Roundabout Evaluations in Virginia:

US 15/US 50 – Gilberts Corner, VA
SR 106/SR 634 – Prince George County, VA

VDOT & FHWA Roundabout Workshop
September 17, 2013

U.S. Department of Transportation
Federal Highway Administration

VDOT Virginia Department of Transportation
Location and Design

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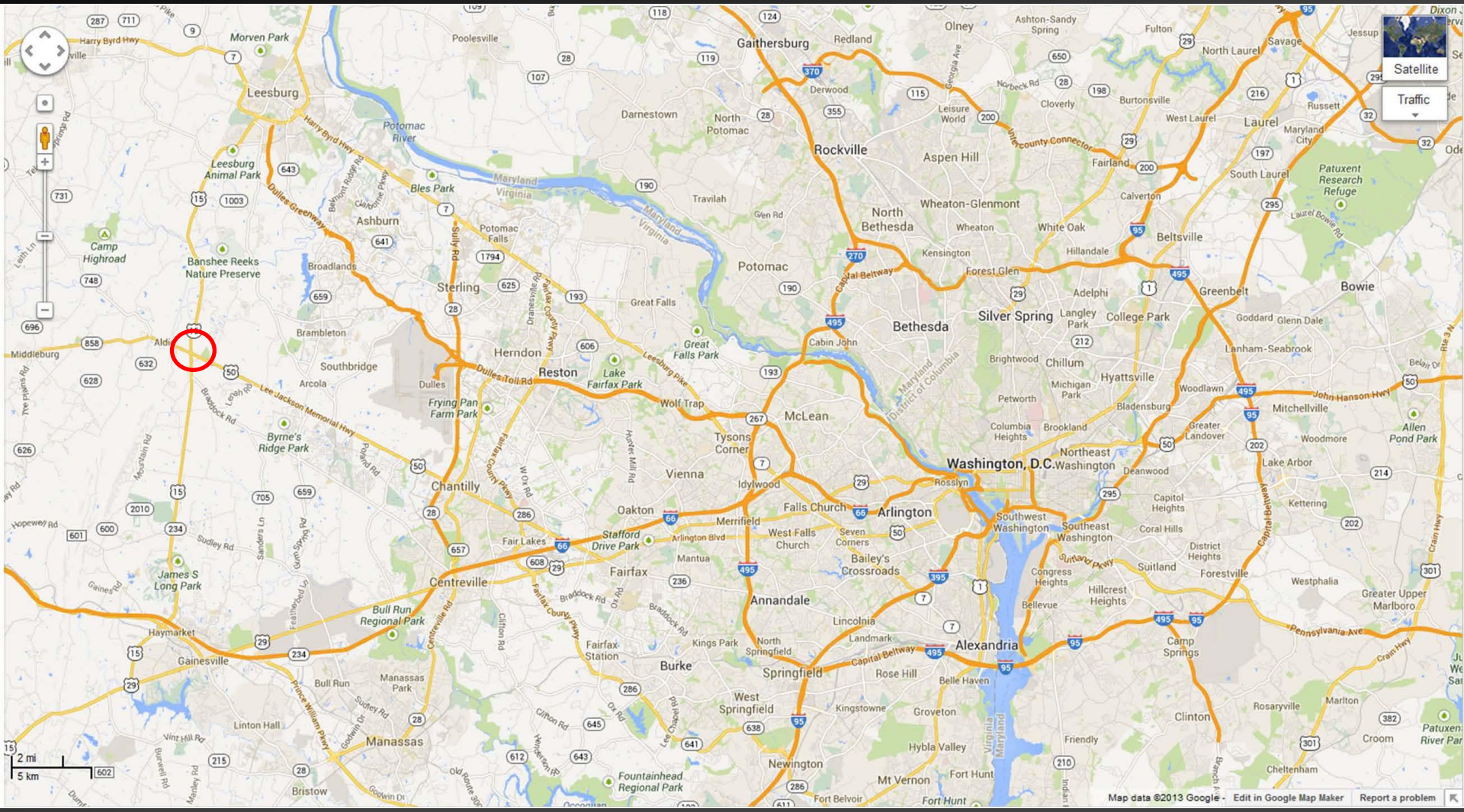
MOVINGFORWARDTHINKING

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

Presentation Outline

- US 15/US 50 (Gilberts Corner, VA)
  - Existing Conditions Review
  - HCM 2010 Model Calibration
  - Suggested Signing/Pavement Marking Modifications
  - Alternatives Considered
  - Next Steps
- SR 106/SR 634 (Prince George County, VA)
  - Existing Conditions Review
  - Design Modifications/Alternatives
  - Next Steps

Gilberts Corner, VA



Gilberts Corner, VA

Timeline

- Traffic signal experienced long delays and queues
- Roundabout constructed in 2009 to replace traffic signal
- Concerns regarding the frequency of crashes since implementation of the roundabout

Existing Conditions

- Traffic Operations
  - Roundabout operates well from capacity standpoint
  - Hybrid multilane, but operates as de facto single-lane
  - Long-term volume growth constrained by two-lane roads
- Crash History
  - 67 reported crashes in two year period (2010-2011)
  - 45 “Failure to Yield” on NB & SB approaches (US 15)
  - Contributing factors may include:
    - High entry speeds
    - Excessive sight distance
    - Unclear signing/pavement markings

Traffic Operations

- HCM 2010 model results did not align with field-observed operations (AM and PM)
- Model results for critical WB approach (PM):
  - V/C = 1.10
  - Control delay: 83.1 sec/veh
  - 95th percentile queue: 625 feet
- Field observed WB operations (PM):
  - Control delay: ~15-20 sec/veh
  - Max back of queue: ~300 feet, dissipated quickly

Traffic Operations

- Field observations of queues and delays during both peaks inconsistent with HCM 2010 capacity model
- Over 90% of all turning movements are <u>through</u> movements during both peak periods
- Likely underestimating capacity of critical approaches

- NEED FOR CALIBRATION

HCM 2010 Model

- Generalized by Equations 21-21 through 21-23:

$$c_{pce} = Ae^{(-Bv_c)}$$

$$A = \frac{3{,}600}{t_f}$$

$$B = \frac{t_c - (\frac{t_f}{2})}{3{,}600}$$

where

c_{pce} = lane capacity, adjusted for heavy vehicles (pc/h)

v_c = conflicting flow (pc/h),

t_c = critical headway (s), and

t_f = follow-up headway (s).

HCM Model Calibration

- Two methods:
  1. Measure critical headway and follow-up headway directly in the field and calculate new A and B coefficients
  2. Reverse calibration using field-measured control delay to back-calculate values of critical headway and follow-up headway that would produce control delay
- Method 2 used
  - Direct observation of critical headway and follow-up headway difficult (not enough queuing or volume – operates "too well"
  - Existing video data allowed for reverse calibration method

HCM Model Calibration

- Control delay calculated in accordance with methodology in Equation 31-160 in Chapter 31 of the HCM (based on observed vehicle-in-queue data)
- Queues recorded in one-minute increments for 30 minutes (AM/PM) around identified peak 15-minute periods
- Corresponding control delay then calculated for two highest-volume approaches per time period
  - Improved sample size
  - Limit uncertainty of results

HCM Model Calibration

- t_f and t_c values selected that produced similar control delay measurements by approach
- Preponderance of through movements and infrequency of side-by-side entries results in all approaches effectively operating as single-lane entries with a single lane circulating

$$\frac{t_c}{t_f} = \frac{5.1929}{3.1858} = 1.63$$

- Ratio held constant to develop t_f and t_c values that produce similar calculated control delays

HCM Model Calibration

- Back-Calculated t_f and t_c values

Approach	t_f	t_c
Eastbound	2.2	3.586
Westbound	2.1	3.423
Northbound	2.7	4.401
Southbound	2.8	4.564

- Control Delay Comparison

Approach (Time Period)	Observed Control Delay (Eq. 31-160 HCM 2010)	Calibrated HCM 2010 Model Control Delay
Eastbound (AM)	12.7	12.7
Westbound (PM)	12.4	12.1
Northbound (AM)	19.6	20.4
Southbound (PM)	13.7	13.9

HCM Model Calibration

- Video footage used to spot-check observed average follow-up headways where possible

Approach (Time Period)	Observed Average Follow-Up Headway	Estimated Follow-Up Headway
Westbound (PM)	2.0	2.1
Southbound (PM)	2.8	2.8

- Different approach configurations yield different t_f and t_c values, but similarities between the EB/WB and NB/SB approach pairs suggest that two t_f and t_c values could be applied
  - A weighted average of t_f and t_c pairs were calculated to calibrate the HCM 2010 model

HCM Model Calibration

- For the eastbound/westbound approaches:
  - $t_f = 2.14$
  - $t_c = 3.488$
  - $A = 1{,}682$
  - $B = 6.717 \times 10^{-4}$
- For the northbound/southbound approaches:
  - $t_f = 2.76$
  - $t_c = 4.499$
  - $A = 1{,}304$
  - $B = 8.664 \times 10^{-4}$

HCM Model Calibration

- Calibrated model uses two capacity models depending on the approach

- Capacity of the eastbound/westbound approaches expressed as:

$$c_{pce} = 1{,}682e^{(-6.717\,x\,10^{-4}v_c)}$$

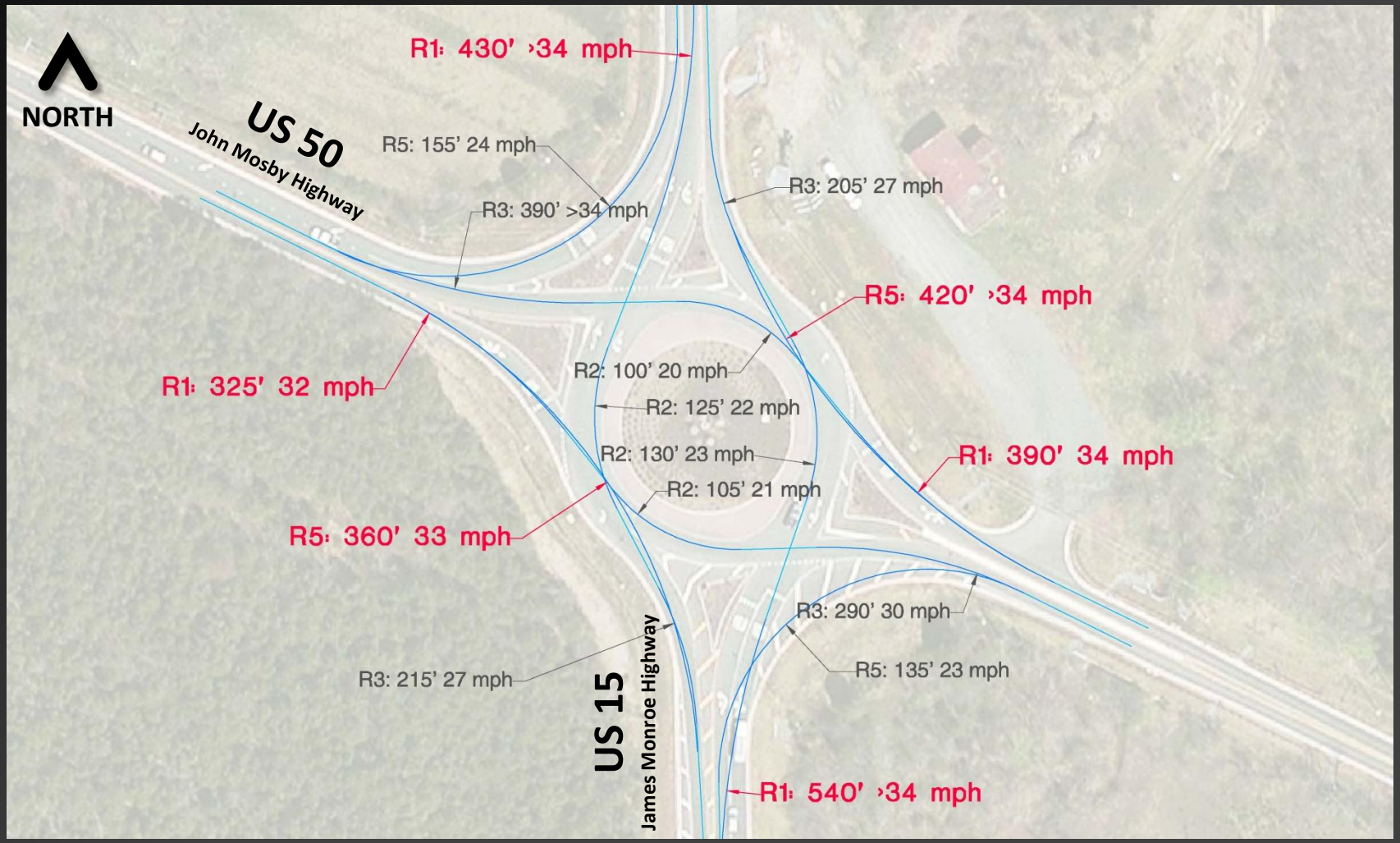
- Capacity of the critical through lane on the northbound/southbound approaches expressed as:

$$c_{pce} = 1{,}304e^{(-8.664\,x\,10^{-4}v_c)}$$

HCM Model Calibration

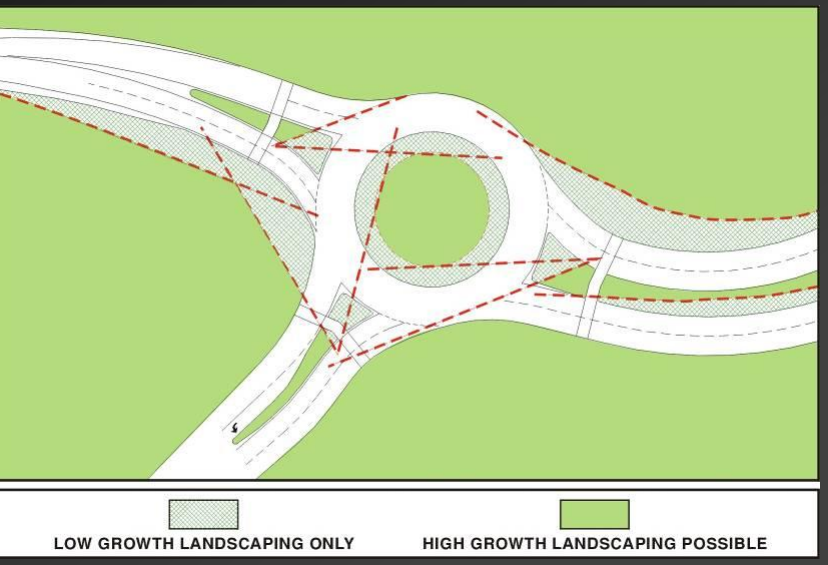
- **IMPORTANT**: Calibration *specific to this roundabout!*
- A variety of factors can influence capacity, including but not limited to
  - Turning movement patterns
  - Roundabout geometry (ICD, horizontal/vertical alignment features, etc.)
  - Driver population/behavior
- MOST SITES WHERE CALIBRATION EFFORTS HAVE BEEN UNDERTAKEN ARE CONSISTENT WITH THE DEFAULT HCM 2010 MODEL

Vehicle Speeds



Sight Distance/Landscaping

- Increase mounding or landscaping in central island to reduce sight distance across the roundabout

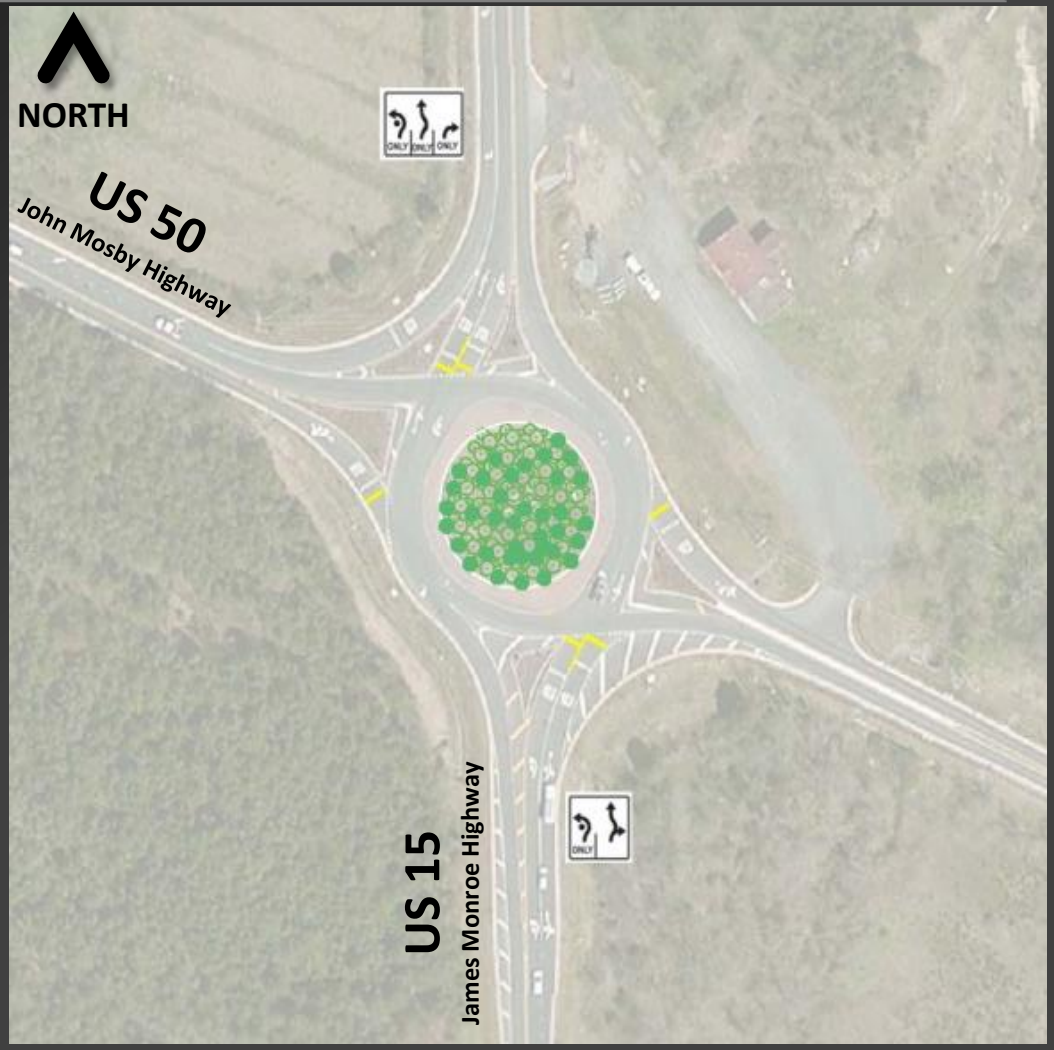


Existing Signing/Pavement Marking Modifications

- Move yield lines ("sharks teeth") forward to entrance line

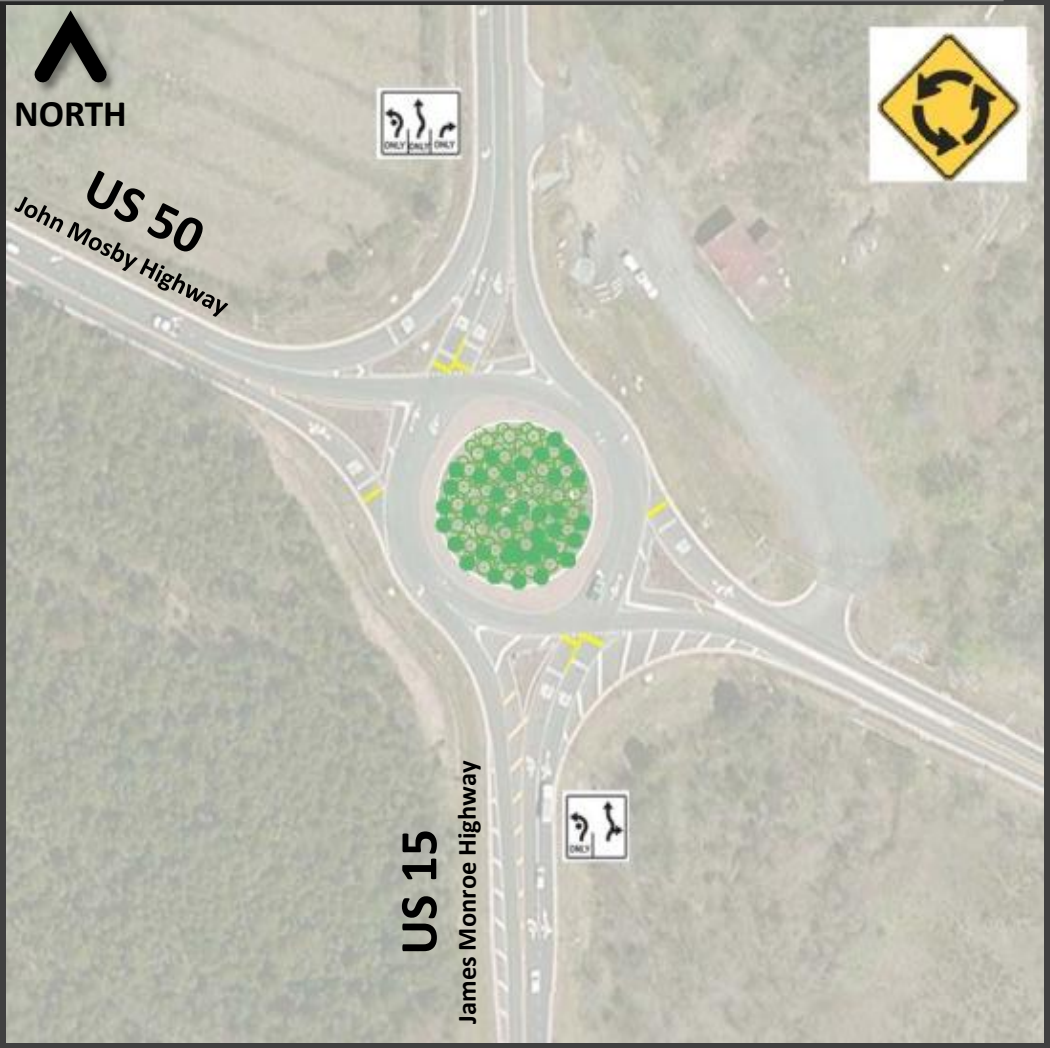
Existing Signing/Pavement Marking Modifications

- Post advance lane configuration signs to encourage correct lane selection



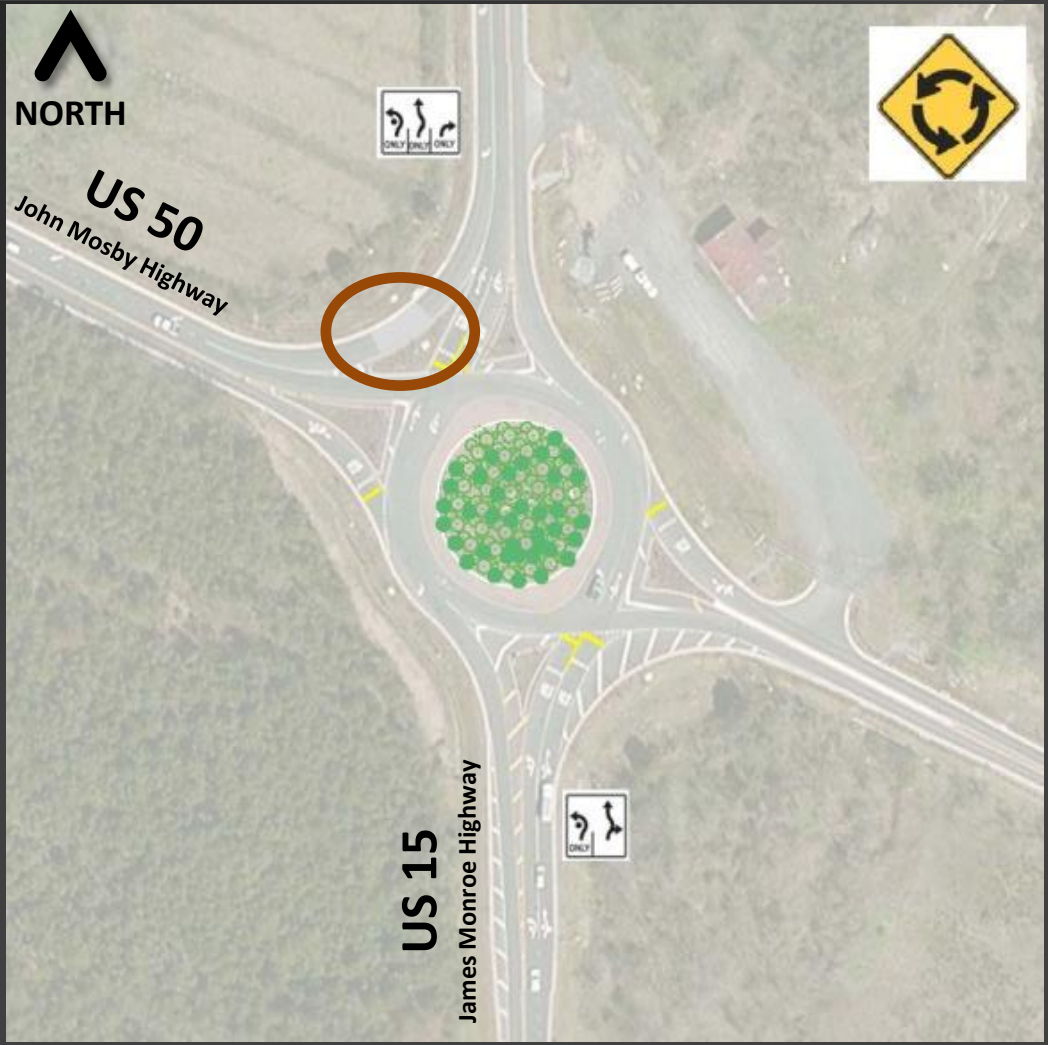
Existing Signing/Pavement Marking Modifications

- Install advance "Roundabout Ahead" (W2-6) signs from current MUTCD



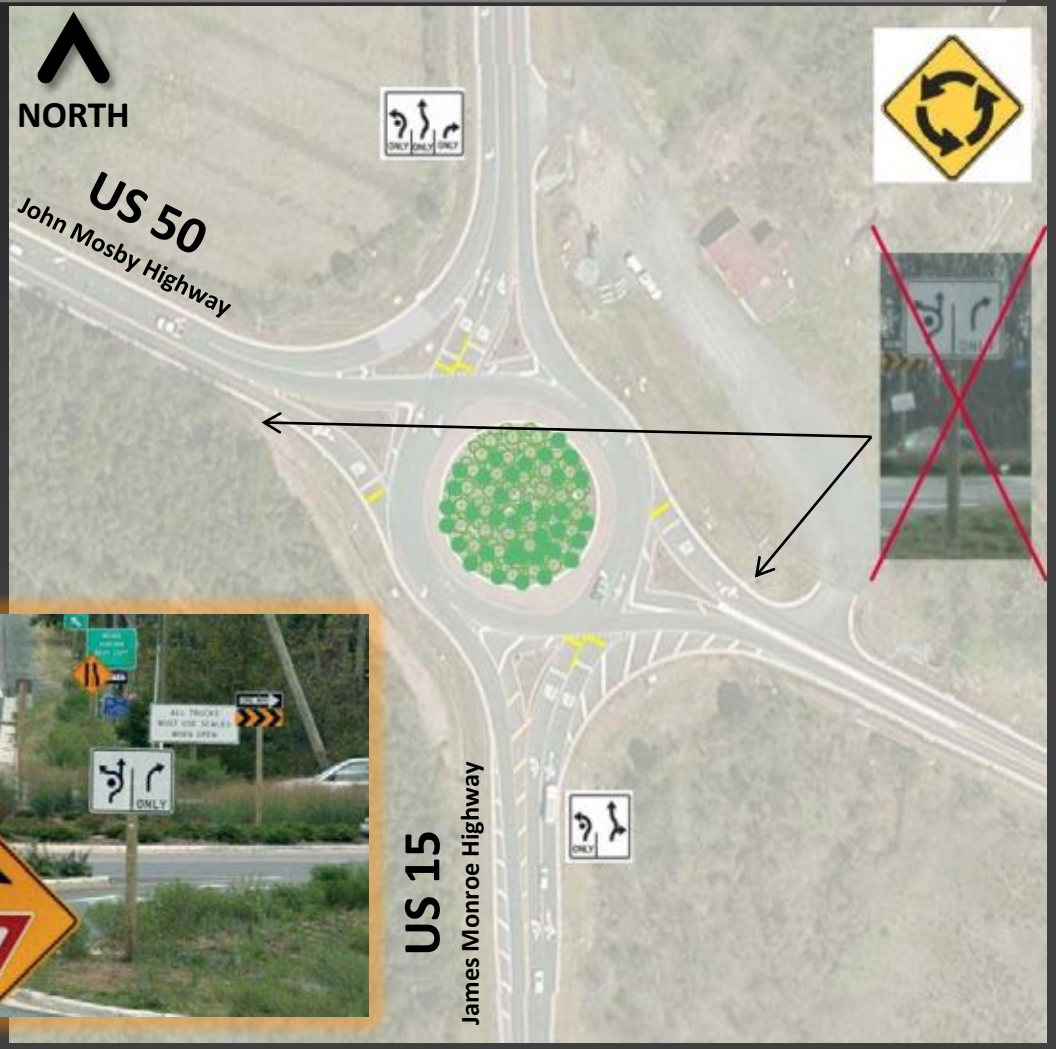
Existing Signing/Pavement Marking Modifications

- Remove "Yield" pavement markings and signs from SB right-turn bypass



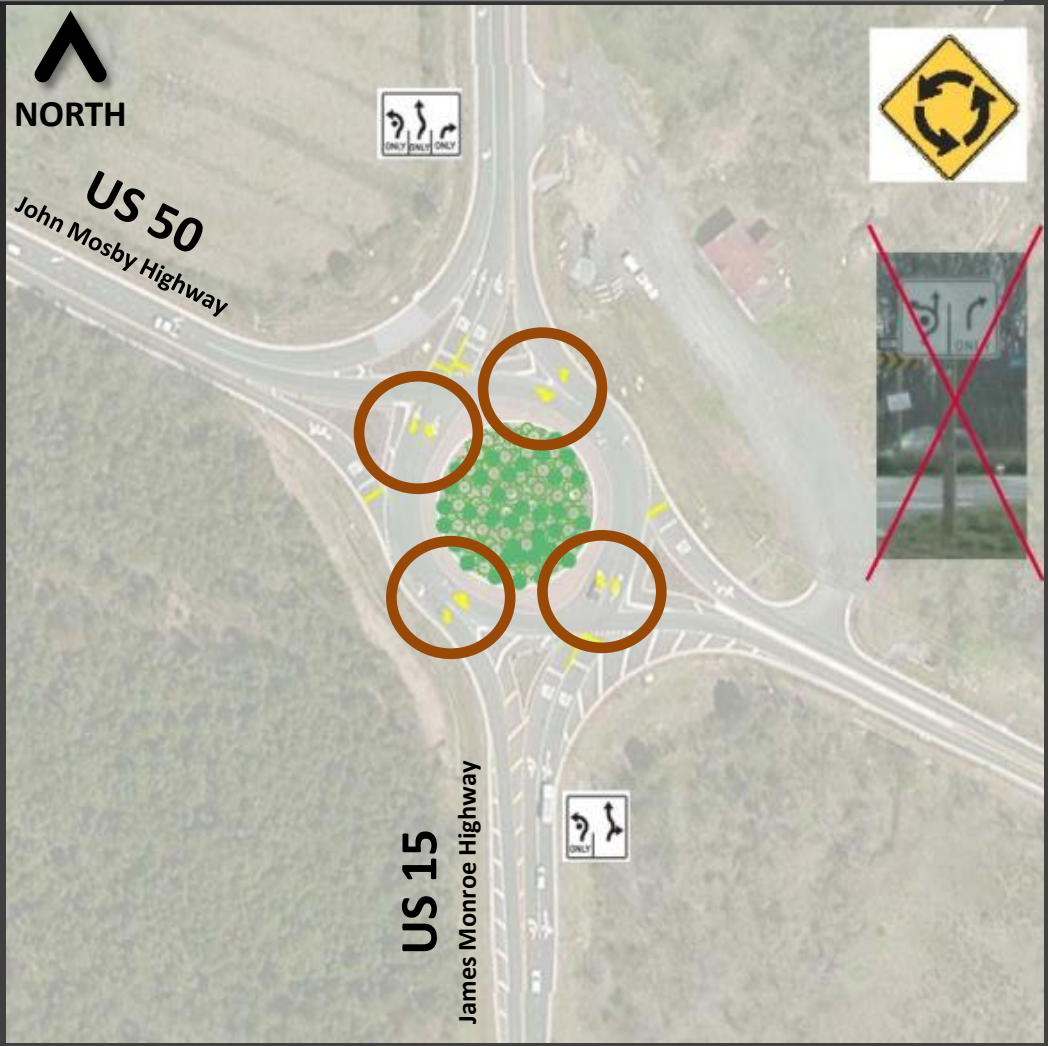
Existing Signing/Pavement Marking Modifications

- Remove incorrect advance lane configuration signs on EB and WB approaches (US 50)



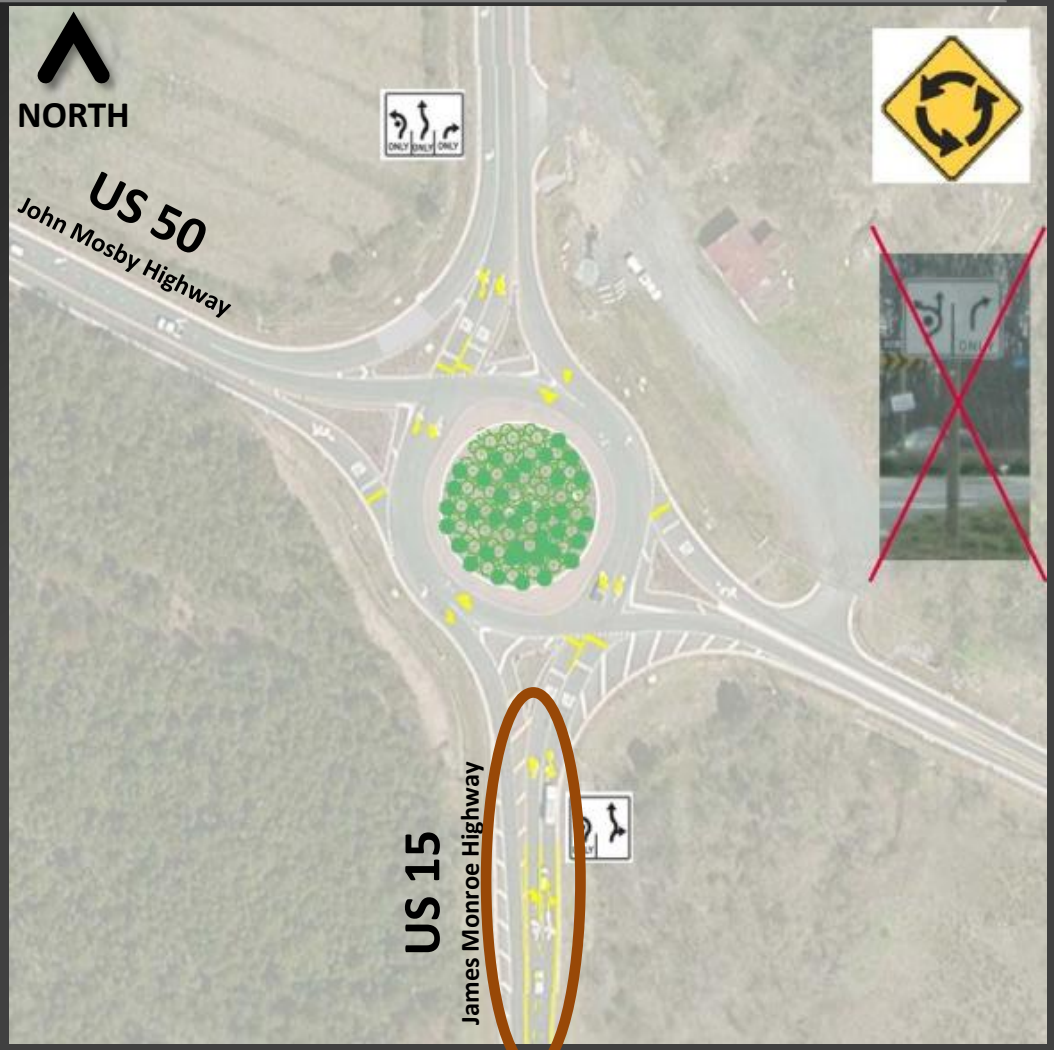
Existing Signing/Pavement Marking Modifications

- Shift circulatory road pavement markings
- Use traditional directional pavement markings in circulatory roadway



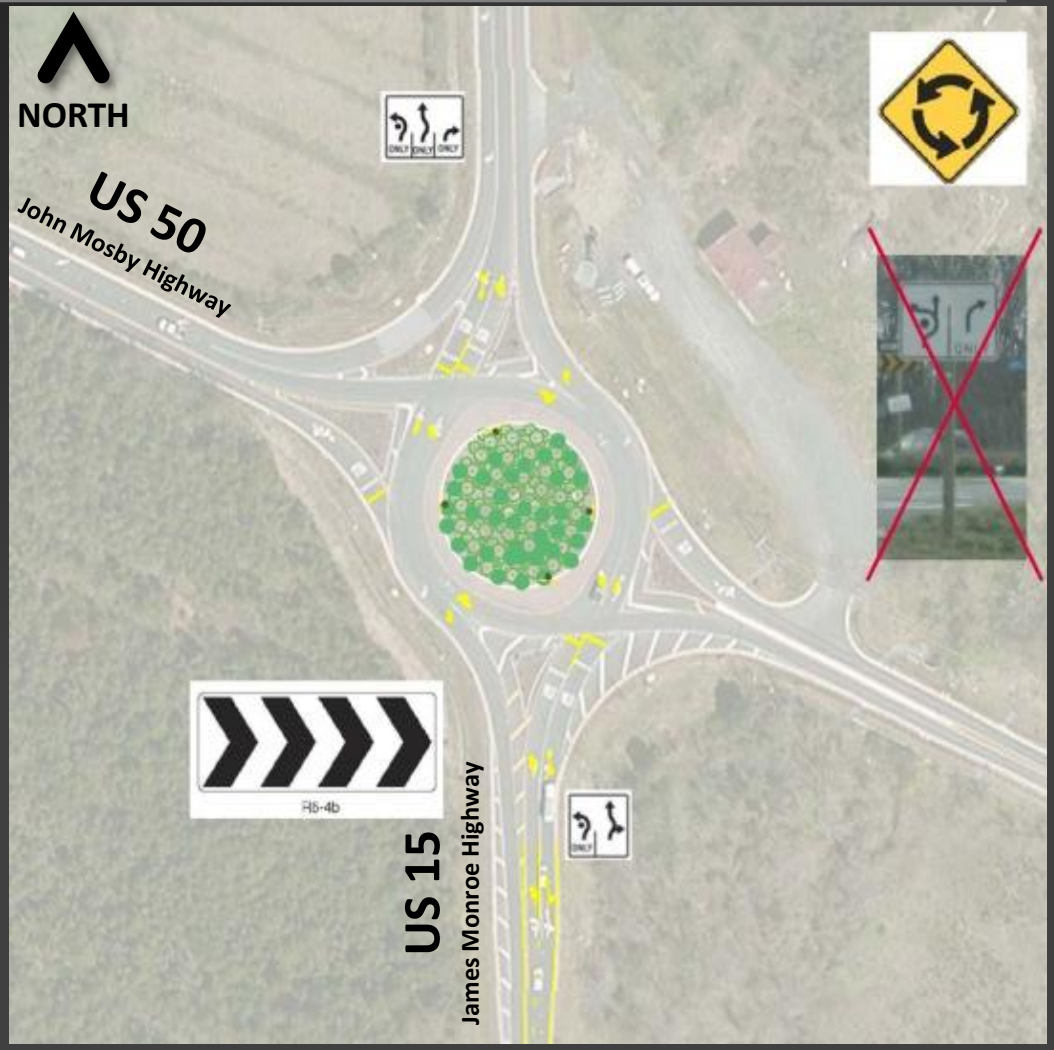
Existing Signing/Pavement Marking Modifications

- Eliminate “dot” on advance pavement marking outside lanes on NB and SB approaches
- Restripe northbound approach to add separate Left-Turn Only lane to the inside



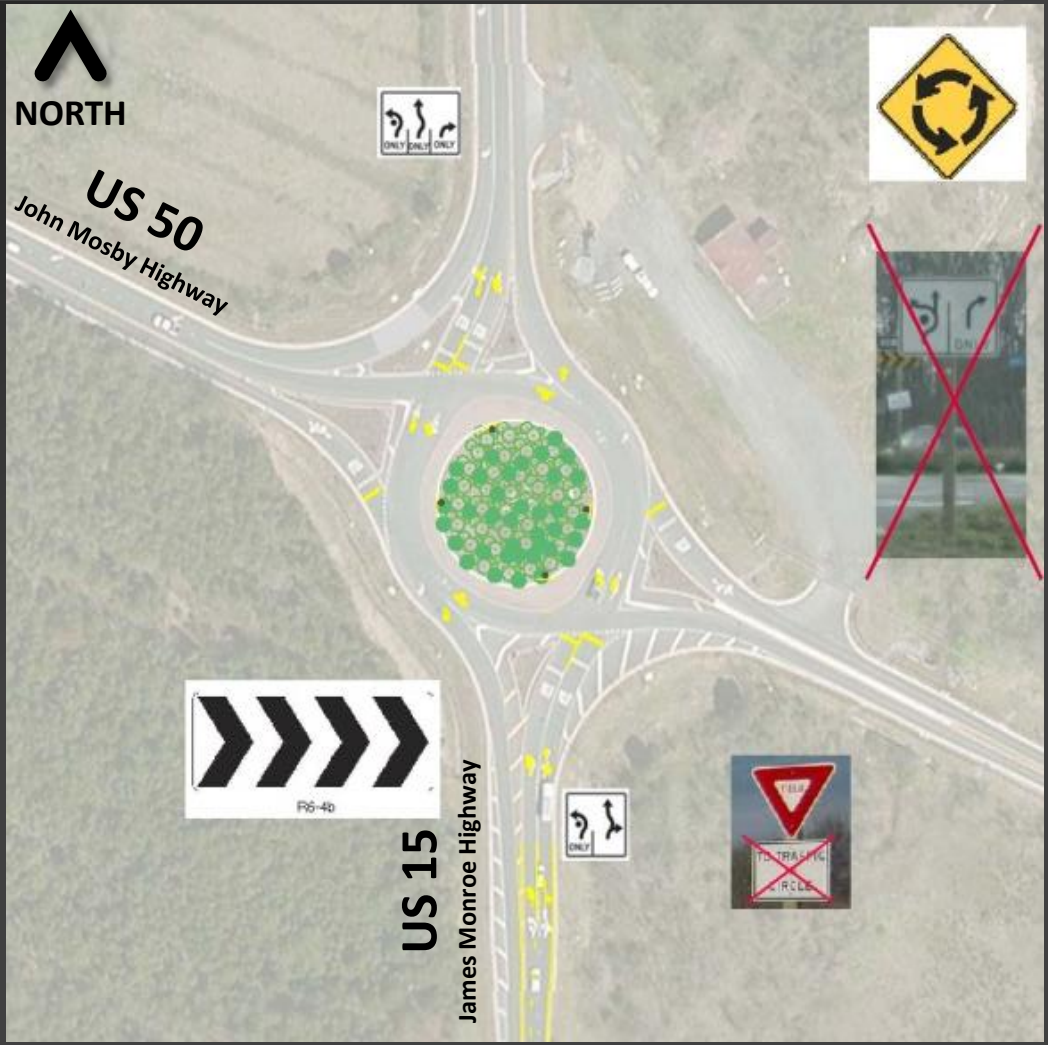
Existing Signing/Pavement Marking Modifications

- Replace current "One-Way" and black-on-yellow chevron signs in circulatory roadway with current black-on-white regulatory chevron signs (R6-4b) from MUTCD



Existing Signing/Pavement Marking Modifications

- Remove “To Traffic In Circle” plaques in all locations



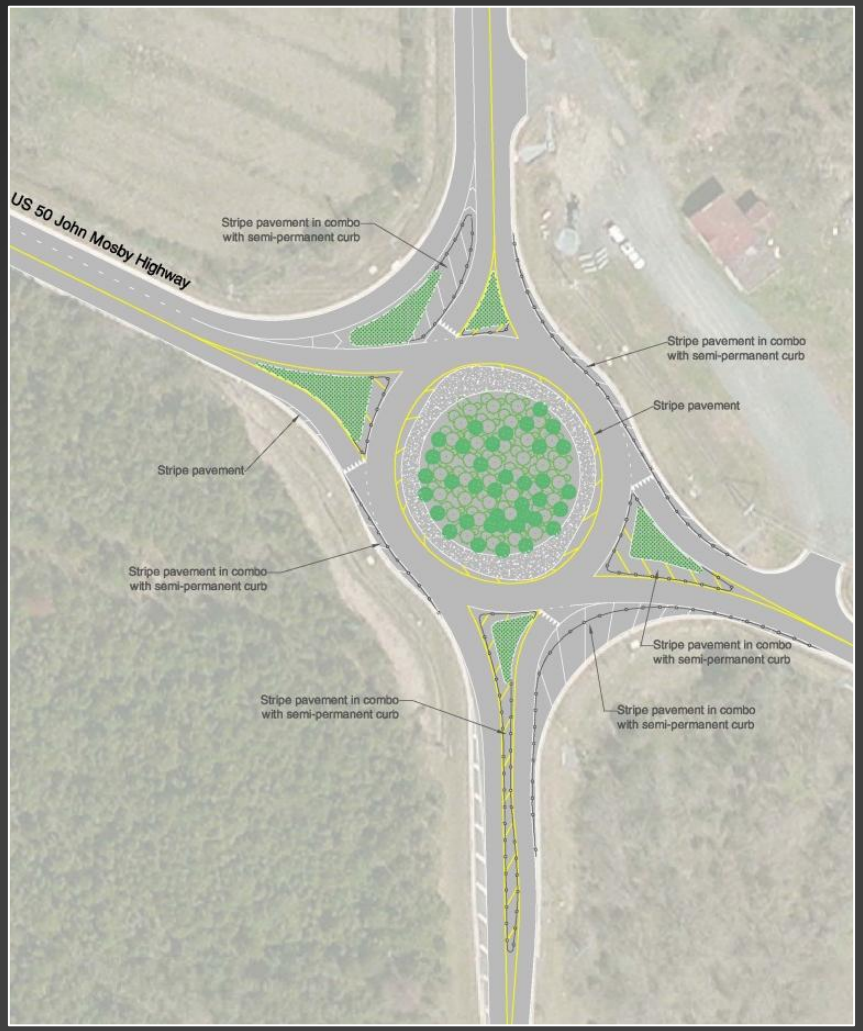
Alternatives Considered

- Temporary Single-Lane Roundabout
- Permanent Single-Lane Roundabout
- Redesigned Multilane Roundabout

Temporary Single-Lane Roundabout

Temporary Single-Lane Roundabout

- Use semi-permanent curb to redefine approaches
- Minor signing/striping changes
- No modification to existing splitter islands or truck apron
- No R/W impacts (stays within existing footprint)



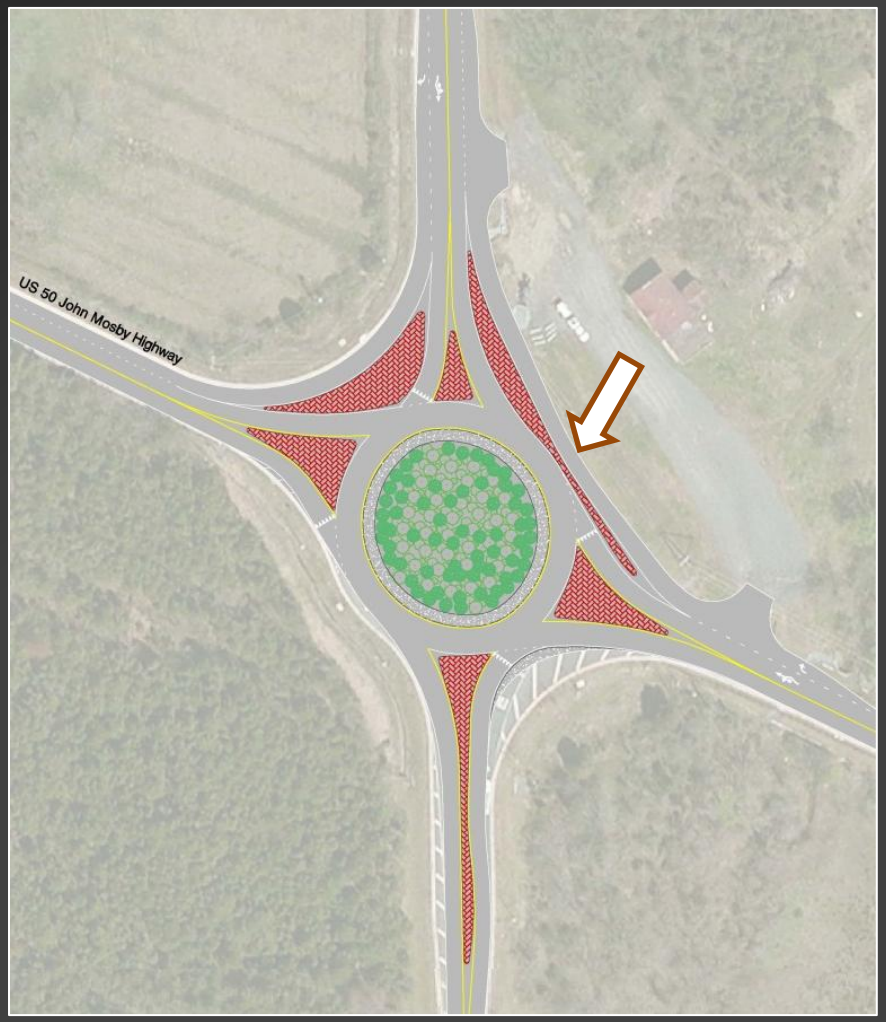
Permanent Single-Lane Roundabout

Permanent Single-Lane Roundabout

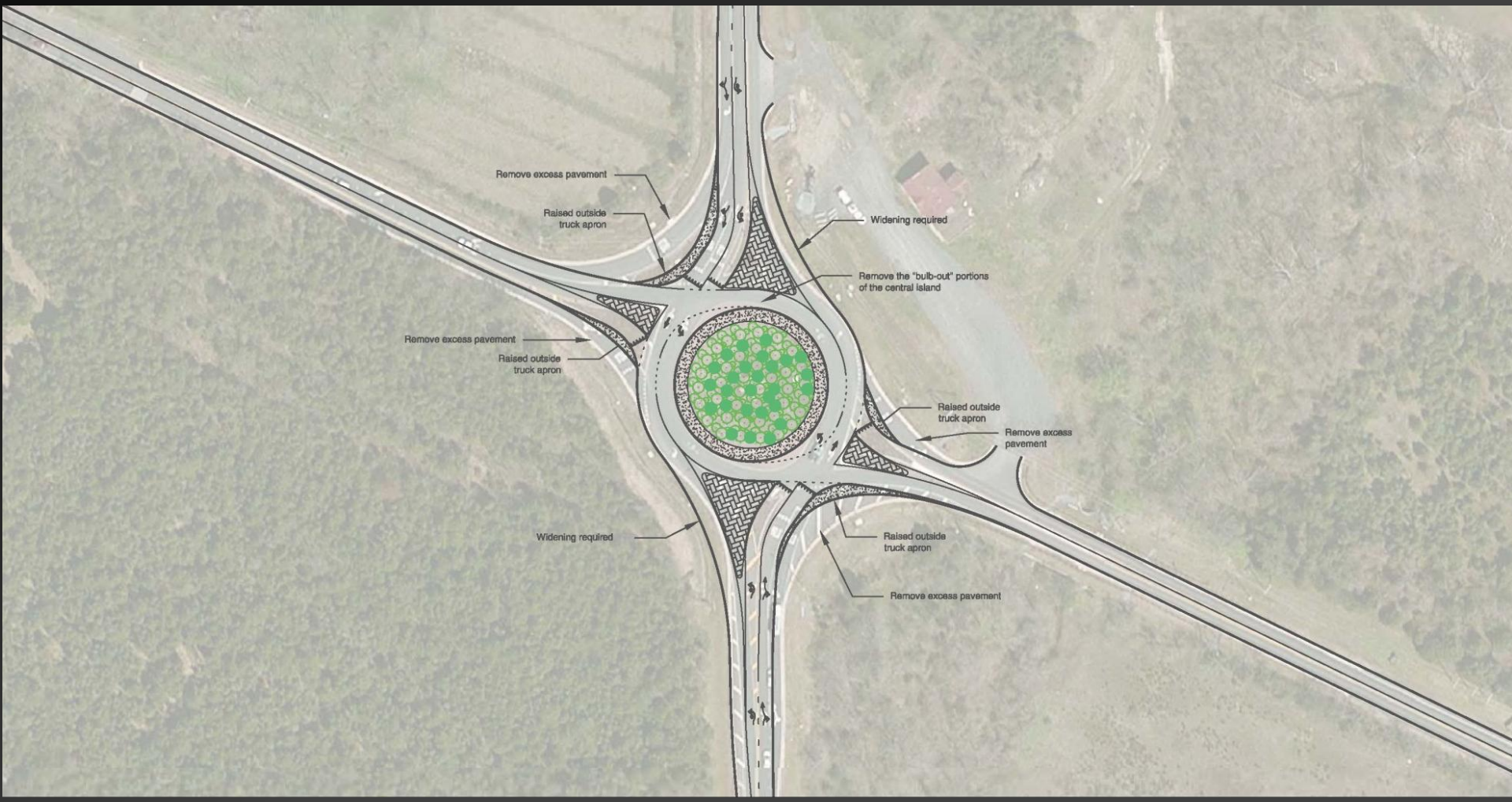
- Reconstruct as single-lane roundabout
- Signing/striping changes
- Reconstruct splitter islands and outside SE quadrant curb
  - Reduce entry speeds

Permanent Single-Lane Roundabout with RT Bypass

- Consider need/feasibility of possible WB-to-NB right-turn bypass
  - Provides additional long-term capacity
  - Additional R/W impacts and constructability issues

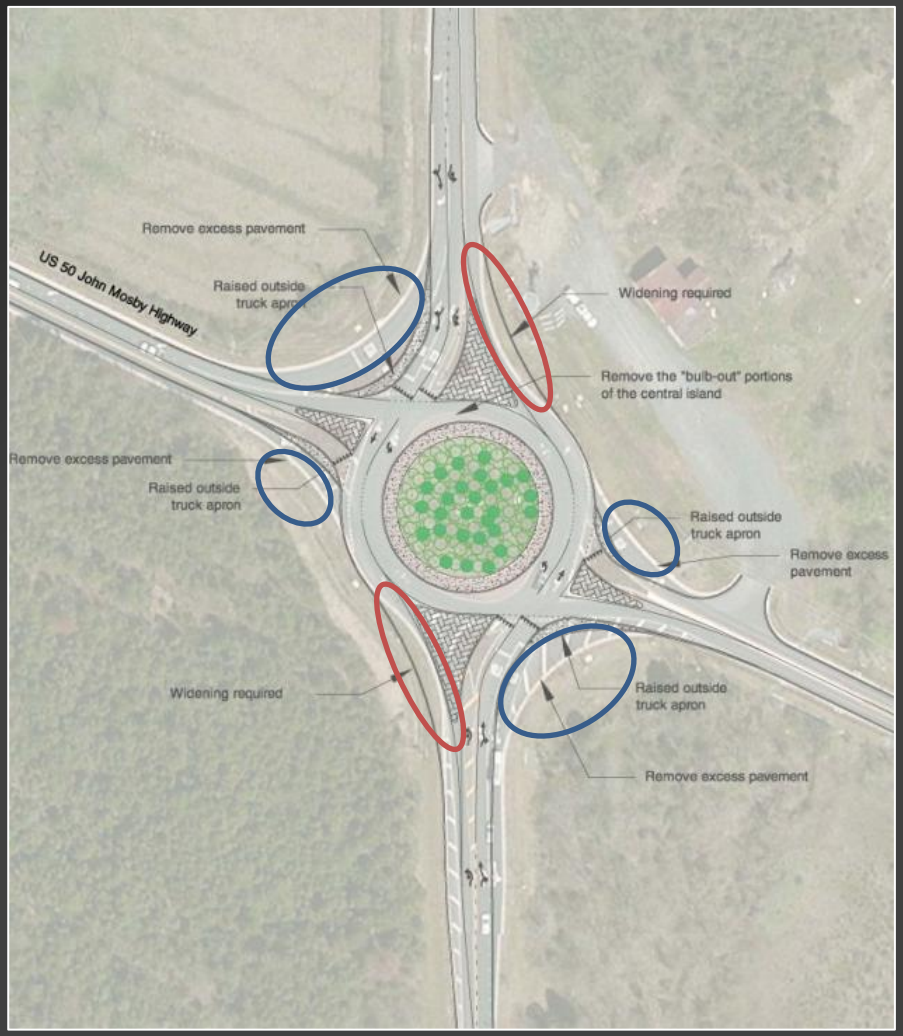


Redesigned Multilane Roundabout



Redesigned Multilane Roundabout

- Reconstruct multilane roundabout
- Signing/striping changes
- Reconstruct splitter islands
- Remove SBRT bypass
- Modify approach geometries
- R/W impacts
  - NE Quadrant
  - SW Quadrant
- Remove excess pavement



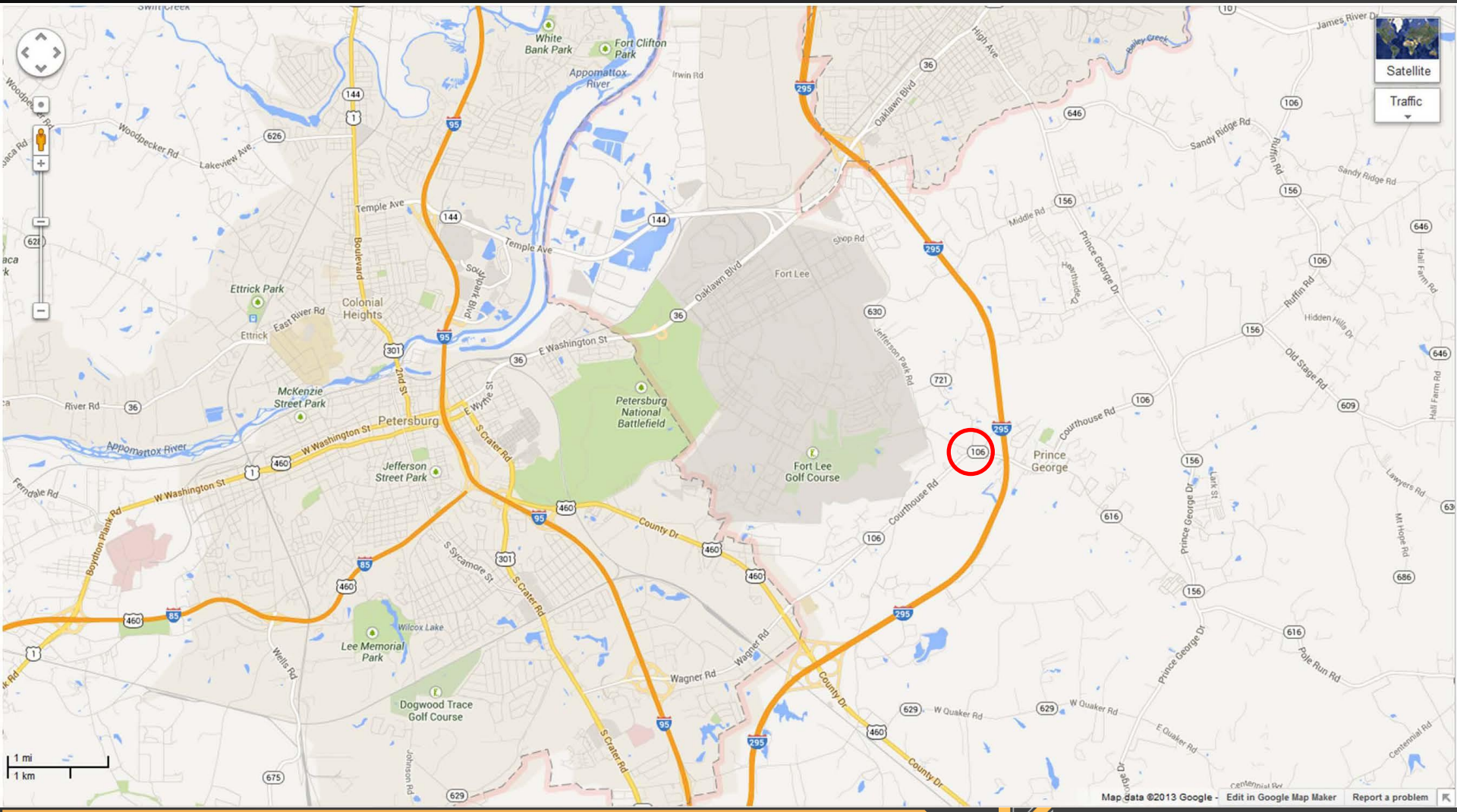
VDOT Next Steps

- VDOT modified NB approach and circulatory roadway striping in July 2013
- VDOT currently designing a permanent single-lane roundabout for installation by end of 2013
  - Low cost, high value
  - No R/W impact
  - Minimal impacts to drainage

Conceptual Design

- Install permanent curb to redefine approach geometry and control speeds on NB/SB
- Minor signing/striping changes
- No modification to existing splitter islands or truck apron & no R/W impact

Prince George County, VA - SR 106/SR 634



Courthouse Road (SR 106)/Allin Rd (SR 634)

SR 106/SR 634 – Existing Roundabout

wondershare™
Allin Rd
A
106

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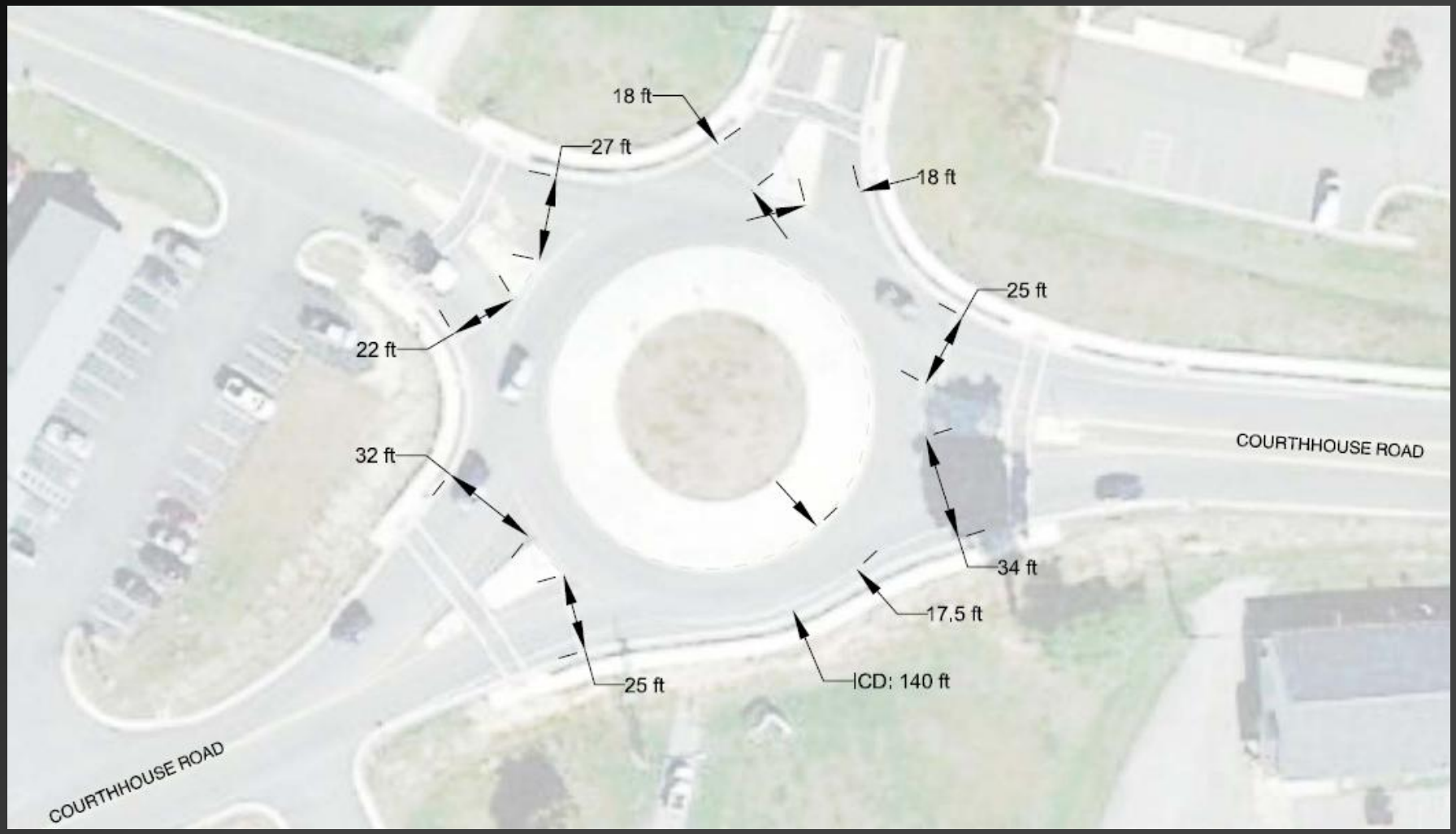
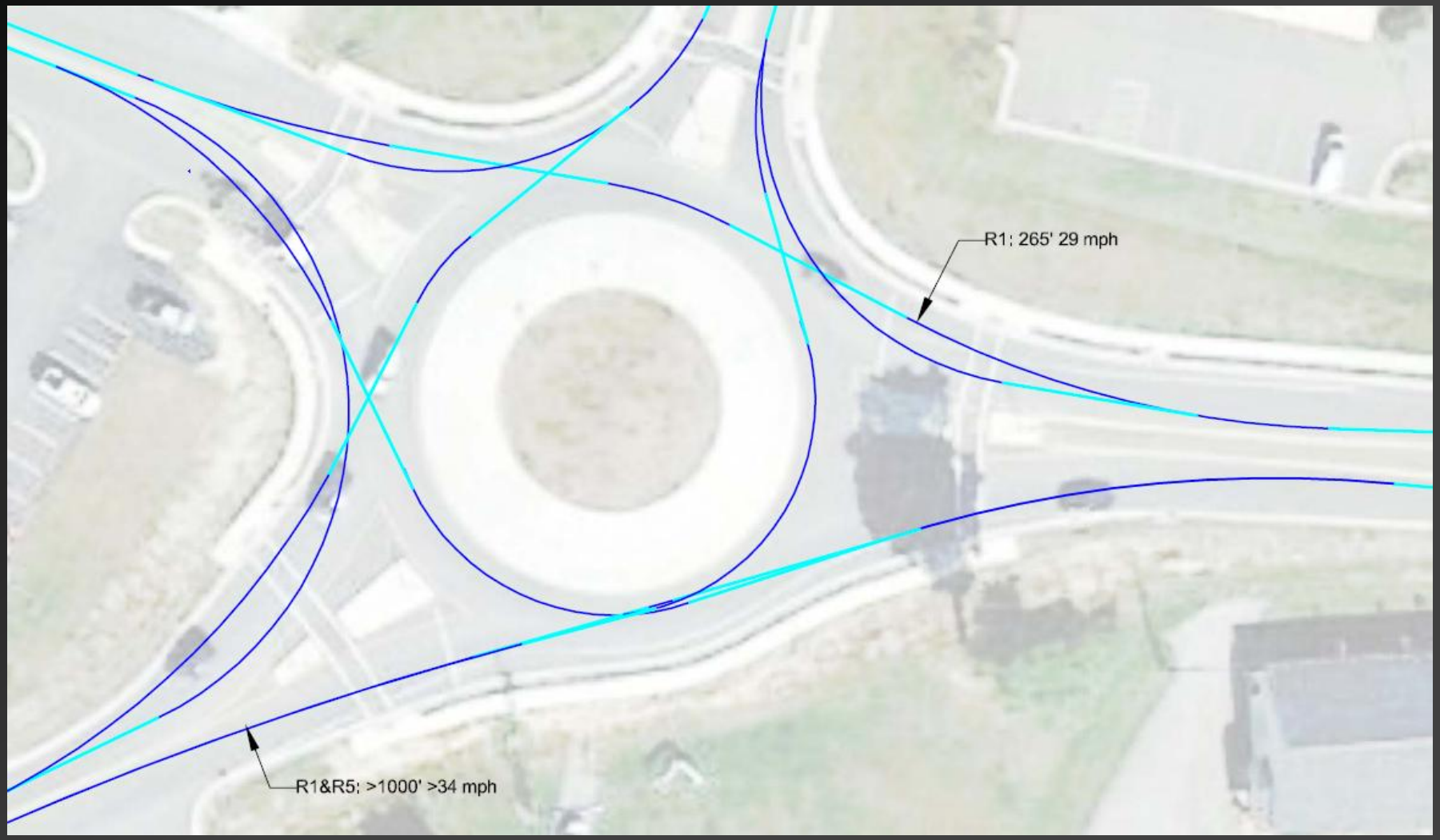
Existing Conditions

- VDOT Previously Identified Geometric Issues:
  - Truck apron and curbing
  - Lack of speed control on northbound approach
  - Size of circulatory roadway
  - Splitter island design
- Improvements Made
  - Plowable pavement markings
  - Edge stripes
  - Edge/Shoulder lines
- Operations
  - Intersection operates under capacity, consistent with site visit observations
- Crash History
  - Insufficient crash data to evaluate crash patterns
  - Safety-related improvements attempt to minimize potential for crashes related to identified deficiencies

Roundabout Geometrics



Vehicle Speeds

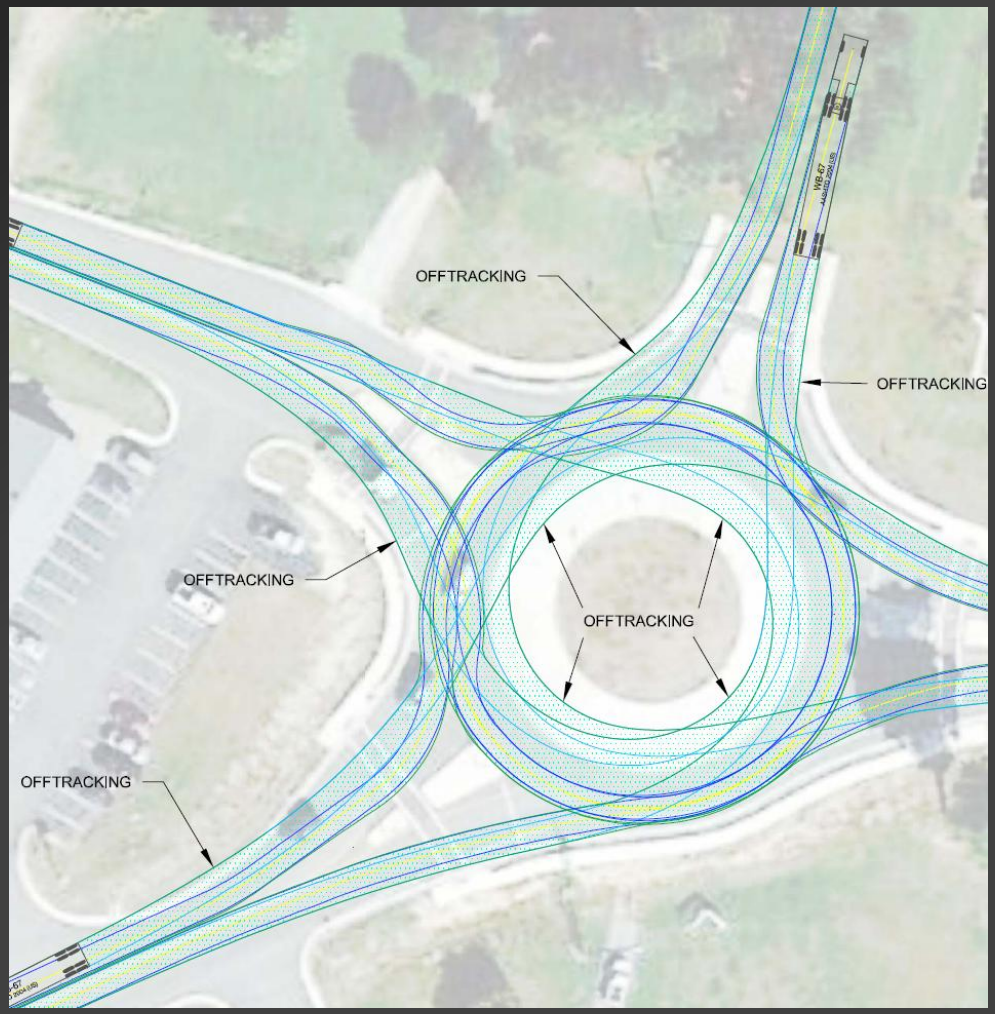


Vehicle Speeds

Looking southeast to NB approach

Large Vehicle Accommodation

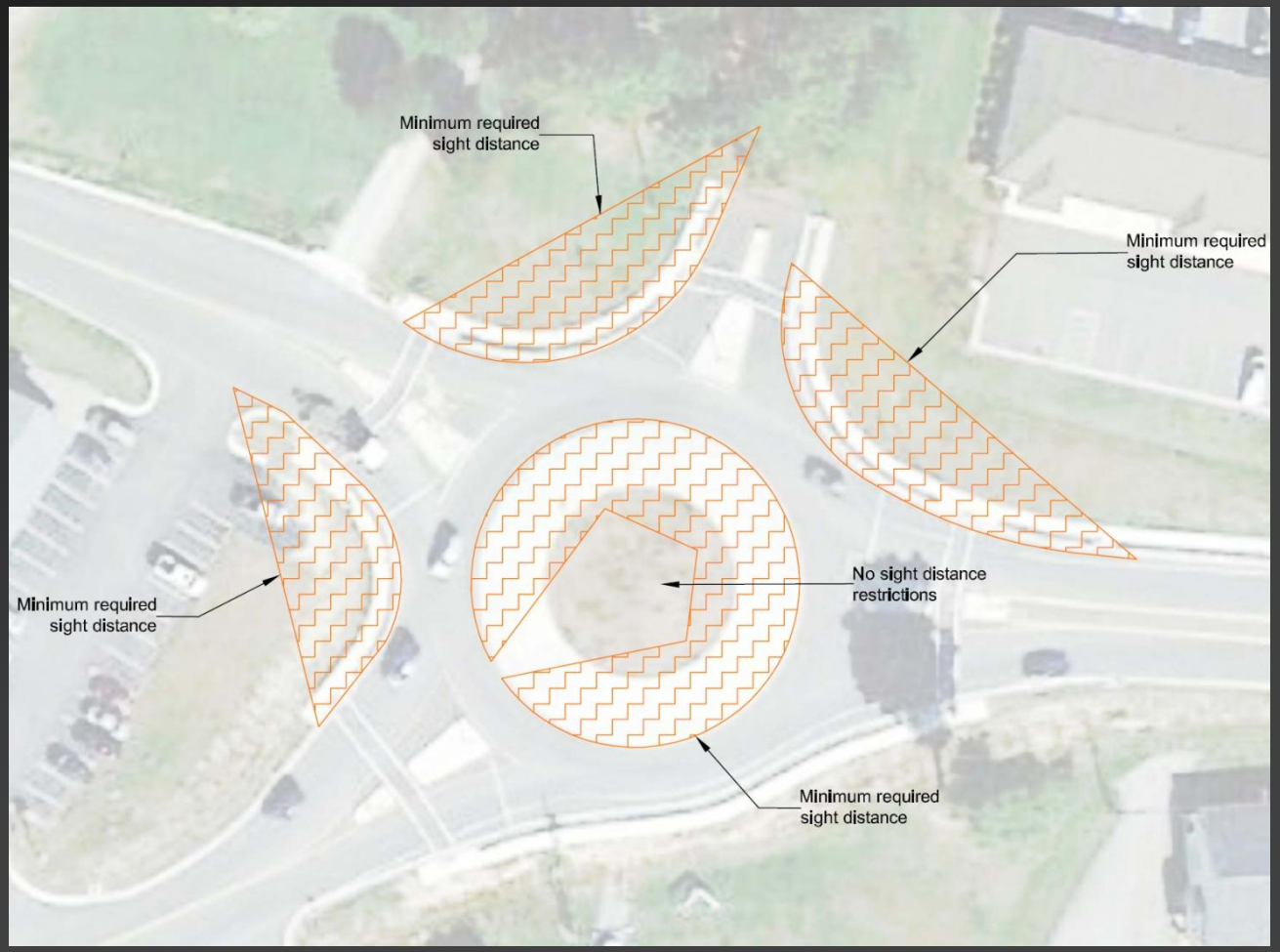
- Off-tracking noted in design checks, and confirmed in site visit
- Large vehicles are not consistently using the provided truck apron



Large Vehicle Accommodation

Sight Distance/Landscaping

- Increase mounding or landscaping in central island to reduce sight distance across the roundabout



Pedestrian and Bicycle Treatments

- Provide speed control
- Detectable warning surfaces in splitter islands
- Edge line treatment in circulatory roadway could be mistaken as a bike lane

Existing Signing/Pavement Marking Modifications

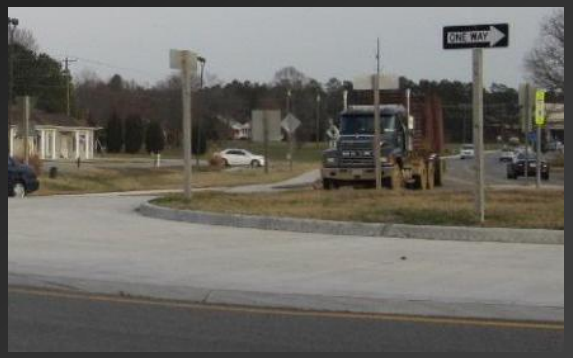
- Increase size of “shark teeth” yield line triangles
- Provide dotted extension of circulatory roadway edge line
- Remove “To Oncoming Traffic” plaque at yield signs

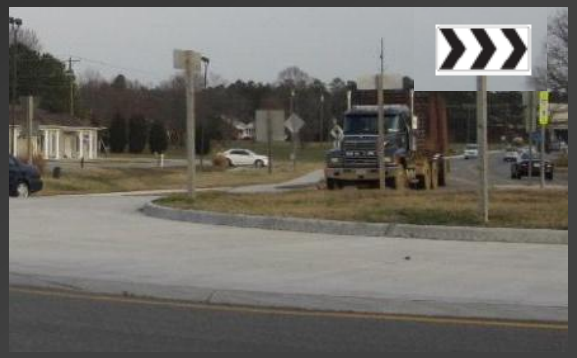
Existing Signing/Pavement Marking Modifications

- Replace Yield Ahead sign with roundabout Intersection Warning sign
- Provide pedestrian warning sign

Existing Signing/Pavement Marking Modifications

- Replace One-Way signs with Roundabout Directional Arrow Signs
- Remove “Yield to Pedestrians Within Crosswalk” signs

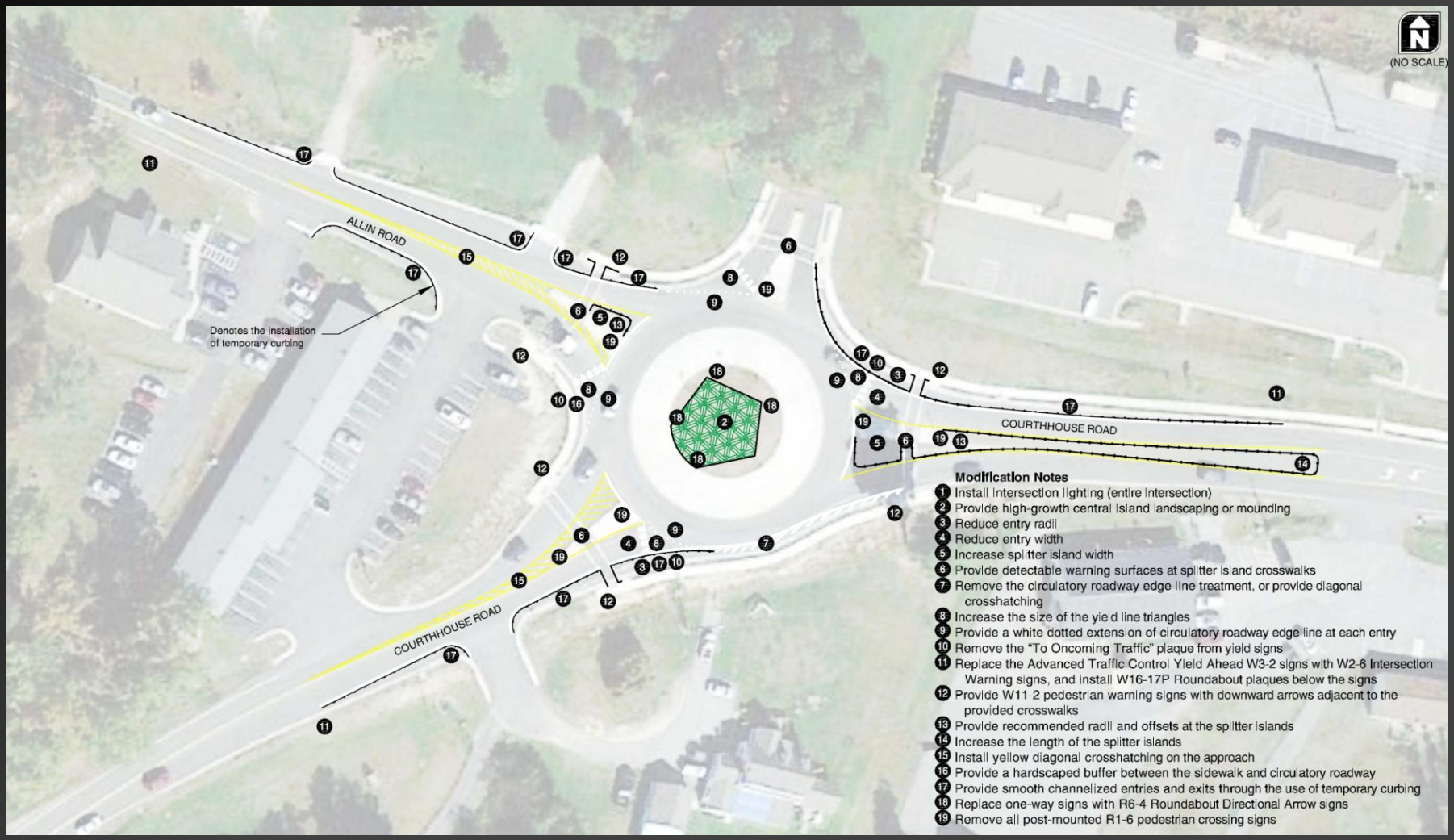




Alternatives Considered

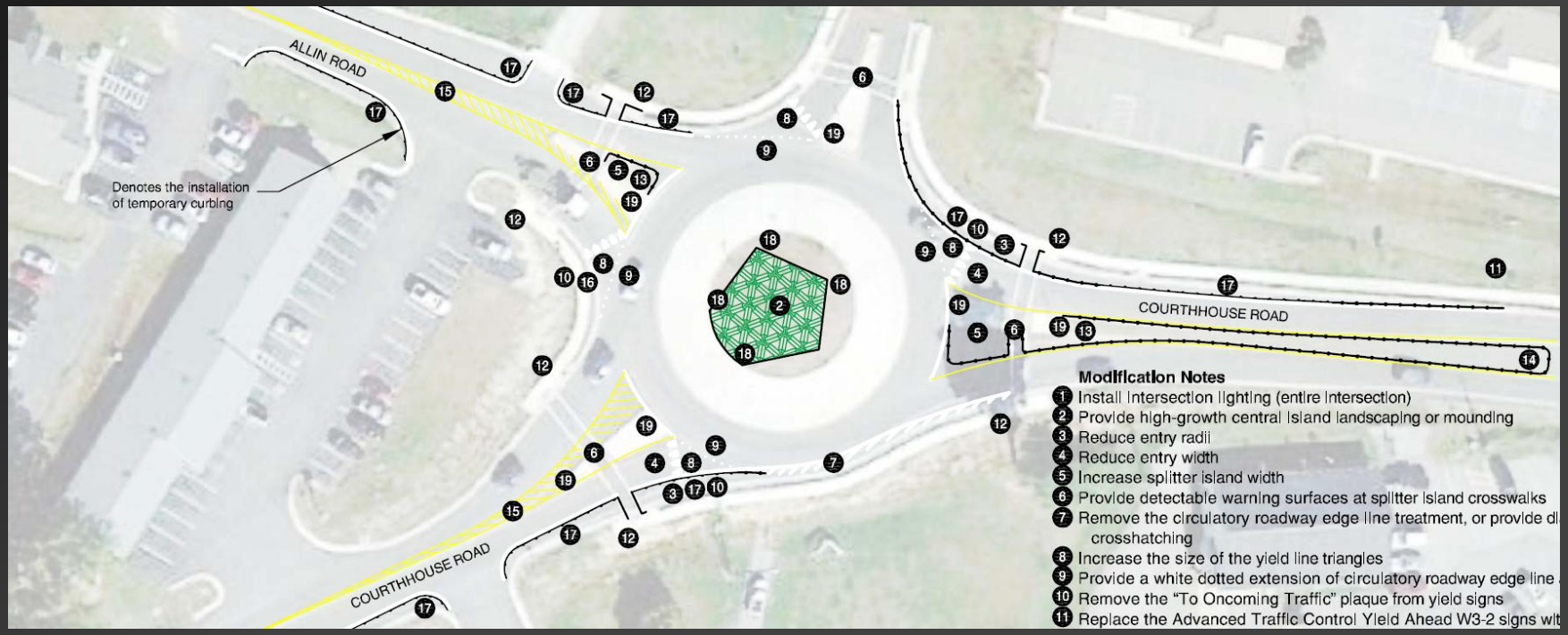
- Temporary Modifications
  - Address as many of the identified deficiencies as possible
  - No impacts to current existing curbs/drainage or R/W
  - Estimated Cost - $400,000
- Permanent Re-design
  - Address all identified deficiencies
  - Re-design approach geometrics as needed to meet all design objectives
  - Estimated Cost - $660,000

Temporary Modifications

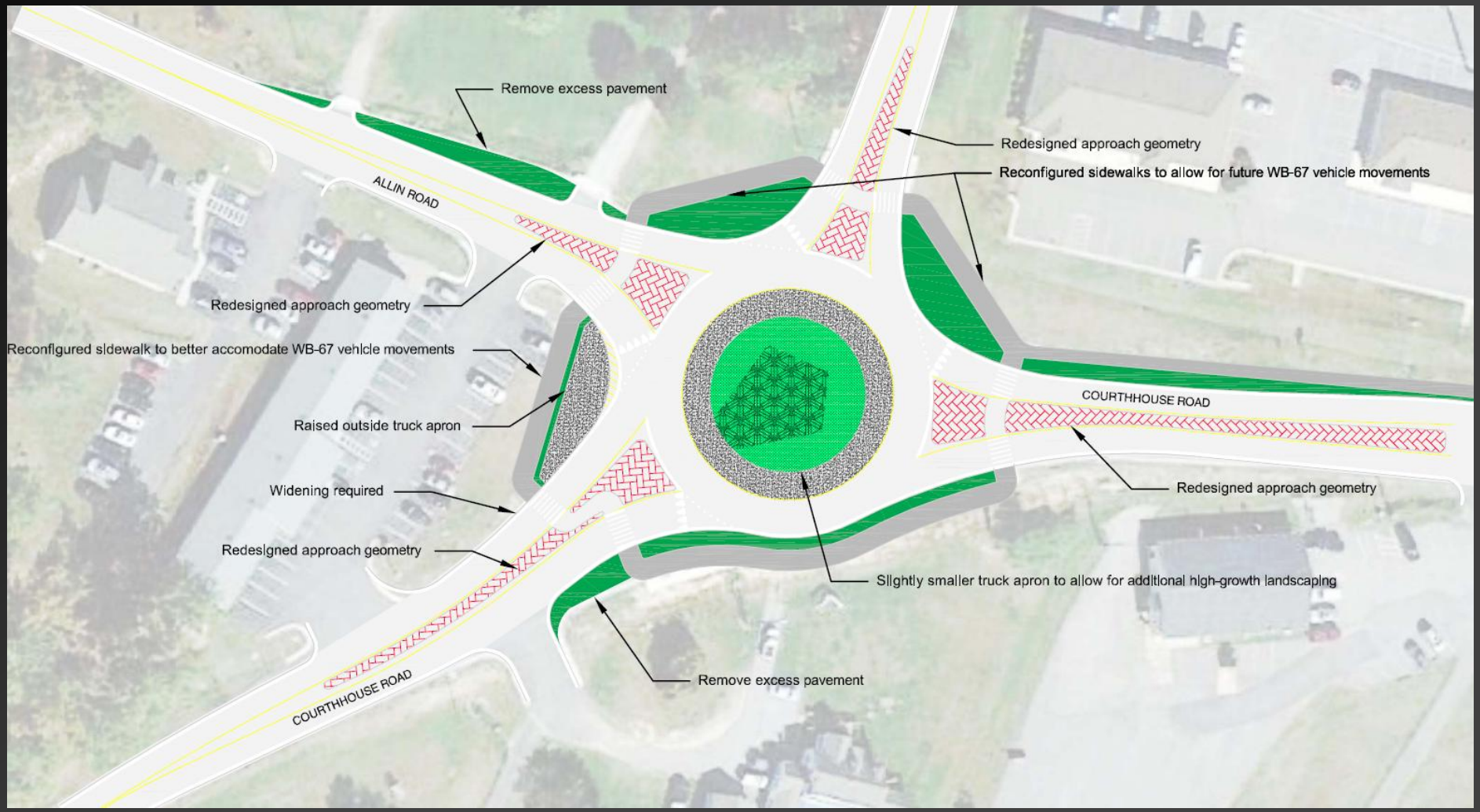


Temporary Modifications

- Install intersection lighting
- Use semi-permanent curb and striping to:
  - Provide speed control
  - Improve splitter island design
  - Provide smooth channelized entries and exits
- Minor signing/striping changes
- No modification to existing splitter islands or truck apron
- No ROW impacts (stays within existing footprint)

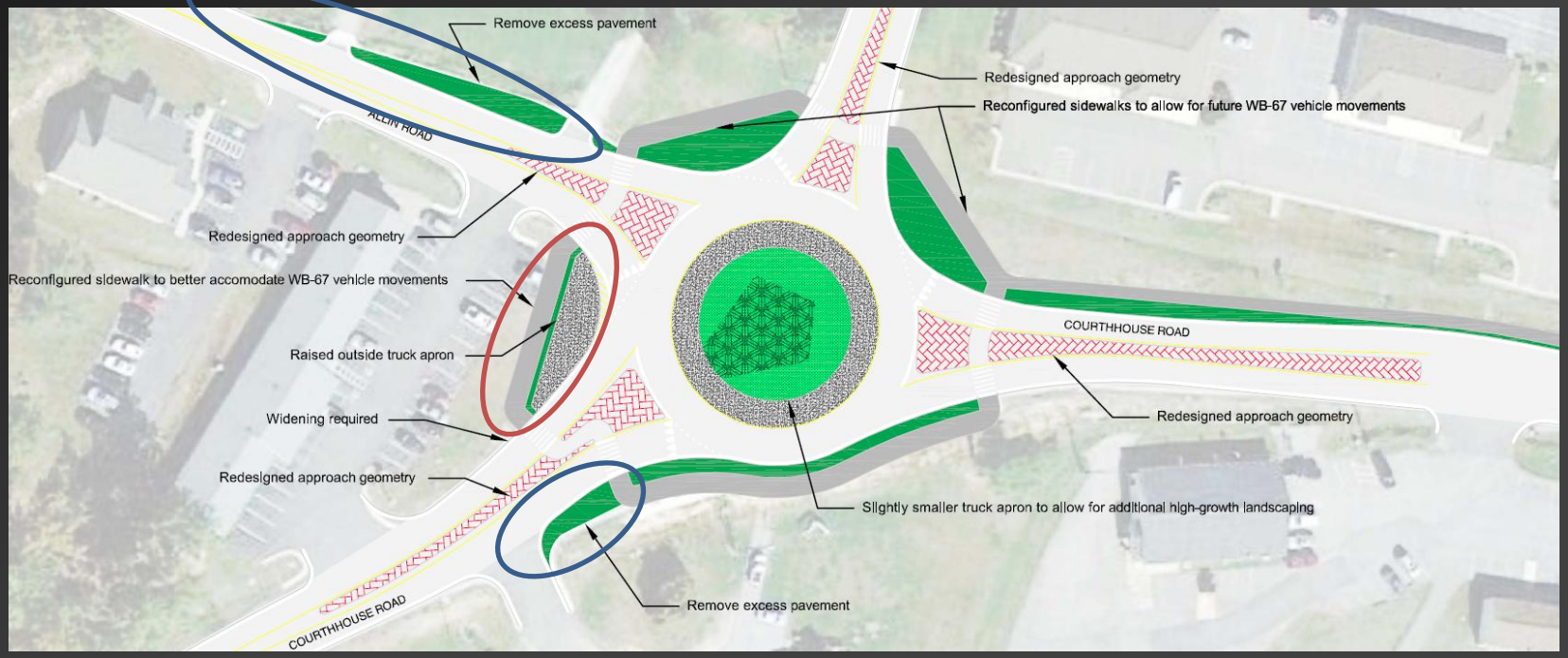


Permanent Single-Lane Roundabout



Redesigned Single-Lane Roundabout

- Reconstruct single-lane roundabout
- Signing/striping changes
- Reconstruct splitter islands
- Modify approach geometries
- R/W impacts
  - SW Quadrant
- Remove excess pavement



VDOT Next Steps

- Move forward with permanent changes and prepare design plans
- Construct with state labor forces and hired equipment labor

QUESTIONS?

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Photo: Lee Rodegerdts