

Traffic Signal Design Manual

Prepared for

City of Redmond

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KEY TERMS

LOS	level of service
MUTCD	Manual of Uniform Traffic Control Devices
NEC	National Electric Code
WSDOT	Washington State Department of Transportation

FOREWARD

This manual establishes uniform procedures for the design preparation of traffic signal plans and installation in the City of Redmond. It is not intended as a textbook or as a substitute for solid working knowledge, experience, and judgment of the principles of traffic signal design, but rather as a guideline to uniformity and to provide the Designer with sufficient information to prepare the desired plans with a minimum of uncertainty.

I. GENERAL TRAFFIC SIGNAL DESIGN REQUIREMENTS

The Designer preparing to design traffic signal plans shall:

- A. Utilize the latest edition of the Washington State Department of Transportation (WSDOT) *Standard Plans and Specifications*.
- B. Utilize the latest edition of the *City of Redmond Standard Special Provisions* (Sections 8-20 and 9-29).
- C. Utilize the latest edition of the City of Redmond Standard Drawings.
- D. Utilize the latest edition of the *Manual of Uniform Traffic Control Devices* (MUTCD) recommended design practices adopted by WSDOT, where applicable.
- E. Be in accordance with the National Electric Code (NEC).
- F. Coordinate with the serving utility for service points and conflicts.
- G. Coordinate with all utility companies to identify potential conflicts.
- H. Be a Civil Engineer with current Washington registration, and sign and seal the finalized Plans.
- I. Design the traffic signal system to be metered through its own circuit, separate from street lighting, transit shelters, irrigation, flashing beacons, or other traffic control devices appurtenant to the traffic signal project.

II. DESIGN PROCESS

The following guidelines describe the typical process for the installation of a traffic signal. The Signal Designer should contact the City for specific requirements prior to beginning work on the signal design.

A. Signal Warrants:

The City requires the proposed signal to meet at least one signal warrant. The requirements for traffic signal warrants are in the MUTCD. A signal warrant is a minimum condition in which a signal may be installed. However, satisfying a warrant does not mandate the installation of a traffic signal. A warranting condition indicates that an engineering study is required to determine whether the signal is justified.

B. Engineering Study:

An engineering study is required for every proposed traffic signal. Typically, the study includes the level-of-service (LOS) analysis of the signal for the p.m. peak hour. Depending on the location and circumstances, a LOS analysis may be required by the City for the a.m. peak hour as well. The goal is to provide an intersection design adequate enough to obtain LOS D or better at the intersection. A queue analysis is required to determine the appropriate lane configuration and length for the intersection. Based on the results of the engineering study, the appropriate number of lanes, length of turning lanes, and signal phasing will be determined. Close coordination with the City is required throughout the engineering study to develop the optimum intersection configuration.

C. Signal Phasing:

When determining the appropriate phasing of the signal in the engineering study, the City has the following preferences:

1. If protected phasing is needed for the left-turn movement (as determined by the engineering study), the City prefers protected only phasing. Protected/permitted left-turn phasing is allowed only if there is a single lane opposing the left turn, and the engineering study can justify the need.
2. Right-turn overlap phasing should be considered at locations with a dedicated right-turn lane where the intersecting street has a complimentary protected left-turn movement and U-turns are prohibited. However, the overlap phase design should take into account any concurrent pedestrian movements that could cause a point of conflict with the right-turning vehicles.
3. Railroad preemption phasing is required at all signalized intersections when the nearest rail of a railroad crossing is within 200 feet of the stop bar of any leg of the intersection. Preemption for intersections beyond 200 feet from the intersection stop line is only considered when the queue on that approach routinely occupies the crossing.
4. The City does not recommend split phasing (i.e., all northbound movements have the green, then all southbound movements have the green, but neither can run concurrently), unless no other feasible alternative exists for the intersection.

5. At “T” intersections, the Designer should consider overlap phasing for the non-conflicting movements.

D. Design Submittal Process:

Typically, three submittals are required for approval for construction of the signal. These roughly relate to 50 percent, 90 percent, and 100 percent submittals. All traffic signal plans shall be submitted on 22" x 34" sheets.

1. The first (50 percent) submittal shall include a cover sheet and a signal plan sheet. The cover sheet shall contain all items as outlined in Section III-A of this document. The signal plan sheet shall contain the proposed location of curbs; construction centerlines; lane configuration and striping; proposed locations of the signal poles; controller and service equipment; existing utility and right-of-way information; proposed right-of-way easements; phase diagram; legend, signal, and pedestrian head locations; numbering and displays; sign locations and displays; and loop detection and numbering. Six sets of check prints are required for the first submittal.
2. The second (90 percent) submittal shall include all additional items as outlined in Section III of this manual. Six sets of check prints are required for the second submittal. The second submittal shall also include six sets of special provisions for review, and a list of items to be removed if the design includes a modification to an existing signal. The City will review the list of items, and notify the Designer of the items to be salvaged and returned to the City. The Designer shall include the list of items to be salvaged in the special provisions. Please contact the City for the most recent copy of special provisions to use as an example.
 - a) Prior to the 90 percent submittal, the Designer shall coordinate an effort to pothole the locations of the proposed signal poles to identify any existing utility conflicts.
3. If there are no outstanding design issues after the second submittal, the third (100 percent) submittal shall be one set of mylar prints and one set of special provisions for approval signatures. These prints and special provisions shall be signed and sealed by a Civil Engineer with a current Washington Professional Engineering license, and contain a Standard City Approval Block. If outstanding design issues exist, the City may require the Signal Designer to submit six sets of check prints again for review and comment, prior to the final (100 percent) submittal.

III. PLAN GUIDELINES

The following are the City's preferences for the format of the signal plans. In addition, please refer to the attached example plan located in Appendix A.

A. Cover Sheet:

If the signal design is a stand-alone project, the plans shall have a cover sheet. If the signal design is a part of a larger plan set, a cover sheet just for the signal design is not necessary. The cover sheet shall include:

1. Project name and number.
2. Vicinity map showing the project site and surrounding roads (up to an approximate 5-block radius).
3. Sheet index.
4. Signal legend of existing and proposed items and shall be drafted in accordance with APWA symbols. If a cover sheet is not necessary, the signal legend shall be located on the signal plan sheet.
5. A City of Redmond construction signature block showing approval.

B. Signal Plan Sheet:

1. At times, the signal plan can contain too much information to place on one sheet. For plans that require two sheets, the City suggests the first sheet to contain the intersection plan, and the second sheet to contain the legs of the intersection. Match lines should be included to provide connectivity between the two sheets. The Designer should try to avoid repetitive information on the sheets (i.e., the wire schedule, construction notes, general notes, phasing diagram etc. should be shown only on the first sheet). The Designer should keep in mind that the plans used in the field will probably be at half-size, so the plans should be clear and easy to read at half-size.

2. Plan Sheet, Base, and Title Block:

The plan sheet shall conform to the following requirements:

- a) North shall always be oriented up or to the right on all plans. The major arterial shall be horizontal on the plan.
- b) The traffic signal plan sheet shall be drawn at a 1"=20' scale. A scale block shall be included in the plan. For areas that require greater detail (such as the corner that has the controller), a blown-up detail may be necessary at a 1"=10' scale.
- c) All proposed signal equipment, including signal poles, mast arms, heads, signs, junction boxes, conduit, loops, controller, and service cabinet shall be shown as bold.

- d) All existing and proposed right-of-way information shall be shown and labeled on the plan, including easements needed for signal equipment. The line type shall be different for easements and right-of-way.
- e) All proposed curb, sidewalk, proposed striping, and existing curb/striping (to remain) information shall be shown on the plan in gray scale (screened back).
- f) Construction centerlines for each road are required, with tie-ins to existing monuments. Stationing shall be labeled every 100 feet.
- g) Sight triangle lines shall be shown on plans in gray scale.
- h) All proposed and existing underground and overhead utilities shall be shown and labeled on the plan in gray scale.
- i) A City of Redmond construction signature block showing approval shall be included on the signal plan sheet.

3. General and Construction Notes:

The plan sheet shall include general and construction notes. General notes shall contain, but not be limited to:

- a) Vehicle and pedestrian head mounting type.
- b) Pedestrian push button type.
- c) Loop placement (loops shall be centered in their respective lanes).
- d) Note stating that “the location of all conduit, junction boxes, and cabinets shown on this plan are for graphic presentation only and final location shall be determined by the Engineer.”
- e) Note stating that “all new foundation locations shall be approved by the Engineer prior to excavation. Contractor shall check for minimum overhead clearance of 16’6” for all signal heads above the street prior to pouring of foundation.”
- f) Note stating that “all traffic signal and pedestrian heads and push buttons shall be securely and completely covered while signal is not in operation.”
- g) Note stating that “all conductors for signal heads, loops, pedestrian heads, push buttons and streetlights shall be labeled in each junction box.”

Construction notes shall contain, but not be limited to:

- a) Signal pole and foundation installation (including pole type, mast arm length, and installation of items on the pole).
- b) Controller cabinet and foundation installation.

- c) Service cabinet and foundation installation.
- d) Coordination of utility removal/relocation.
- e) Coordination of connection of power, and power source type.
- f) Interconnect connection to other signals.
- g) Removal of existing signal and/or street light equipment.

4. Displays:

The plan sheet shall include the following displays:

- a) Phase diagram display according to Redmond Standard Drawing 451. The Signal Designer shall contact the City to confirm the signal phasing prior to the first submittal.
- b) Signal display showing signal layout of all vehicle signal heads and pedestrian heads.

5. Detection:

The plan sheet shall include:

- a) Stop bar, intermediate and advanced loop location and numbering.
- b) Pedestrian push button location.
- c) Preemption detection location and numbering.

6. Signal Poles and Associated Equipment:

The plan sheet shall contain, but not be limited to:

- a) Signal Pole Locations and Numbering:

The locations shall be called out by the major arterial station and offset.

- b) Signal head location and numbering.
- c) Pedestrian head location and numbering.

7. Controller and Service Location:

At least one corner of the controller/service foundation shall be called out by the major arterial station and offset. The footprint of the foundation shall be shown on the plans with the controller and service cabinets oriented on the foundation as they would be placed in the field. If the information required to show all the controller/service conduit connections and foundation footprint makes the plan too cluttered, a blown-up detail of the corner containing this information is needed at a 1"=10' scale.

8. Power Source Location:

The location of the power source shall be identified on the plans.

9. Interconnect:

If interconnect is included with the design, it should be identified on the signal plan and wire schedule to the point of the advanced loop location. An interconnect schematic shall be included to show how it connects to adjacent signals and shall include approximate distance, number of junction boxes, and conduit size.

10. Wire Schedule:

A wire schedule table shall include run numbers, conduit size, wire type, and comments.

- a) Comments shall include, but not be limited to, number of twisted loop pairs for runs between the detection loops and adjacent junction box, identification of spare conduits, conduits utilized only by interconnect or illumination, and power cables.
- b) For designs that include modifications to an existing signal, all existing wire runs affected by the design shall be shown on the wire schedule.

11. Junction box type and approximate location.

12. Signing:

- a) Signs shall be shown on all mast arms. Signs that are post mounted but are signal related (such as a “signal ahead” sign) shall be shown on the signal plan.
- b) A sign display shall be shown on the plan with the MUTCD sign designation, dimensions, and lettering type for all signs.
- c) Removal of existing stop signs.
- d) Installation of “New Signal Ahead” or “Signal Revision Ahead” signs.

13. Other Illumination:

- a) Proposed illumination that will use the signal service cabinet, but is located outside the four quadrants of the intersection, shall be shown as proposed on a separate illumination plan sheet. On the signal plan sheet, the illumination shall be shown as gray scale and labeled as “proposed illumination, see illumination plans.” However, once the illumination enters the quadrants of the intersection (i.e., when it is using the same junction box as the signal equipment), it shall be shown as proposed on the signal plan and gray scale on the illumination plan.
- b) The street lights on the signal poles shall be on one circuit. Other street lights shall be on a separate circuit(s).

C. Wire Diagram:

Please refer to the attached plan set (Appendix A) for the appropriate format to use for the wire diagram. In general, the wire diagram shall include the following:

1. All signal heads, pedestrian heads, pedestrian push buttons, luminaires, preemption detectors, loops, and junction boxes drawn in schematic forms.
2. All termination points in the controller cabinet. The wire diagram should include every termination point the controller will have, including those that may not be used for this particular signal design. This is required because the City will then have the option of interchanging the controller with another if needed in the future.
3. All wiring associated with the items above, as well as the wiring for interconnect. The wire diagram should show how these items are connected to the controller.
4. Location of wire splices.
5. All termination numbering at each end of each wire. For example, the 5-conductor cable connecting a signal head to the controller should have the termination numbering called out at the signal head and in the termination points in the controller.
6. All wire colors at each end of the wire.
7. A call out to each wire run noting the number and type of each wire.
8. Intersection schematic with a north arrow showing approach phase.
9. Pole, signal head, pedestrian head, preemption detection, and loops shall be numbered on the wire diagram.
10. Interconnect shall be shown on the wire diagram.

D. Pole Schedule:

The pole schedule shall conform to the following requirements:

1. The pole schedule shall include a signal standard detail chart. Refer to the attached signal plan (Appendix A) example for the chart format.
2. Wind-load calculations shall assume 4.1 square feet of area for a 3-section signal head, and 5.5 square feet for a 4-section signal head.
3. Foundation calculations shall use the WSDOT standard foundation table (see WSDOT Design Manual, Foundation Depth Table, Figure 850-13).
4. The pole schedule shall include pole orientation attachment and base detail, pole foundation detail, and signal standard detail. The pole foundation detail shall not show the bolt size. The bolt size is to be determined by the pole manufacturer.

IV. DESIGN GUIDELINES

The following guidelines are to inform the Designer of the City's requirements for signal design.

A. Left-Turning Traffic:

1. Left-turning traffic can be better accommodated when the opposing left-turn lanes are directly opposite each other. For every intersection, a turning analysis should be conducted using SU-30 as the design vehicle, using Autoturn software or equivalent. The analysis should show that opposing left-turning vehicles do not approach any closer than 10 feet from each other. For intersections that are anticipated to consistently encounter larger trucks, such as an intersection located close to a facility which uses large trucks, a larger design vehicle shall be used for the turning analysis. The analysis should be submitted to the City with the first submittal of the plans.

B. "T" Intersections:

1. "T" intersections provide a good opportunity to apply the overlap phase methodology. Specifically, the left-turning traffic on the major leg and the right-turning traffic on the minor leg can run concurrently, if the turning traffic approaches have a turn-only lane. In addition, the pedestrian movement crossing the major leg can be added to the overlap phase if the crosswalk is not in conflict with the minor leg right-turning traffic. The engineering study should consider the use of overlap phasing in this situation by placing the crosswalk on the left-hand side of the intersection.

C. Crosswalks and Pedestrians:

1. Pedestrian displays and push buttons are required at all signalized intersections unless the pedestrian movement is prohibited. Crosswalks should be located as close as possible to the intersection. Push buttons shall not be placed more than 5 feet from the normal path of the pedestrian, and no more than 15 feet from the center point at the end of the associated crosswalk. Special consideration should be given to people with disabilities when locating the push buttons. When the push button is installed on a vehicle signal standard, a paved path at least 4-feet wide from the shoulder or sidewalk to the standard shall be provided. If this is not possible, a pedestrian push button post shall be provided. If installed behind a guardrail, pedestrian push button posts should not be greater than 1.5 feet from the face of the guardrail.

D. Controller and Service Equipment:

1. The City uses a TS2 Type I traffic controller cabinet assembly. The signal controller shall be placed in an area such that a service vehicle could "hop" the curb and park adjacent to the controller. In addition, the controller should be placed so that an operator can see the traffic signal while accessing the controller. The door to the controller shall always open in the direction away from the intersection. The controller shall be placed in a location such that it should not require relocation if widening of the intersection happens in the future. Where possible, the controller should be located outside of sight triangle lines for safe right-turn-on-red turning movements.

2. The City uses a Skyline Electric service cabinet, Drawing No. 47995-R2. The signal service cabinet shall be located adjacent to the controller. See Redmond Standard Drawings 459, 460, and 461 for controller and service foundation dimensions and placement.
- E. Phase Numbering:
1. Typically, phase numbering shall be according to Redmond Standard Drawing 451. However, the City may request that the phase numbering be different from the standard in order to match existing phase numbering along a particular corridor. Therefore, the Signal Designer shall contact the City to confirm the signal phasing prior to the first submittal.
- F. Preemption Location and Numbering:
1. Emergency vehicle preemption detection shall be provided for all legs of the intersection. Typically, one preemption sensor is placed on each signal pole mast arm. However, the sensors should be placed in a location where it can detect emergency vehicles up to 800 feet away from the intersection. For intersections where the opposing mast arms are 35 feet apart or less, the preemption sensors shall be placed on the “back side” of the mast arm, so the sensors will not accidentally pick up a false call from the emergency lights reflecting off of the street name signs. For intersections where the opposing mast arms are greater than 35 feet apart, the preemption sensors shall be placed on the front side of the mast arm.
 2. Preemption sensors are numbered P1 for Phases 1 and 6, P2 for Phases 2 and 5, P3 for Phases 3 and 8, and P4 for Phases 4 and 7.
 3. The City utilizes the 3M Opticom emergency vehicle preemption system for its signalized intersections. Model 721 is used for single direction mode, and Model 722 is used for dual direction.
- G. Loop Location and Numbering:
1. See Redmond Standard Drawing 454 for stop-bar loop placement. The intermediate and advanced loop placement shall follow the guidelines in Table IV-1.

Table IV-1. Redmond Standard Loop Placement^a

Approach Speed (mph)		Loop Detector Placement (feet) ^b	
15 Percent	85 Percent ^c	6' Round Intermediate Loop Location	6' Round Advance Loop Location
20	20*	—	119
25	25*	—	144
30	30*	—	194
35	35*	—	248
40	40*	—	278
30	45	194	321
35	45*	248	321

(Table Continues)

Table IV-1. Redmond Standard Loop Placement^a

Approach Speed (mph)		Loop Detector Placement (feet) ^b	
15 Percent	85 Percent ^c	6' Round Intermediate Loop Location	6' Round Advance Loop Location
40	45	278	321
30	50	194	394
35	50*	248	394
40	50	278	394
45	50	321	394
30	55	194	444
35	55	248	444
40	55	278	444
45	55	321	444
50	55	394	444

a See Redmond Standard Detail 454 for stop-bar loop placement.

b The number of feet between the back of stop bar and the front of loop.

c If 15% and 85% speed data are not available, use 5 mph over the posted speed for the 85% speed and use the case marked with an asterisk*.

2. Loops shall be identified with a three-digit number. The first digit shall correspond with the phase number, the second digit shall correspond with the lane (Number 1 being the lane furthest from the curb), and the third digit shall correspond with the proximity of the stop bar (Number 1 being closest to the stop bar).

H. Signal Poles:

1. Signal poles shall be placed no closer than 4.5 feet from the face of the curb. For locations that do not have a sidewalk, the WSDOT requirements for clear zone distance apply (see Figure 700-1 of the WSDOT Design Manual).
2. If possible, signal poles shall be placed in a location such that they should not require relocation if widening of the intersection happens in the future.
3. Pot-holing for utility conflicts is required prior to approval of the signal plans and should be conducted between the first and second submittal.
4. Typically, each signal pole has a luminaire. The luminaire arm should be long enough so that the luminaire extends over the curb. See City Standard Drawing No. 425 for luminaire arm type.

I. Signal/Pedestrian Heads:

1. Signal Head Location and Size:

- a) Signal head location shall be in accordance with the MUTCD, but shall be centered over their respective lanes if possible. Redmond Standard Drawing No. 452 shows the City preference of signal head locations for certain lane configurations.
- b) Only Type M mounting of signal heads on the mast arms is allowed. The mounting is connected to the signal head between the red and yellow signal faces.
- c) Protected left-turn movements shall have a left-turn head on the mast arm, and a supplemental follow-through, left-turn head located on the far-left signal pole.
- d) All signal heads shall have 12-inch lenses.
- e) Five-section signal heads are not allowed.

2. Signal Head Numbering:

- a) See Redmond Standard Drawing 451 for signal head numbering.
- b) For left-turn signal heads with protective/permissive phasing, the signal head shall have a two-digit number for each phase. For example, a four-section signal head has a green display for both Phases 4 and 7, and if the signal head is on the mast arm and furthest from the pole, the signal head number shall be 41/71.
- c) For signal heads that are part of an overlap phase (i.e., phases that do not normally run concurrently), including protective/permissive right-turn signal heads, the signal head number shall be the overlap "letter" and a number. For example, if a signal head has a green display during the Overlap A phase, which is defined to be green during Phases 4 and 5, the signal head number shall be A1.

3. Pedestrian Head Location:

- a) A pedestrian head shall be provided at each end of every signalized crosswalk at the intersection. Pedestrian head location shall be in accordance with the MUTCD.
- b) Type E (clamshell) mounting is preferred.

4. Pedestrian Head Numbering:

- a) See Redmond Standard Drawing 451 for pedestrian head numbering.

J. Power Source:

- 1. The location of the power source shall be identified on the plans. If possible, the location should be in the same corner as the service cabinet. The power source shall be 120/240-volt single phase.

2. It is the responsibility of the Designer to contact the power company to determine the power location and add hook-up coordination instructions to the plans prior to plan approval. The signal design shall include enough cable and conduit for the Contractor to bring the power cable to the power source and leave enough left over for the utility company for hook-up.

K. Interconnect:

1. The Signal Designer should contact the City to identify if interconnect is a part of the signal design. If interconnect is included, it should be identified on the signal plan wire schedule to the point of the advanced loop location.
2. An interconnect schematic shall be included to show how it connects to adjacent signals and shall include approximate distance, number of junction boxes, and conduit size.
3. If interconnect is not included, the signal plan shall include a 3-inch conduit with pull wire along the project limits for future installation. Interconnect should be contained in a Type 2, or larger, junction box.
4. Interconnect cables shall be located in a separate conduit from other cables, except in the conduit run between the controller and the adjacent junction box to the controller.

L. Conduit:

1. The City uses Schedule 80 PVC conduit for street crossings, and Schedule 40 PVC conduits for all other areas.
2. Conduit Size:
 - a) Conduit sizes shall be 2, 3, or 4 inches only. Conduit size is based on total area of cable enclosed in the conduit and shall be determined by Tables IV-2 and IV-3. See City of Redmond Special Provisions for cable and conduit type.

Table IV-2. Signal Conductor Sizing Table

Cable	Area (in x in)	Use of Cable
#8	0.060	Illumination/Ground
#4	0.109	Controller-Service
#2	0.147	Service-Power Source
2cs-#14	0.090	Detection Loop
3cs-#20	0.070	Preemption
5c-#14	0.140	Vehicle/Pedestrian Heads
6pcc-#19	0.320	Interconnect

NOTE:

c = conductor

cs = conductor shielded

pcc = pair communications cable

Table IV-3. Conduit Fill Area

Size (in)	Max Cable Fill – New Conduit (in x in)	Max Cable Fill – Existing Conduit (in x in)
2	0.87	1.34
3	1.92	2.95
4	3.27	5.03

3. Spares:

- a) A spare 2-inch conduit shall be provided in every street crossing, and a spare 3-inch conduit shall be provided between the controller and adjacent junction box(es). A spare 2-inch conduit shall be provided between each signal pole and its adjacent junction box.

4. Conduits Containing Illumination Wires:

- a) Illumination wires shall always run in separate conduits from other signal wires.

M. Wires:

1. See Redmond Standard Drawing 457 for loop wire splicing and lead-in cable requirements.
2. Signal heads shall only use 5-conductor cables. Between the signal head and the terminal cabinet on the pole, each signal head shall have its own 5-conductor cable. Two 5-conductor cables shall service protective/permissive signal heads. Between the terminal cabinet and the controller, one 5-conductor cable can service a maximum of three signal heads sharing the same phase.
3. One additional 5-conductor cable shall be installed between the controller and each Type 2 and Type 3 signal poles for future use. The 5-conductor cable shall be landed in the pole terminal cabinet, and labeled as a spare. The 5-conductor cable shall not be landed in the controller.
4. One 5-conductor cable shall service a pedestrian head and push button assembly.
5. One 2-conductor shielded cable can serve each pedestrian push button on a stand-alone push-button post.
6. One 3-conductor shielded cable shall service each preemption detector. No splices shall be allowed for 3-conductor shielded cables between the detector and the controller.
7. Three #8 insulated wires shall service the illumination on the signal poles. Illumination cables shall be located in a separate conduit from other cables.
8. Typically, interconnect cables are 6-pair #19 AWG wires or 6-strand single mode fiber optic cable.
9. Three #4 insulated wires shall connect the controller to the service cabinet.

10. Three #2 insulated wires shall connect the service to the power source and shall be located in a separate conduit run and, if applicable, junction box with locking lid.

11. One #10 AWG grounding wire is required per conduit carrying greater than 50 volts.

N. Wire Termination Numbering and Colors:

1. See City of Redmond Standard Drawing 458 for standard loop termination numbering. Please refer to Tables IV-4, IV-5, IV-6 for the standard termination numbering and wire color for vehicle heads, pedestrian heads, and preemption detectors.

Table IV-4. Signal Heads Termination Numbering and Wire Color

Termination Number	Wire Color	Color Code	Use
6*1	Red	R	Red
6*2	Orange	O	Yellow
6*3	Green	G	Green
6*6	White	W	Neutral
6*7	Black	B	Spare

Note:

* corresponds with the phase number.

Table IV-5. Pedestrian Heads/Push Buttons Termination Numbering and Wire Color

Termination Number	Wire Color	Color Code	Use
7*1	Red	R	Don't Walk
7*2	Green	G	Walk
7*3	White	W	Neutral
7*4	Orange	O	Push Button
7*5	Black	B	Push Button

Note:

* corresponds with the phase number.

Table IV-6. Preemption Detection Termination Numbering and Wire Color

Termination Number	Wire Color	Color Code
5*1	Orange	O
5*2	White	W
5*3	Blue	BL

Note:

* corresponds with the phase number. For preemption, 1 is used for Phases 1 and 6, 2 is for Phases 2 and 5, 3 is for Phases 3 and 8, and 4 is for Phases 4 and 7.

O. Junction Boxes:

Junction boxes shall be placed and sized using the following criteria:

1. Adjacent to advanced loops.
2. Adjacent to stop-bar loops.
3. Adjacent to signal poles.
4. Adjacent to controller.
5. At each end of every conduit street crossing.
6. Junction boxes shall be placed as far away from the back of curb as possible to provide safe access for the City maintenance staff.
7. If possible, the junction box shall be placed behind the sidewalk to avoid the possibility of pedestrians slipping on the junction box during rainy or frosty days.
8. Junction boxes shall be placed such that no conduit run shall be greater than 300 lineal feet.
9. Junction boxes shall be placed outside of wheelchair ramps.
10. Junction boxes shall be placed every time a conduit run has to turn 90 degrees horizontal or greater.
11. Junction boxes shall be sized according to WSDOT Standard Plan J 11a. A Type 2 or greater junction box is required for all junction boxes containing interconnect wires.
12. Type 3 junction boxes shall have a dual-hinged lid (see Redmond Drawing No. 463).
13. For junction boxes located in landscape areas or on a steep slope, where overgrowth or the slope may make it difficult to open the junction box lid, the junction box shall follow Redmond Drawing No. 464.
14. Illumination wires serving luminaires on the signal poles may share a junction box with signal equipment. Illumination wires for other luminaires shall not share junction boxes containing signal equipment, except for the junction boxes at the end of each street crossing, and the junction box immediately adjacent to the controller/service cabinet. Junction boxes containing illumination wire shall have the letters "LT" inscribed on the lid.
15. Junction boxes carrying the wire between the service cabinet and the power source shall have a locking lid and shall not contain any other wires.
16. All junction boxes carrying signal equipment and/or interconnect shall have the letters "TS" inscribed on the lid. All junction boxes carrying only interconnect equipment shall have the letters "INTC" inscribed on the lid. For junction boxes carrying both signal and illumination wires shall have the letters "LT" and "TS" inscribed on the lid.

P. Signing:

1. Determination of sign placement shall be in accordance with the MUTCD.
2. Each signal pole mast arm shall have one street name sign. Typically, the street name signs are centered between the through signal heads. See Redmond Standard Drawing 417 for street name sign specifications.