cabinet.

*Common wire is inclusive to wire count.

24.3 Loop Detector Information

Loop Detector Placement		
Location	Posted Speed (MPH)	Detector Spacing (ft.) from stop bar to center of detection
Mainline Note: If mainline has a shared thru-left turn lane, install stopbar detection in the lane at 5' & 15' in addition to the detection shown for mainline based on posted speed.	25	140
	30	180
	35	110/220
	40	160/320
	45	160/320
	50	190/380
	55	225/450
Right Turn Lane (mainline) Note: not applicable to unsignalized slip lanes		140 (115 if lane is short)
Side Street & Left Turns		5/15/75
Interchange Ramps	Low volume &/or low exit speed	5/15/75/150
	High volume &/or high exit speed	5/15/110/220
Bike Lane (mainline)	15	50
Bike Lane (side street)	10	5/50
Mainline Temporary Bridge (one lane/two-way)		5/15/100 & 65 for bypass loop in opposing lane

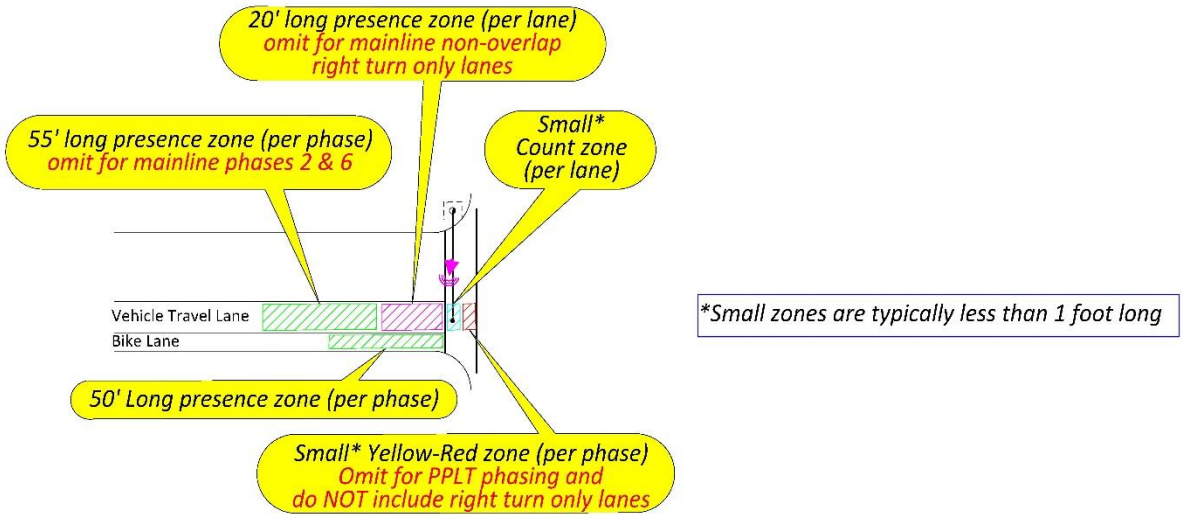
Loop Wire Entrance Type	
Region 1	Sand Pocket
Region 2	Sand Pocket
Region 3	Sand Pocket
Region 4	PVC Sleeve
Region 5	Sand Pocket

Loop Feeder Cables Allowed In Conduit	
# of Loop Feeders	**Conduit Size***
1-5	1 ½"
6-9	2"
10-13	2 ½"
14-21	3"

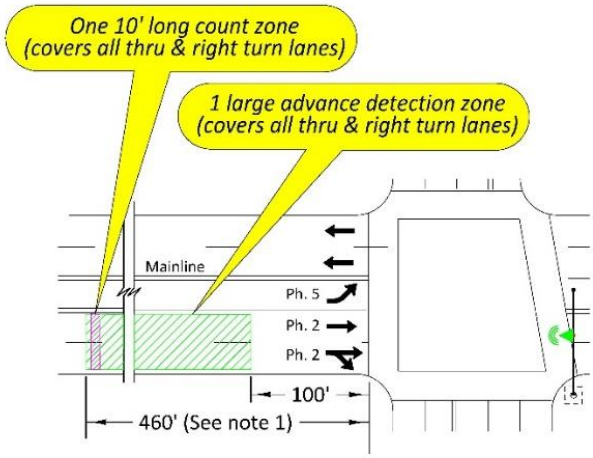
*Note: Regions may have a minimum value that is larger than the statewide minimum standard. Verify with Region Traffic and Region Electrical.

Loop Wires Allowed in Loop Wire Entrance Conduit	
Number of Loops (one loop has 2 loop wires entering the loop wire entrance conduit)	**Loop Wire Entrance Conduit Size**
1-2 Preformed Loops	2"
3-4 Preformed Loops	2 ½"
1-4 Standard Loops	2"
5-8 Standard Loops	2 ½"
Note: If more than 4 preformed loops or more than 8 standard loops are need to enter at one location, install multiple loop wire entrances.	

24.4 Non-Invasive Detection Information



STANDARD PRESENCE DETECTION (Near-Range Unit)



STANDARD ADVANCE DETECTION (Far-Range Unit)

Notes:

1. Detection that starts 100' from the stop bar and extends a minimum of 460' from the stop bar is acceptable for all posted speeds. However, the standard far-range unit is likely to start detection prior to 100' and is capable of reaching 600'. The alternative far-range unit is capable of reaching 900' if necessary (verify with Region Traffic).

2. If MaxAdapt is used (Verify with Region Traffic), add a Near-Range Unit to provide advance Count Detection Zones as shown below

24.5 Input File Info

24.5.1 Input File for 332S: ATC controller with C11 Connector

"I" File		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper	#	14	1	21	9	16	3	23	11	18	X			25	26
	Fn	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 3	Ph 3	Ph 4	Ph 4	Ph 4	V.R.C.M.	V.R.C.M.	Ped 2	Ped 6
	C1-##	C1-56	C11-16	C1-39	C1-63	C1-47	C1-58	C11-18	C1-41	C1-65	C1-49	C11-23	C11-24	C1-67	C1-68
	VD #	VD 1	VD 29	VD 9	VD 11	VD 13	VD 3	VD 32	VD 14	VD 16	VD 18				
	XXX													PB1	PB2
Lower	#	X	5	30	X	X	7	32	X	20	X			27	28
	Fn	Ph 1	Ph 1	Ph 2	Ph 2	Ph 2	Ph 3	Ph 3	Ph 4	Ph 4	Ph 4			Ped 4	Ped 8
	C1-##	C1-60	C11-20	C1-43	C1-76	C11-10	C1-62	C11-22	C1-45	C1-78	C11-12	C11-25	C11-26	C1-69	C1-70
	VD #	VD 2	VD 30	VD 10	VD 12	VD 31	VD 4	VD 33*	VD 15	VD 17	VD 34*				
	XXX			PB6	PB6	PB6	PB6	PB6	PB6	PB6	PB6			PB3	PB4

"J" File		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper	#	13	2	22	10	15	4	24	12	17	X		SP5	SP1	SP2
	Fn	Ph 5	Ph 5	Ph 6	Ph 6	Ph 6	Ph 7	Ph 7	Ph 8	Ph 8	Ph 8	SPARE	RR	EVA	EVB
	C1-##	C1-55	C11-15	C1-40	C1-64	C1-48	C1-57	C11-17	C1-42	C1-66	C1-50	C1-54	C1-51	C1-71	C1-72
	VD #	VD 5	VD 35*	VD 19	VD 21	VD 23	VD 7	VD 38*	VD 24	VD 26	VD 28		(PCOI)		
	XXX												SP5	SP1	SP2
Lower	#	X	6	31	X	X	8	SP7	X	19	X		SP6	SP3	SP4
	Fn	Ph 5	Ph 5	Ph 6	Ph 6	Ph 6	Ph 7	Ph 7	Ph 8	Ph 8	Ph 8	GPS	RR	EVC	EVD
	C1-##	C1-59	C11-19	C1-44	C1-77	C11-11	C1-61	C11-21	C1-46	C1-79	C11-13	C1-75	C1-52	C1-73	C1-74
	VD #	VD 6	VD 36*	VD 20	VD 22	VD 37*	VD 8	VD 39*	VD 25	VD 27	VD 40*		(VCOI)		
	XXX	PB6		PB7	PB6	PB6		SP7	PB6		PB6	PB5	SP6	SP3	SP4

#	*Slot Number*
#	*SCATS Det #*
Fn	*Slot Function*
C1-##	*C1 Pin #*
VD #	*Voyage Detector #*
XXX	*SCATS Function*

* VD # has limited functionalities (Call, Extend and Count only)

Each VD # without an astericks has full functionality (Extend, Call, Carryover, Delay, & Count)

Definitions:

V.R.C.M=Video Remote Communications Module

SCATS=Sydney Coordinated Adaptive Traffic System

DEFAULT STANDARD FOR VIDEO DETECTION EQUIPMENT LAYOUT

"I" File	1	2	3	4	5	6	7	8	9	10	11	12
Upper / Lower	4 I/O: T		VIP: T		2 I/O: T	4 I/O: T		VIP: T		2 I/O: T	V.R.C.M.	

#	*Slot Number*
Equip.	*Video Equipment*

"J" File	1	2	3	4	5	6	7	8	9	10	11	12
Upper	4 I/O: T		VIP: T		2 I/O: T	4 I/O: T		VIP: T		2 I/O: T		
Lower												

Definitions:

VIP = Video Image Processor

2 I/0 = 2 channel Input/Output Module

4 I/0 = 4 channel Input/Output Module

T = camera

V.R.C.M. = Video Remote Communications Module

24.5.2 Input File for 332: ATC controller without C11 Connector

"I" File		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper		14	1	21	9	16	3	23	11	18			25	26	
		Ph 1	Ph 2	Ph 2	Ph 2	Ph 3	Ph 4	Ph 4	Ph 4	Ph 1	V.R.C.M.	V.R.C.M.	Ped 2	Ped 6	
		C1-56	C1-39	C1-63	C1-47	C1-58	C1-41	C1-65	C1-49	C1-60			C1-67	C1-68	
		VD 1	VD 9	VD 11	VD 13	VD 3	VD 14	VD 16	VD 18	VD 2					
													PB1	PB2	
Lower			5	30			7	32		20			27	28	
			Ph 2	Ph 2			Ph 4	Ph 4		Ph 3			Ped 4	Ped 8	
			C1-43	C1-76			C1-45	C1-78		C1-62			C1-69	C1-70	
			VD 10	VD 12			VD 15	VD 17		VD 4					
				PB6				PB8					PB3	PB4	

"J" File		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper		13	2	22	10	15	4	24	12	17			SP1	SP2	SP5
		Ph 5	Ph 6	Ph 6	Ph 6	Ph 7	Ph 8	Ph 8	Ph 8	Ph 5		SPARE	EVA	EVB	RR
		C1-55	C1-40	C1-64	C1-48	C1-57	C1-42	C1-66	C1-50	C1-59		C1-54	C1-71	C1-72	C1-51
		VD 5	VD 19	VD 21	VD 23	VD 7	VD 24	VD 26	VD 28	VD 6					
													SP1	SP2	SP5
Lower			6	31			8	SP7		19			SP3	SP4	SP6
			Ph 6	Ph 6			Ph 8	Ph 8		Ph 7		SPARE	EVC	EVD	RR
			C1-44	C1-77			C1-46	C1-79		C1-61		C1-75	C1-73	C1-74	C1-52
			VD 20	VD 22			VD 25	VD 27		VD 8					
				PB7				SP7				PB5	SP3	SP4	SP6

#	*Slot Number*
#	*SCATS Det #*
Fn	*Slot Function*
C1-##	*C1 Pin #*
VD #	*Voyage Detector #*
XXX	*SCATS Function*

Each VD # has full functionality (Extend, Call, Carryover, Delay, & Count)

Definitions:

V.R.C.M. = Video Remote Communications Module

SCATS = Sydney Coordinated Adaptive Traffic System

DEFAULT STANDARD FOR VIDEO DETECTION EQUIPMENT LAYOUT

"I" File		1	2	3	4	5	6	7	8	9	10	11
Upper		2 I/0: T	VIP: T		4 I/0: T		VIP: T		4 I/0: T		V.R.C.M.	
		Ph. 2	Ph. 2	Ph. 2	Ph.5	Ph.5	Ph. 4	Ph. 4	Ph.4	Ph. 7		
Lower			Ph. 2	Ph. 2			Ph. 4	Ph. 4		Ph. 7		

"J" File		1	2	3	4	5	6	7	8	9	10	11
Upper		2 I/0: T	VIP: T		4 I/0: T		VIP: T		4 I/0: T			
		Ph. 6	Ph. 6	Ph. 6	Ph.1	Ph.1	Ph. 8	Ph. 8	Ph.8	Ph. 3		
Lower			Ph. 6	Ph. 6			Ph. 8	Ph. 8		Ph. 3		

#	*Slot Number*
Equip.	*Video Equipment*
Fn	*Slot Function*

Note: The phase assignment for video layout is different than the default standard phase assignment shown above.

Definitions:

VIP = Video Image Processor

2 I/0 = 2 channel Input/Output Module

4 I/0 = 4 channel Input/Output Module

T = camera

V.R.C.M. = Video Remote Communications Module

24.5.3 Input File for 336: ATC controller

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper	14 **Ph 1** C1-56 VD 1	1 **Ph 2** C1-39 VD 9	16 **Ph 3** C1-58 VD 3	3 **Ph 4** C1-41 VD 14	13 **Ph 5** C1-55 VD 5	2 **Ph 6** C1-40 VD 19	15 **Ph 7** C1-57 VD 7	4 **Ph 8** C1-42 VD 24	21 **Ph 2** C1-63 VD 11	23 **Ph 4** C1-65 VD 16	SP1 **EVA** C1-71	SP2 **EVB** C1-72	25 **Ped 2** C1-67	26 **Ped 6** C1-68
Lower	18 **Ph 1** C1-60 VD 2	5 **Ph 2** C1-43 VD 10	20 **Ph 3** C1-62 VD 4	7 **Ph 4** C1-45 VD 15	17 **Ph 5** C1-59 VD 6	6 **Ph 6** C1-44 VD 20	19 **Ph 7** C1-61 VD 8	8 **Ph 8** C1-46 VD 25	22 **Ph 6** C1-64 VD 21	24 **Ph 8** C1-66 VD 26	SP3 **EVC** C1-73	SP4 **EVD** C1-74	27 **Ped 4** C1-69	28 **Ped 8** C1-70

#	*Slot Number*
#	*SCATS Det #*
Fn	*Slot Function*
C1-##	*C1 Pin #*
VD#	*Voyage Detector #*

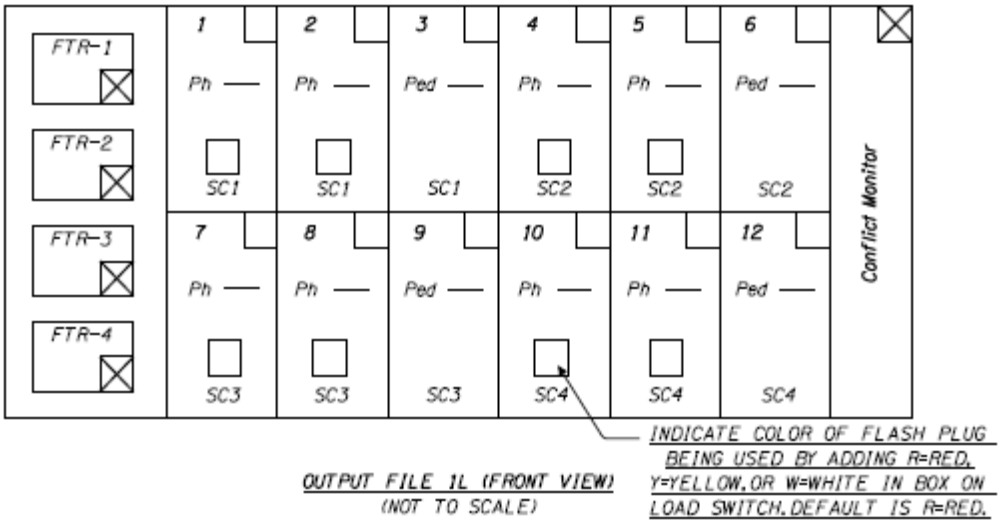
Each VD # has full functionality (Extend, Call, Carryover, Delay, & Count)

Definitions:

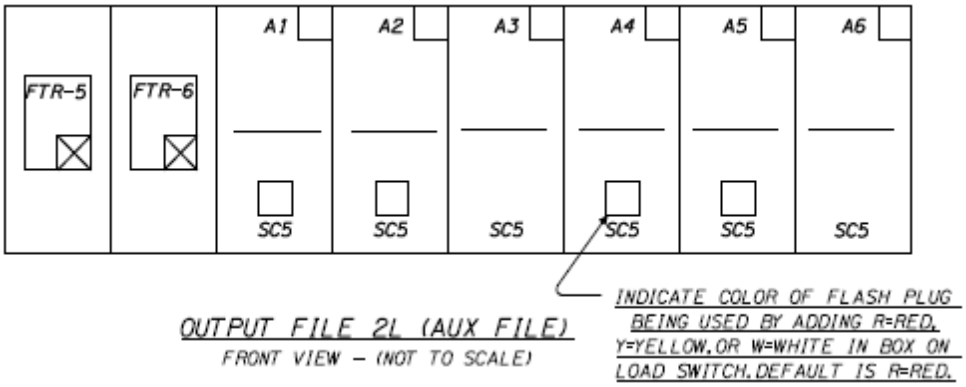
SCATS = Sydney Coordinated Adaptive Traffic System

24.6 332S and 332 Cabinet Limitations – Output File

1. 18 switch packs
2. 16 are conflict monitored
    a. Switch packs A3 and A6 are not monitored
    b. 2018 monitor can be used in extreme cases for all 18 switch packs
3. 12 have the ability to cabinet flash via flash plugs
    a. Switch packs 3, 6, 9, 12, A3, and A6 go dark in cabinet flash



OUTPUT FILE 1L (FRONT VIEW)
(NOT TO SCALE)



OUTPUT FILE 2L (AUX FILE)
FRONT VIEW – (NOT TO SCALE)

24.7 332S and 332 Cabinet Limitations – Input File

1. 28 vehicle inputs for a 332 using 9 slots and 2 input files
    a. Slots 10, I11, and 14 have no inputs
        i. Slots 1, 4, 5, and 8 have one input per slot (not two)
        ii. 4 ped
        iii. 4 EV
        iv. 2 rail – indirect via 4 C1 pins using 252 Isolator
        v. 0 spares
2. 40 vehicle inputs for a 332S using 10 slots and 2 input files
    a. All 14 slots are populated with C1 and C11 pins
        i. 4 ped
        ii. 4 EV
        iii. 2 rail – direct via inverting 255 Isolator
        iv. 1 GPS
        v. 5 spares

332 cabinet

1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 E,C C1-56 VD1 1 E,C	2 E,C C1-39 VD9 VD10 C1-43 2 E,C	2 E,C C1-63 VD11 VD12 C1-76 2 E	2 C C1-47 VD13 2 C	3 E,C C1-58 VD3 3 E,C	4 E,C C1-41 VD14 VD15 C1-45 4 E,C	4 E,C C1-65 VD16 VD17 C1-78 4 E	4 C C1-49 VD18 4 C	1 E,C C1-60 VD2 VD4 C1-62 3 E,C	—	—	2 Ped C1-67 C1-69 4 Ped	6 Ped C1-68 C1-70 8 Ped	—
1	2	3	4	5	6	7	8	9	10	11	12	13	14
5 E,C C1-55 VD5 5 E,C	6 E,C C1-40 VD19 VD20 C1-44 6 E,C	6 E,C C1-64 VD21 VD22 C1-77 6 E	6 C C1-48 VD23 6 C	7 E,C C1-57 VD7 7 E,C	8 E,C C1-42 VD24 VD25 C1-46 8 E,C	8 E,C C1-66 VD26 VD27 C1-79 8 E	8 C C1-50 VD28 8 C	5 E,C C1-59 VD6 VD8 C1-61 7 E,C	—	C1-54 C1-75	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD	—

332S cabinet

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	I14
ϕ1 C1-56 VD1 VD2 C1-60 ϕ1	ϕ1 C11-16 VD29 VD30 C11-20 ϕ1	ϕ2 C1-39 VD9 VD10 C1-43 ϕ2	ϕ2 C1-63 VD11 VD12 C1-76 ϕ2	ϕ2 C1-47 VD13 VD31 C11-10 ϕ2	ϕ3 C1-58 VD3 VD4 C1-62 ϕ3	ϕ3 C11-18 VD32 VD33 C11-22 ϕ3	ϕ4 C1-41 VD14 VD15 C1-45 ϕ4	ϕ4 C1-65 VD16 VD17 C1-78 ϕ4	ϕ4 C1-49 VD18 VD34 C11-12 ϕ4	SPARE C11-23 C11-25 SPARE	SPARE C11-24 C11-26 SPARE	2 PED C1-67 C1-69 4 PED	6 PED C1-68 C1-70 8 PED
J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12	J13	J14
ϕ5 C1-55 VD5 VD6 C1-59 ϕ5	ϕ5 C11-15 VD35 VD36 C11-19 ϕ5	ϕ6 C1-40 VD19 VD20 C1-44 ϕ6	ϕ6 C1-64 VD21 VD22 C1-77 ϕ6	ϕ6 C1-48 VD23 VD37 C11-11 ϕ6	ϕ7 C1-57 VD7 VD8 C1-61 ϕ7	ϕ7 C11-17 VD38 VD39 C11-21 ϕ7	ϕ8 C1-42 VD24 VD25 C1-46 ϕ8	ϕ8 C1-66 VD26 VD27 C1-79 ϕ8	ϕ8 C1-50 VD28 VD40 C11-13 ϕ8	SPARE C1-54 C1-75 GPS	PCOI C1-51 C1-52 VCOI	EVA C1-71 C1-73 EVC	EVB C1-72 C1-74 EVD

INPUT FILE I & J (FRONT VIEW)

24.8 332S and 332 Cabinet Limitations – Conflict Monitor

1. 16 channels with 32 outputs of conflict monitoring (green & yellow)
    a. Monitor all greens and flashing yellow arrows
    b. Do not monitor solid yellows
    c. Green and Yellow per channel must be the same
2. Flashing yellow arrow
    a. Use the opposing ped yellow output and yellow monitor
    b. Examples
        i. 4 section FYA signal head on Phase 1
            1. Use R Y G outputs on switch pack 1
                a. Monitor G on channel 1
            2. Use Y output on switch pack 3 for FY
                a. Monitor FY on channel 13 via yellow inhibit jumpers
        ii. 3 section FYA signal head on Phase 1 (center flash)
            1. Use R G outputs on switch pack 1
                a. Monitor G on channel 1
            2. Use Y output on switch pack 3 for FY and solid Y
                a. Monitor FY on channel 13 via yellow inhibit jumpers

CONFLICT MONITOR - TYPICAL CONNECTOR PIN ASSIGNMENTS

Term	Function	Pin	Pin	Function	Term
130	SP2-G	1	A	SP2-Y	129
115	SP3-W	2	B	SP8-G	136
135	SP8-Y	3	C	SP9-W	121
103	SP5-G	4	D	SP5-Y	102
106	SP6-W	5	E	SP11-G	109
108	SP-11Y	6	F	SP12-W	112
133	SP7-G	7	H	SP7-Y	132
114	SP3-Y (FLTYA)	8	J	SP1-G	127
126	SP1-Y	9	K	SP9-Y (FLTYA)	120
124	SP10-G	10	L	SP10-Y	123
105	SP6-Y (FLTYA)	11	M	SP4-G	118
117	SP4-Y	12	N	SP12-Y (FLTYA)	111
A123	ASP1-G	13	P	NC	–
–	NC	14	R	ASP2-G	A126
–	T&B	15	S	ASP4-G	A116
–	T&B	16	T	NC	–
–	NC	17	U	T&B	–
–	T&B	18	V	ASP5-G	A103
–	NC	19	W	NC	–
TB01-9	EQ Gnd	20	X	NC	–
TB01-10	AC-	21	Y	DC Gnd	TB02-2
C4-37	Watch Dog	22	Z	Ext. Reset	TB02-5
TB02-1	+24VDC	23	AA	T&B	–
LRCoIL	Interlock	24	BB	Stop Time	TB02-3
TB02-2	Interlock	25	CC	NC	–
–	NC	26	DD	NC	–
–	NC	27	EE	Clapper	TB01-12
TB01-11	Norm. Closed	28	FF	AC+	TB01-11

CHANNEL ASSIGNMENTS (TYPICAL)

Ch	PH
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	OLA
10	OLB
11	OLC
12	OLD
13	2PED Φ1 FLTYA
14	4PED Φ3 FLTYA
15	6PED Φ5 FLTYA
16	8PED Φ7 FLTYA

CONFLICT MONITOR DIODE CARD

CHANNEL ASSIGNMENT

Ch.1	Ch.5	Ch.9	Ch.13
Ch.2	Ch.6	Ch.10	Ch.14
Ch.3	Ch.7	Ch.11	Ch.15
Ch.4	Ch.8	Ch.12	Ch.16

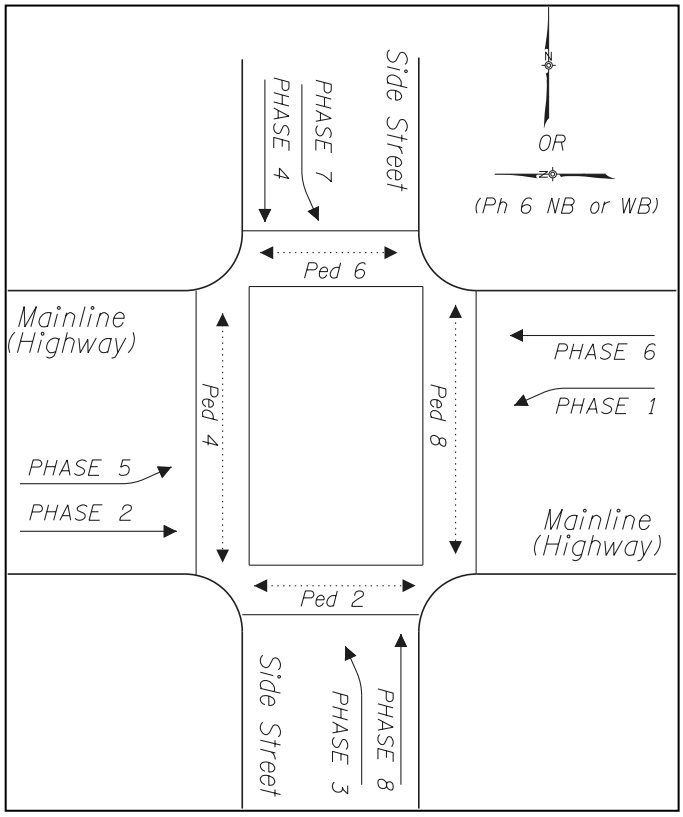
YELLOW INHIBIT JUMPERS

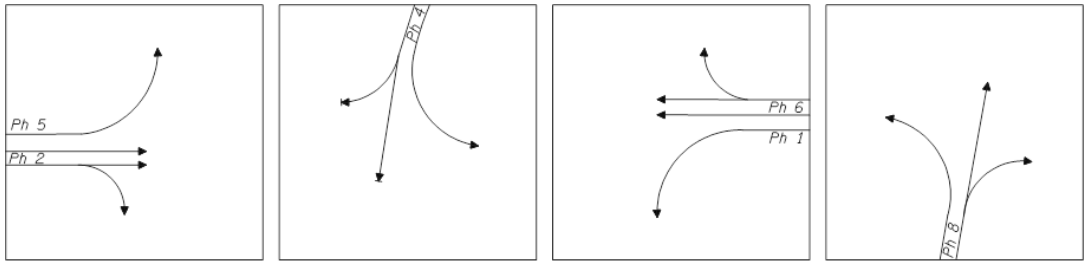
1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16

DIODES – Diode Removed Makes Movement Allowable (Diode IN4148)

1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9
1-3	2-4	3-5	4-6	5-7	6-8	7-9	8-10
1-4	2-5	3-6	4-7	5-8	6-9	7-10	8-11
1-5	2-6	3-7	4-8	5-9	6-10	7-11	8-12
1-6	2-7	3-8	4-9	5-10	6-11	7-12	8-13
1-7	2-8	3-9	4-10	5-11	6-12	7-13	8-14
1-8	2-9	3-10	4-11	5-12	6-13	7-14	8-15
1-9	2-10	3-11	4-12	5-13	6-14	7-15	8-16
1-10	2-11	3-12	4-13	5-14	6-15	7-16	9-16
1-11	2-12	3-13	4-14	5-15	6-16	10-16	9-15
1-12	2-13	3-14	4-15	5-16	11-16	10-15	9-14
1-13	2-14	3-15	4-16	12-16	11-15	10-14	9-13
1-14	2-15	3-16	13-16	12-15	11-14	10-13	9-12
1-15	2-16	14-16	13-15	12-14	11-13	10-12	9-11
1-16	15-16	14-15	13-14	12-13	11-12	10-11	9-10

24.9 Phasing Standards





CHANNEL A CHANNEL B CHANNEL C CHANNEL D

FIRE PREEMPTION OPERATION

24.10 Signal Pole & Signal Head Information

Signal Head Placement/Spacing Dimensions	
From the stop line to signal face	45’ minimum
From the stop line to signal face	180’ or greater requires a near-side head
Spacing of heads for the same phase	8’ minimum, 10’ desirable
Spacing of heads to adjacent phase	6’-12’ desirable
Spacing of heads (except Type 4L head) to adjacent sign	3’ minimum
Spacing of Type 4L head to adjacent sign	4’ minimum

Signal Pole Placement
18” minimum from face of curb to any equipment mounted on pole.
5’ recommended minimum from face of curb
6’ recommended minimum from EP
5’ recommended minimum clearance on all sides of a raised island

Mast Arms		
Mast Arm Length	Std. Dwg. TM650	
	Pole Type	Pole Type w/Illum.
15’	SM1	SM1L
20’	SM2	SM2L
25’	SM2	SM2L
30’	SM3	SM3L
35’	SM3	SM3L
40’	SM4	SM4L
45’	SM4	SM4L
50’	SM5	SM5L
55’	SM5	SM5L

24.11 Sign Information

SIGN NUMBERS & SIZE (signs beginning with an "O" are Oregon specific)	SIGN TYPES: Aluminum	SIGN TYPES: Part Time Restriction	RECOMMENDED OR REQUIRED
R6-2L 30"x36"	AL 1L		Required for one-way streets. One way signs can be installed on the mast arm (R6-2L) OR ground mounted (R6-1L). See MUTCD 2B.40(P10)
R6-2R 30"x36"	AL 1R		Required for one-way streets. One way signs can be installed on the mast arm (R6-2R) OR ground mounted (R6-1R). See MUTCD 2B.40(P10)
R10-11A 30"x36"	AL 3		Region Traffic Engineer Operational Approval Required
OR3-12 30"x36"	AL 3U		
R5-2 30"x30"	AL 3T		
OR3-5TD 30"x36"	AL 4		
R3-6L 30"x36"	AL 4L		
R3-6R 30"x36"	AL 4R		
OR3-5TT 30"x36"	AL 4T		
R3-5L 30"x36"	AL 5L		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5R 30"x36"	AL 5R		Required for a trap lane (where a through lane becomes a mandatory turn lane at the intersection) if the trap lane does not have a signal head with arrow indications
R3-5A 30"x36"	AL 5T		
R3-3 36"x36"	AL 6		Use of appropriate lane use signs is preferred over R3-3
R3-2 36"x36"	AL 6L	PR 6L	Use of appropriate lane use signs is preferred over R3-2. PTR version used for RxR applications
R3-1 36"x36"	AL 6R	PR 6R	Use of appropriate lane use signs is preferred over R3-1. PTR version used for RxR applications
R5-1 36"x36"	AL 7		
R10-28 24"x30"	AL 8		For overhead mounting
OR20-1 24"x12"	AL 8s		
R10-6 24"x36"	AL 9		
R10-12 30"x36"	AL 11		Required with a Type 4L signal head. Recommended when a permissive left turn phase has an exclusive left turn lane. Optional otherwise.
OR10-15 30"x36"	AL 12		Required with a Type 5 signal head
W3-8 36"x36"	AL 16		
OR20-5 24"x30"	AL 17		
W3-4 36"x36"	AL 18		
W16-13p 24"x18"	AL 19		
OR3-7a 30"x9"	AL 20		

SIGNS NO LONGER USED	
OR10-10L 30"x36"	"LEFT TURN SIGNAL" sign
OR10-10R 30"x36"	"RIGHT TURN SIGNAL" sign
OR17-1 30"x36"	"LEFT TURN YIELD TO ONCOMING TRAFFIC" sign replaced by R10-12
OR22-14 30"x36"	"RIGHT TURN YIELD TO PEDS ON GREEN ball symbol" sign replaced by OR10-15

24.12 Junction Box & Conduit Information

Minimum Junction Box Type/Size	
Type/Size	**Location/use**
JB-3T: Two (Tandem) 30”x17”x12” boxes	The same quadrant as the signal controller: first access point for all signal, detector and interconnect circuits.
JB-2: Single 22”x12”x12” box	All quadrants without the signal controller: secondary access point for signal, detector, and/or interconnect circuits
JB-1: Single 17”x10”x12” box	All approach legs: detector and/or interconnect circuits

Type	Size	Total Conduit Diameters Allowed (Inches)	Remarks	Material
JB-1	17”x10”x12”	12	Non-traffic areas only	Concrete
JB-2	22”x12”x12”	18	Non-traffic areas only	Concrete
JB-3	30”x17”x12”	34	Non-traffic areas only	Concrete
JB-4	8”x6”x6”	5	No loop splices	Cast Iron
JB-5	12”x10”x6”	8	No loop splices	Cast Iron
JB-6	12”x10”x8”	8	Loop spices OK	Cast Iron
JB-7	16”x12”x6”	13	No loop splices	Cast Iron
JB-8	16”x12”x8”	13	Loop splices OK	Cast Iron

Junction Box Spacing
300’ maximum spacing. Check with the Region Electrician for the preferred spacing.

Conduit Requirements*	
Conduit crossing mainline or side street	2” minimum
Spare conduit from large signal pole to nearest junction box (if alternative detection is NOT used on project)	2”
Spare conduit from controller cabinet to nearest junction box	2”
Minimum conduit size allowed	1 ½“
Maximum conduit size allowed	3”
Max wire fill for new conduits	70% of NEC maximum
Max wire fill for existing conduits	100% of NEC maximum

*Note: Regions may have a minimum value that is larger than the statewide minimum standard. Verify with Region Traffic and Region Electrical.

24.13 Electrical Crew Preferences

It is important to ensure the electrical crew that will be maintaining the signal (ODOT or Local Agency) has a chance to review and comment on signal plans during the design phase. As such, standard documentation (specific for each region) shall be used and can be found at:

ftp://ftp.odot.state.or.us/techserv/Traffic-Engineering/Traffic_Signal_Design_Manual/ElectricalCrewPreference/

This documentation contains a list default preferences that have been approved by the Region Electrical Manager. Review this list and incorporate these preferences into the signal design. Note that for any particular project, the Region Electrical Manager may elect to change any of the default preferences. This documentation also contains a space for the electrical crew to make additional project specific comments. Follow the instructions on the documentation for use.

24.14 QA/QC Signal Plan Sheet Checklists with Examples

Before submitting plans for Traffic Standard Design review (see Chapter 2), it is recommended that the excel QA/QC file is used. This file is available on the Traffic Signal Design Manual website and contains worksheets for each type of signal plan sheet: http://www.oregon.gov/ODOT/Engineering/Pages/Signal-Design-Manual.aspx

- General
- Legend Sheet
- Signal Sheet
- Detector Sheet
- Interconnect Sheet
- Details Sheet
- Existing Utilities Sheet
- Ramp Meter Sheet
- Rail Preemption Sheet

The majority of the checklist items have hyperlinked examples to provide clarity.

Oregon
Department
of Transportation