

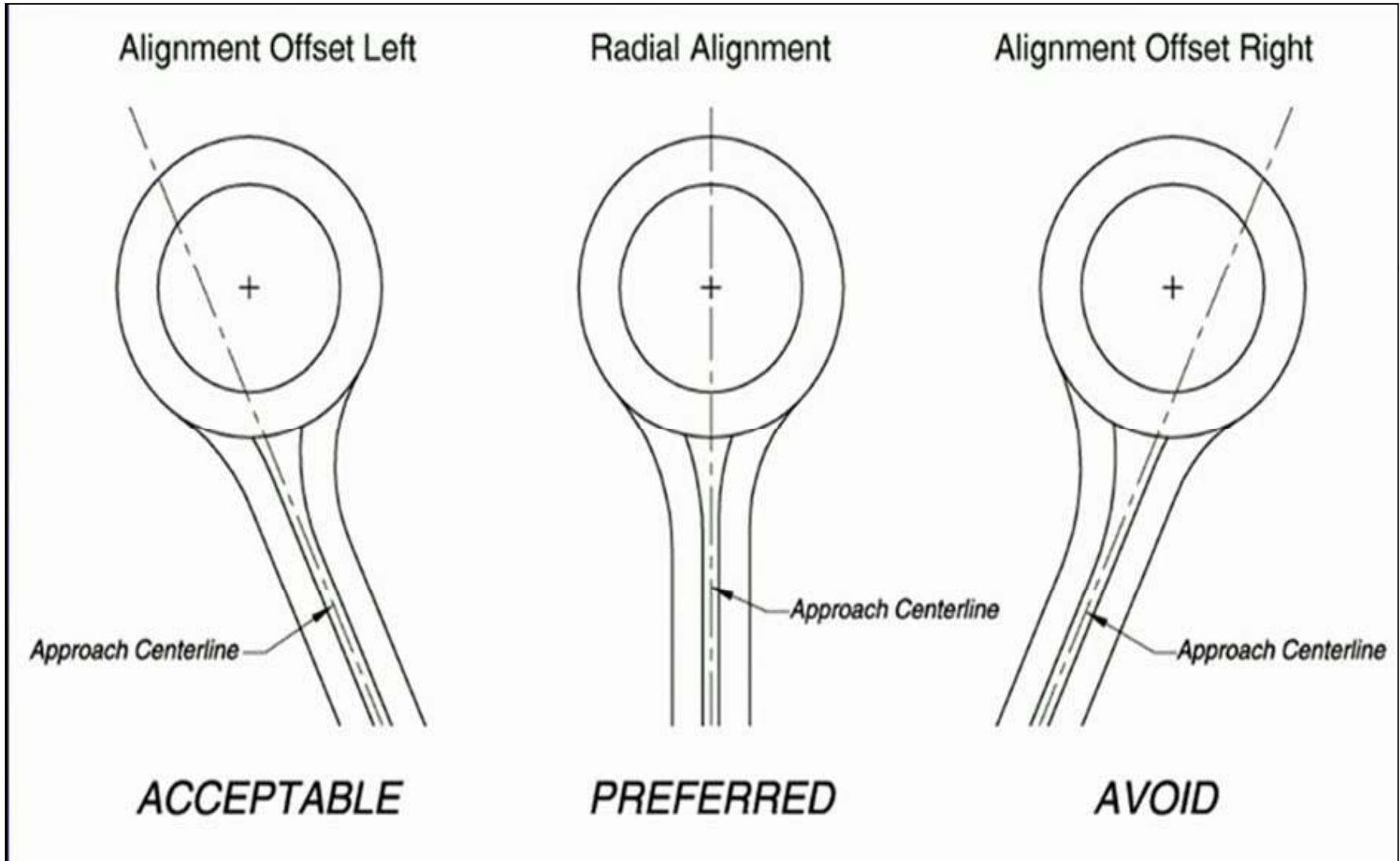
Modern Roundabout Design



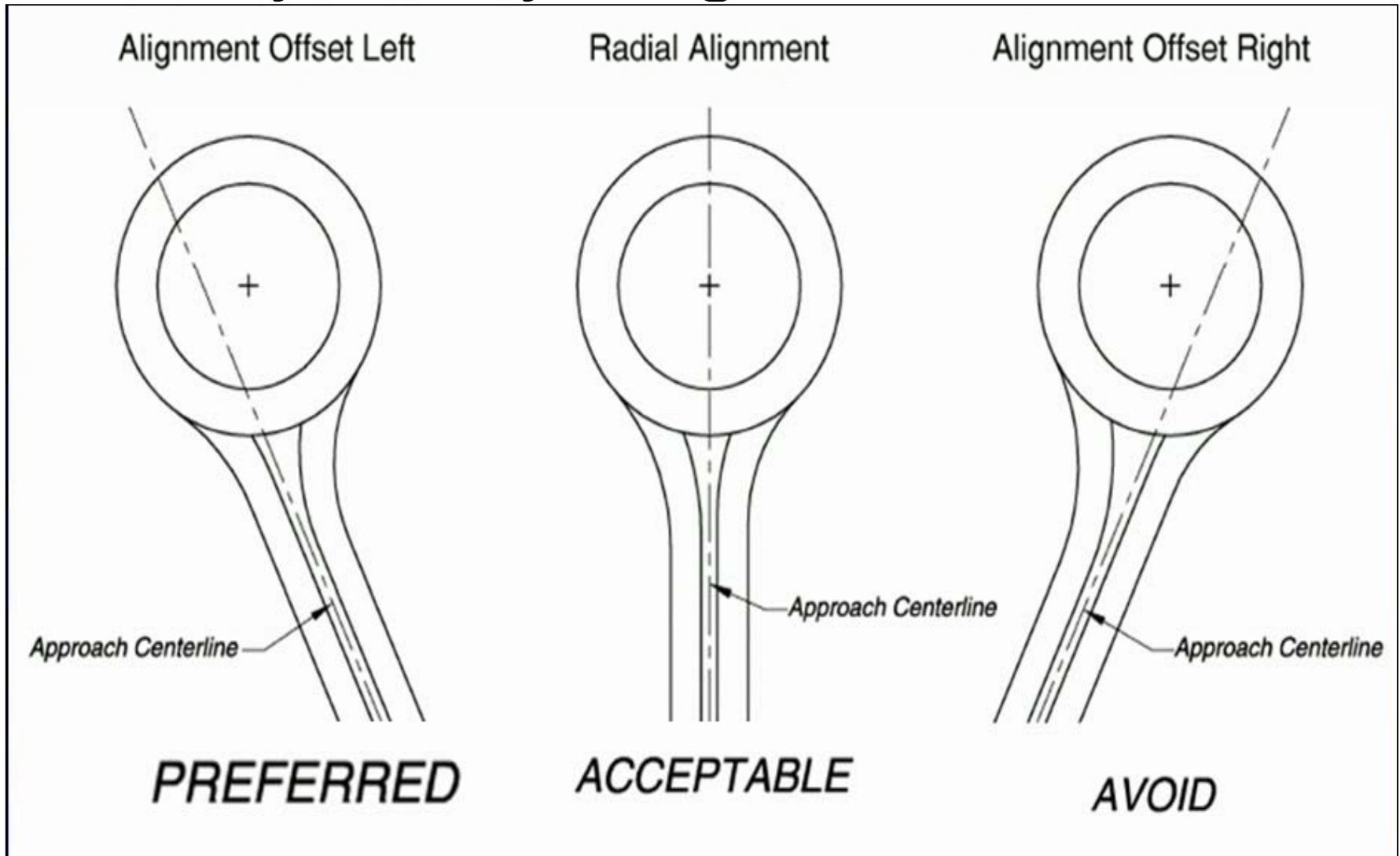
Geometric Summary

- Single lane roundabout – 110' to 150'
- Two lane roundabout – 150' to 230'
- Three lane roundabout – 200' to 260'
- Entry width – 18' practical maximum
- Exit width – Based on design vehicle
- Circulatory roadway width – Based on bus tracking
- Truck apron width – Based on design vehicle tracking

FHWA Recommendations



Offset Left Now Preferred by Many Organizations



Benefits of Left Offset

- Desired deflection is easier to achieve, especially with smaller diameter circle diameters
- Entry path overlap is easier to remove from multi-lane approaches
- Tangential exits (or large radius exits) remove the possibility of exit path overlap

Required Design Data:

- Existing AM and PM turning volumes
- Design year AM and PM turning volumes
 - Check that design year flows do not exceed the capacity of the surrounding network... it may never see that traffic.
- Design vehicle
- Base plan with defined constraints

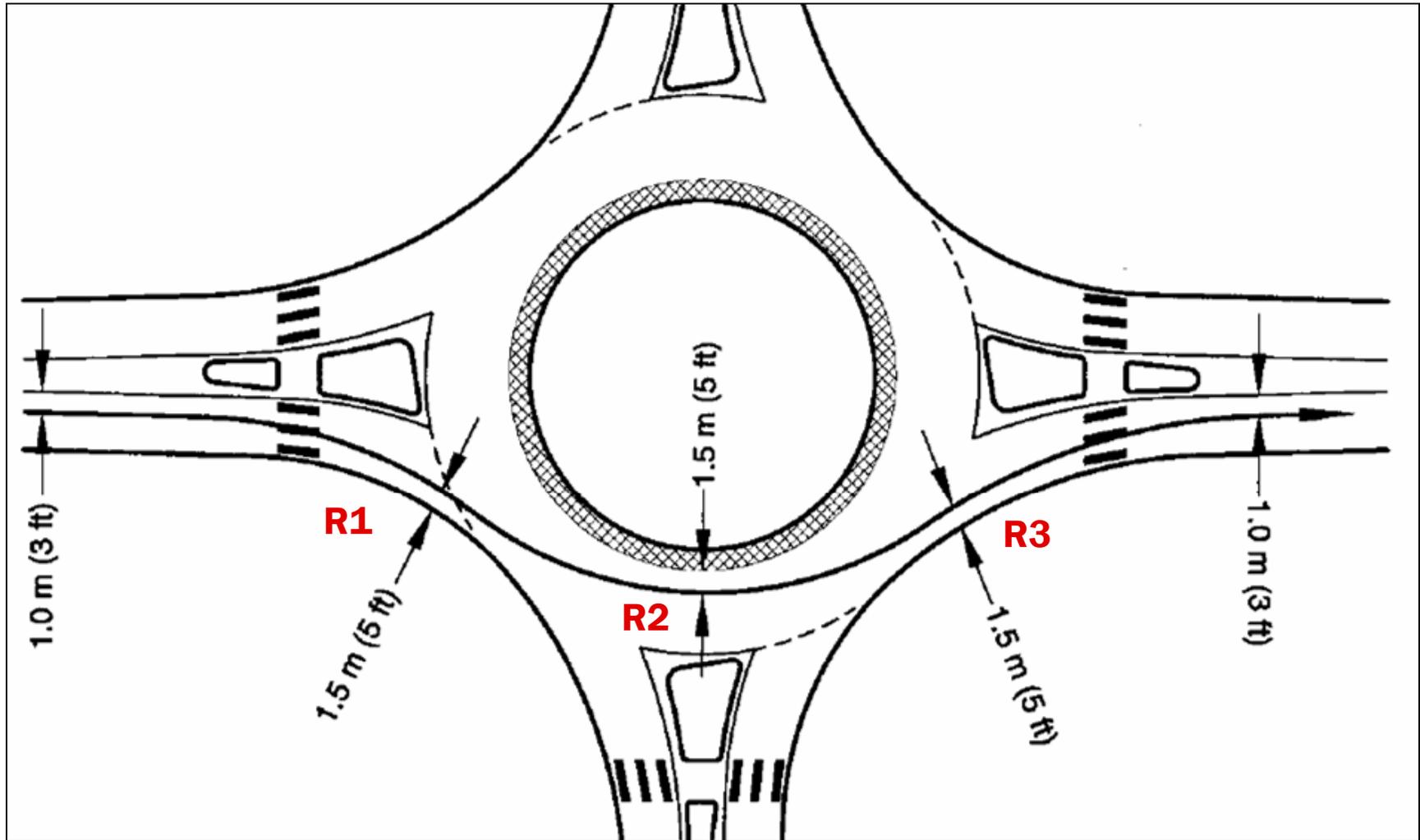
Sizing your roundabout

- Most roundabouts are 100 to 200 ft in diameter.
 - The minimum inscribed diameter to accommodate a WB-67 should be greater than 110 feet.
 - A smaller inscribed diameter may not allow for the WB-67 to make a left turn or U-Turn... which may be fine.
- Circulatory road width should readily accommodate buses.

Roundabout speeds – circulating vs. entering

- Conflicting speeds are optimally separated by no more than 6 mph.
 - But life is rarely optimal...
- A maximum speed difference of 12 mph is suggested.

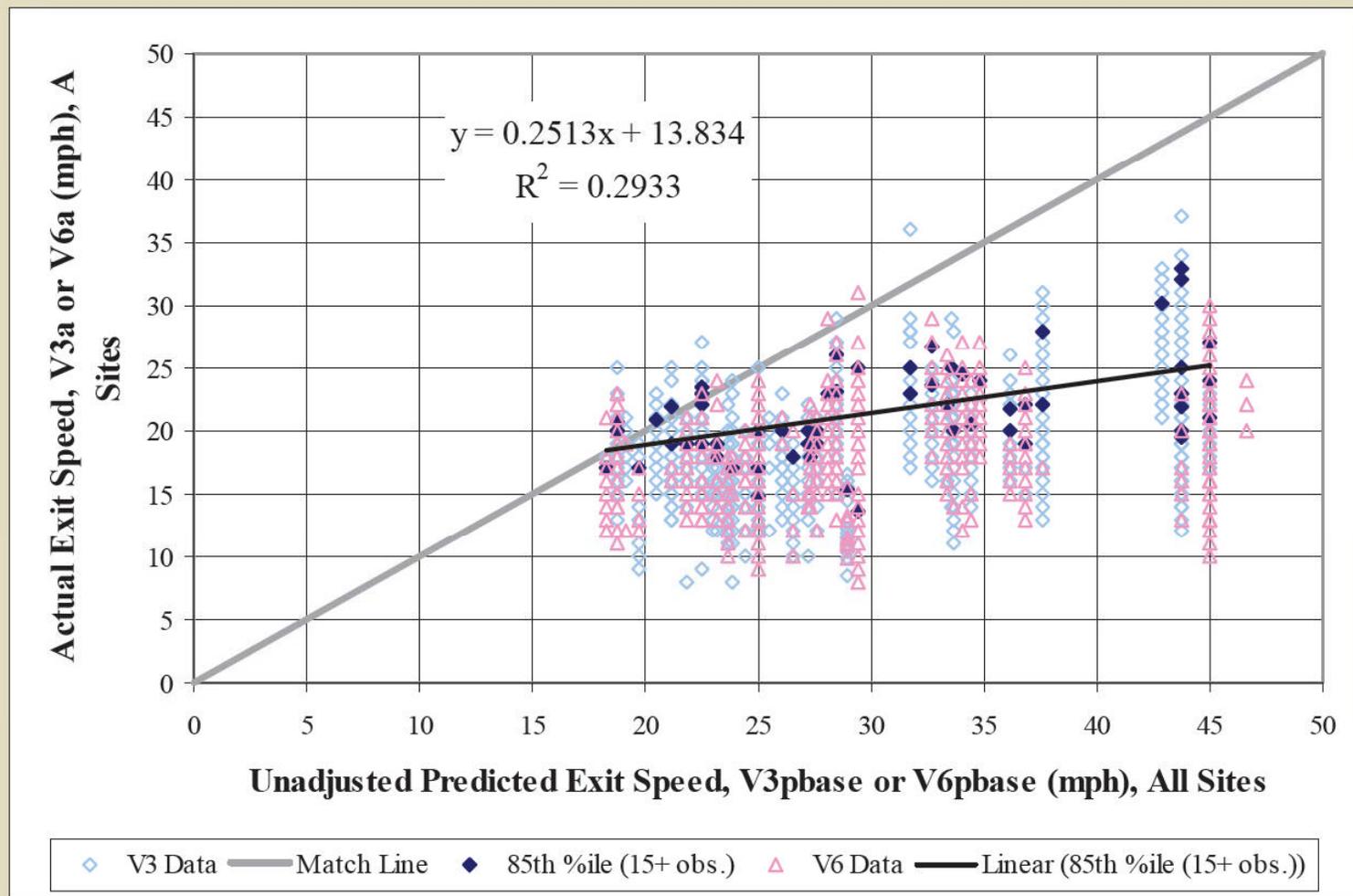
Roundabout speeds - Fastest Path



Note: R3 only matters if you haven't done your job with R1 or 2...
(R2 speed + possible acceleration to crosswalk is reality)

Measuring R3 *DOES NOT* accurately predict Exit Speed

Design speed modeling: Exit speed (all sites), unadjusted



Exit Speed is based on circulating speed plus acceleration

Proposed exit speed equation

$$V_3 = \min \left\{ \begin{array}{l} V_{3pbase} \\ \frac{1}{1.47} \sqrt{(1.47V_2)^2 + 2a_{23}d_{23}} \end{array} \right.$$

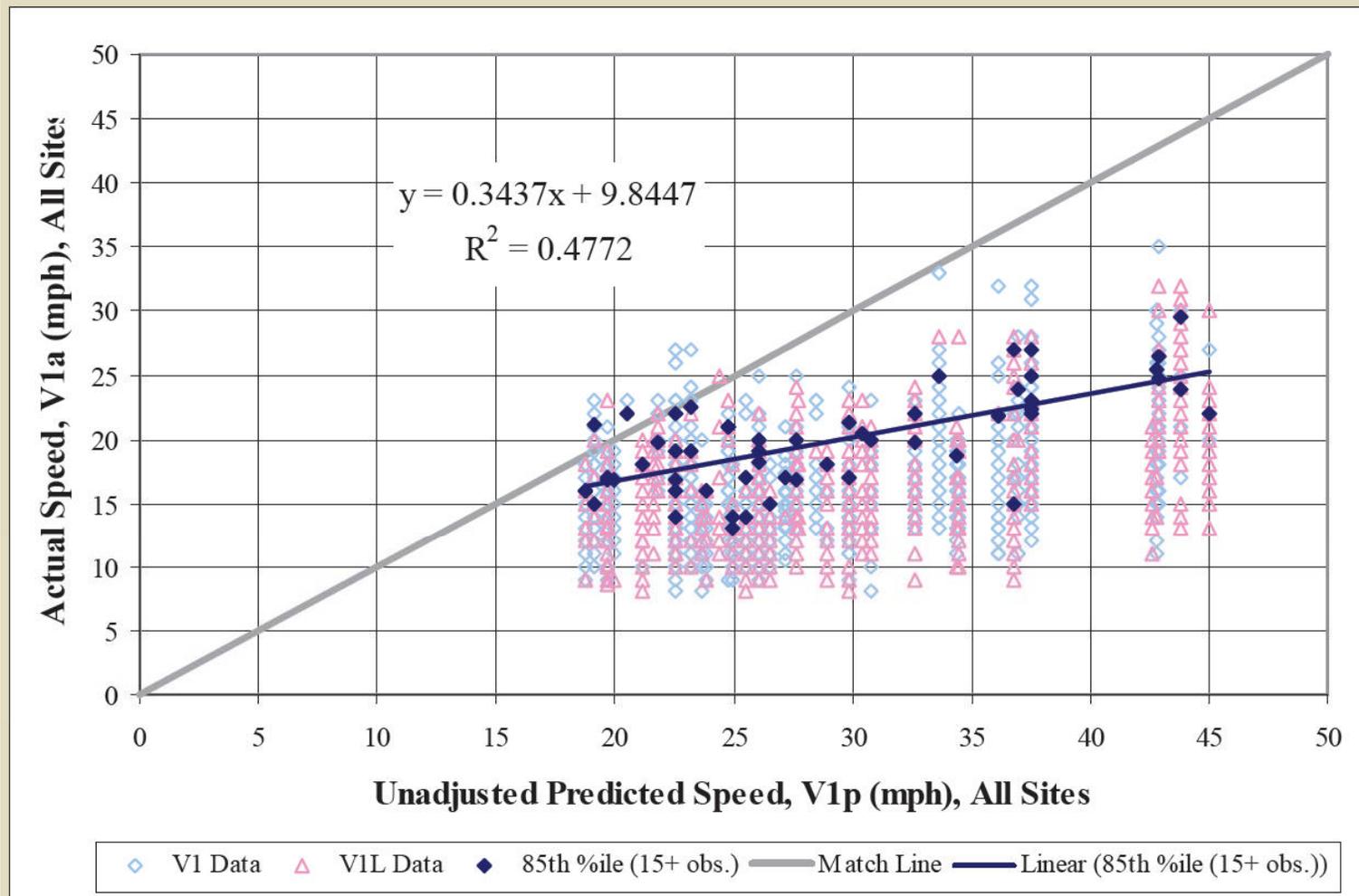
Speed where exit radius is limiting factor

Speed where circulating speed and acceleration distance is limiting factor

- where:
- V_3 = V_3 speed, in mph
- V_{3pbase} = V_3 speed predicted based on path radius, in mph
- V_2 = V_2 speed predicted based on path radius, in mph
- a_{23} = acceleration along the length between the midpoint of V_2 path and the point of interest along V_3 path = **6.9 ft/s²**
- d_{23} = distance between midpoint of V_2 path and point of interest along V_3 path, in ft

Measuring R1 *DOES NOT* accurately predict Entry Speed

Design speed modeling: Entry speed (all sites), unadjusted



Entry Speed is based on driver's estimated speed in roundabout

Proposed entry speed equation

$$V_1 = \min \left\{ \begin{array}{l} V_{1pbase} \\ \frac{1}{1.47} \sqrt{(1.47V_2)^2 + 2a_{12}d_{12}} \end{array} \right.$$

Speed where entry radius is limiting factor

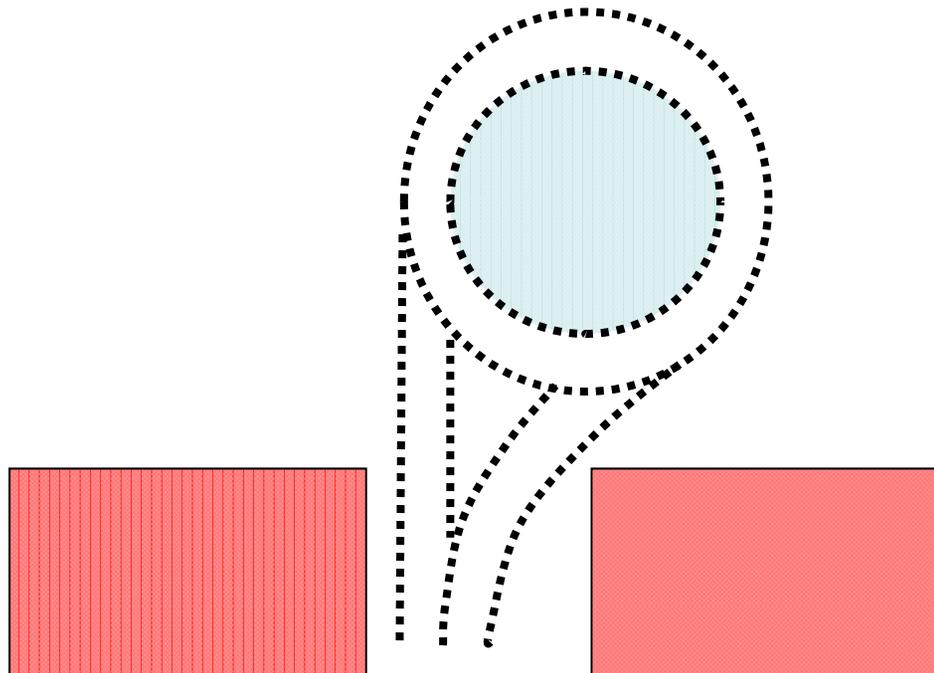
Speed where circulating speed and deceleration distance is limiting factor

- where:
- V_1 = V_1 speed, in mph
- V_{1pbase} = V_1 speed predicted based on path radius, in mph
- V_2 = V_2 speed predicted based on path radius, in mph
- a_{12} = deceleration between the point of interest along V_1 path and the midpoint of V_2 path = **-4.2 ft/s²**
- d_{12} = distance along the vehicle path between the point of interest along V_1 path and the midpoint of V_2 path, in ft

Where to start...

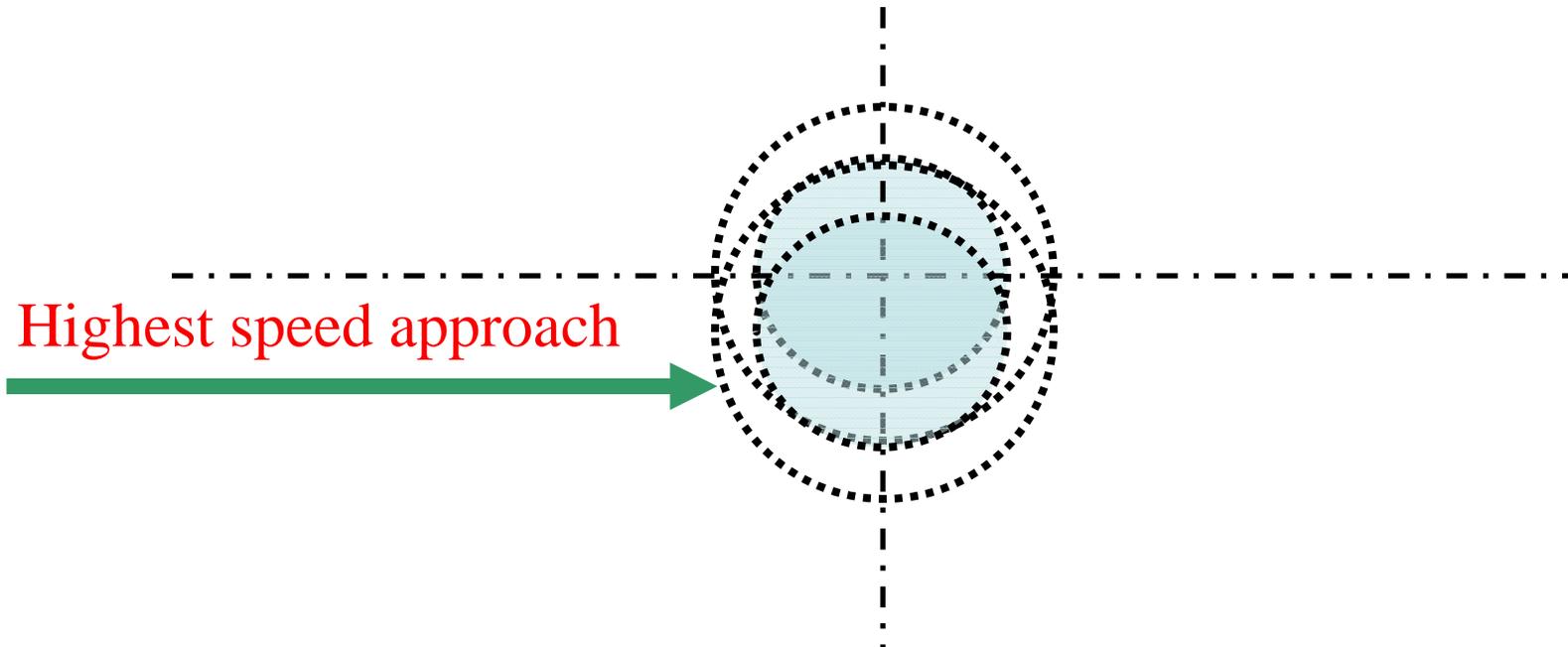
Placing the circle.

- Usually dictated by ROW.
- The most restricted ROW approach gets the straightest exit in that direction.

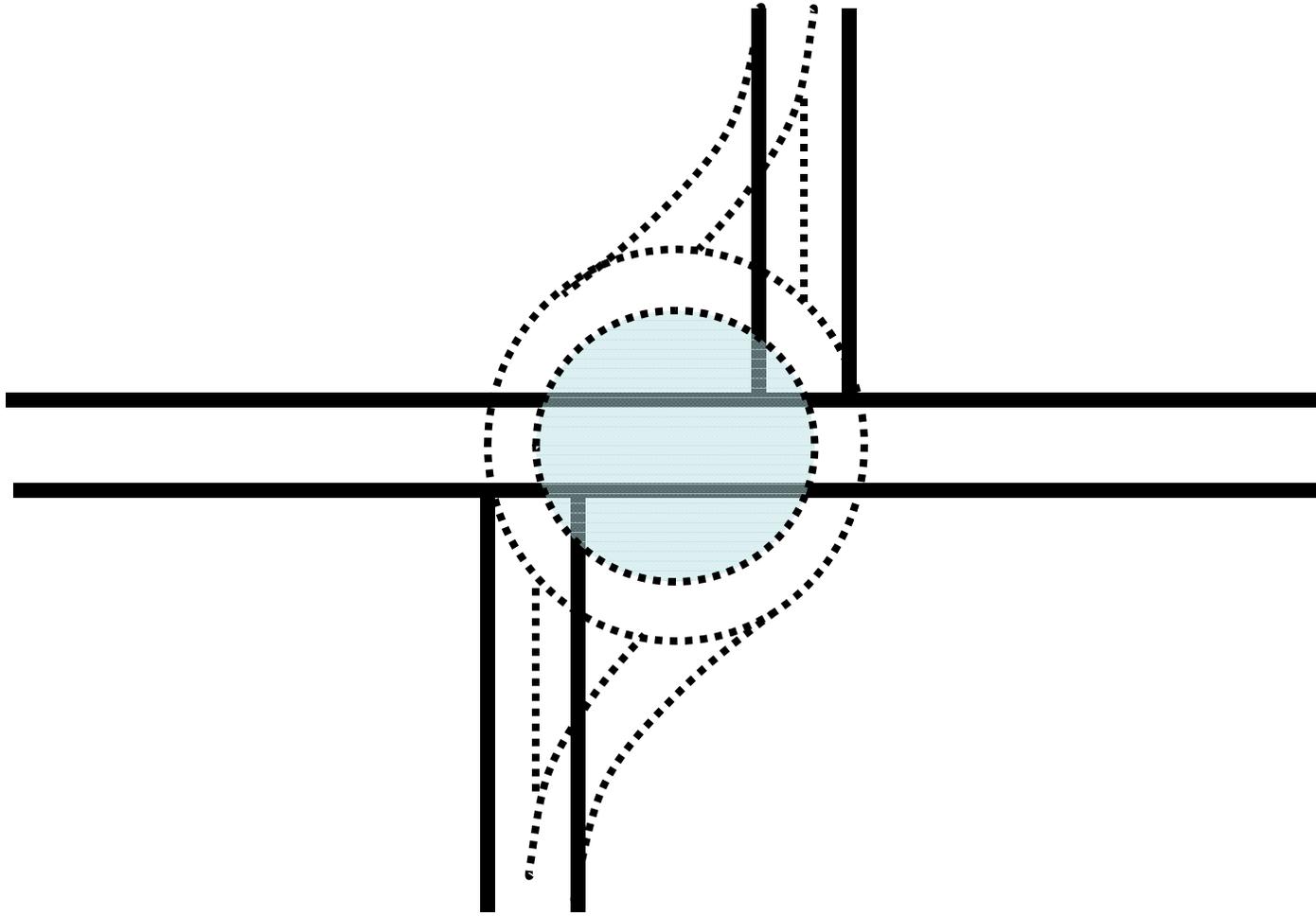


Placing the circle

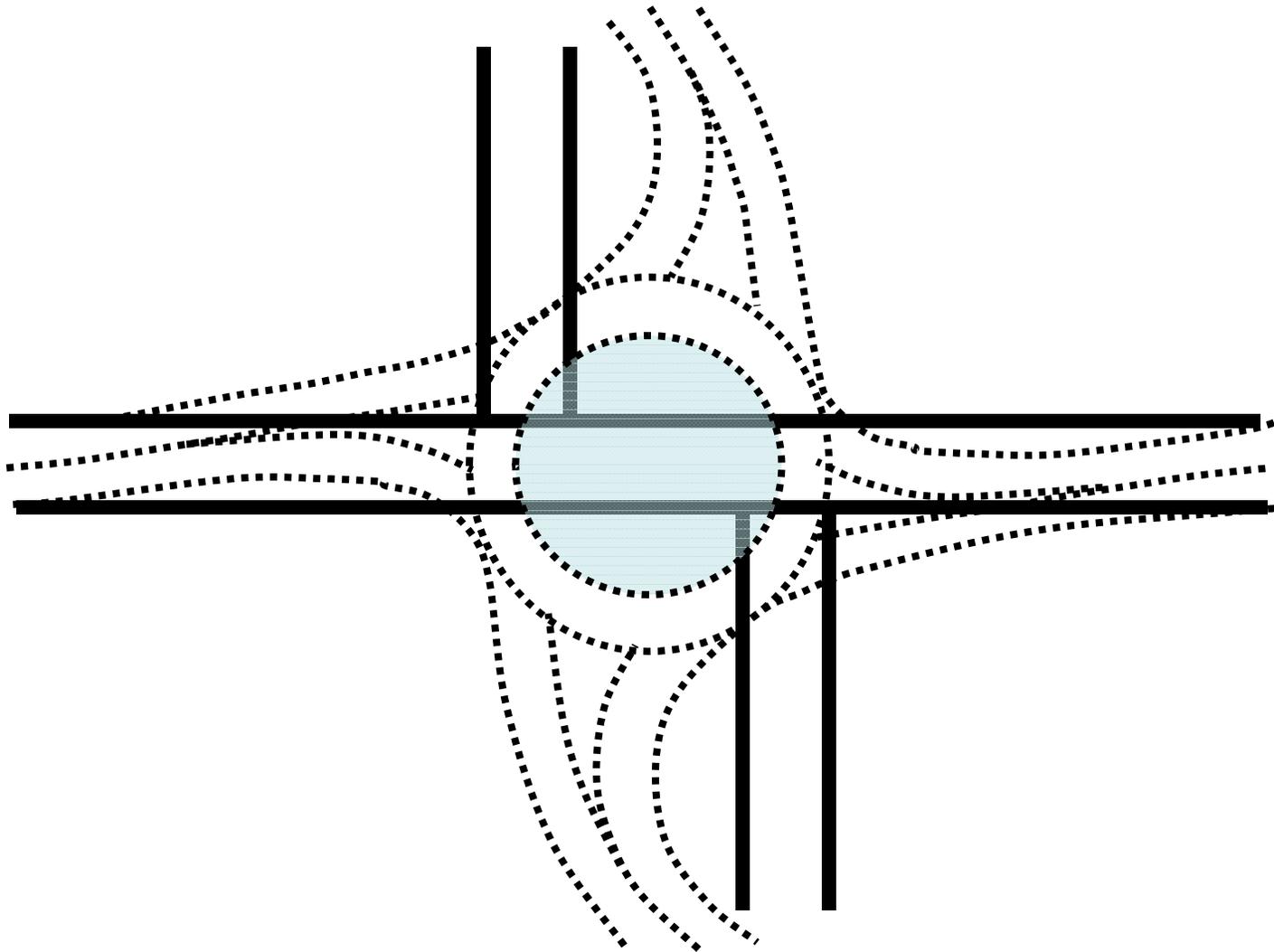
- The highest speed approach gets the most deflection.
 - Shift center of roundabout to the right of the highest speed approach centerline... if possible.



Offset Intersections, The *good*...



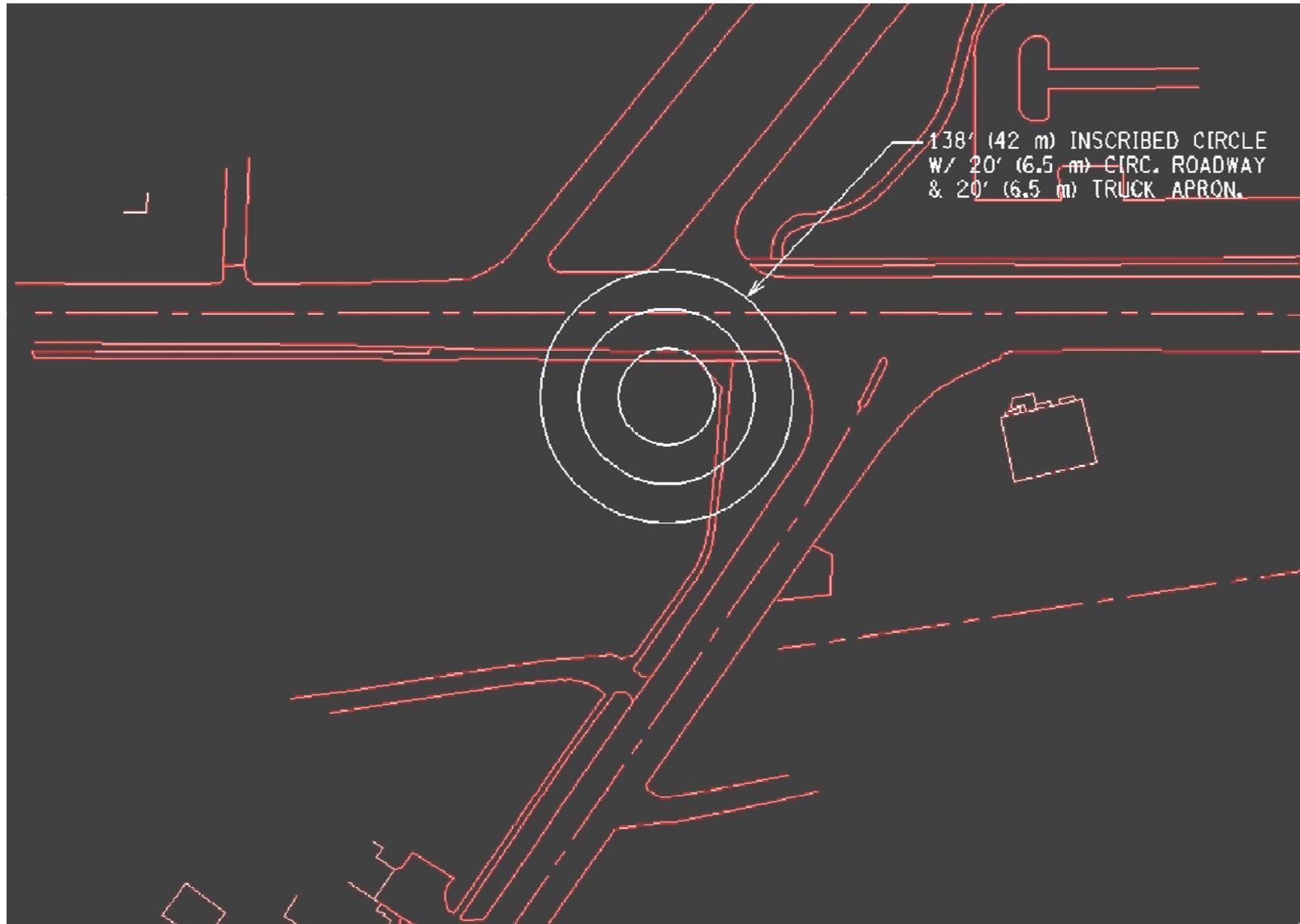
Offset Intersections, The *bad*... (well, let's say difficult.)



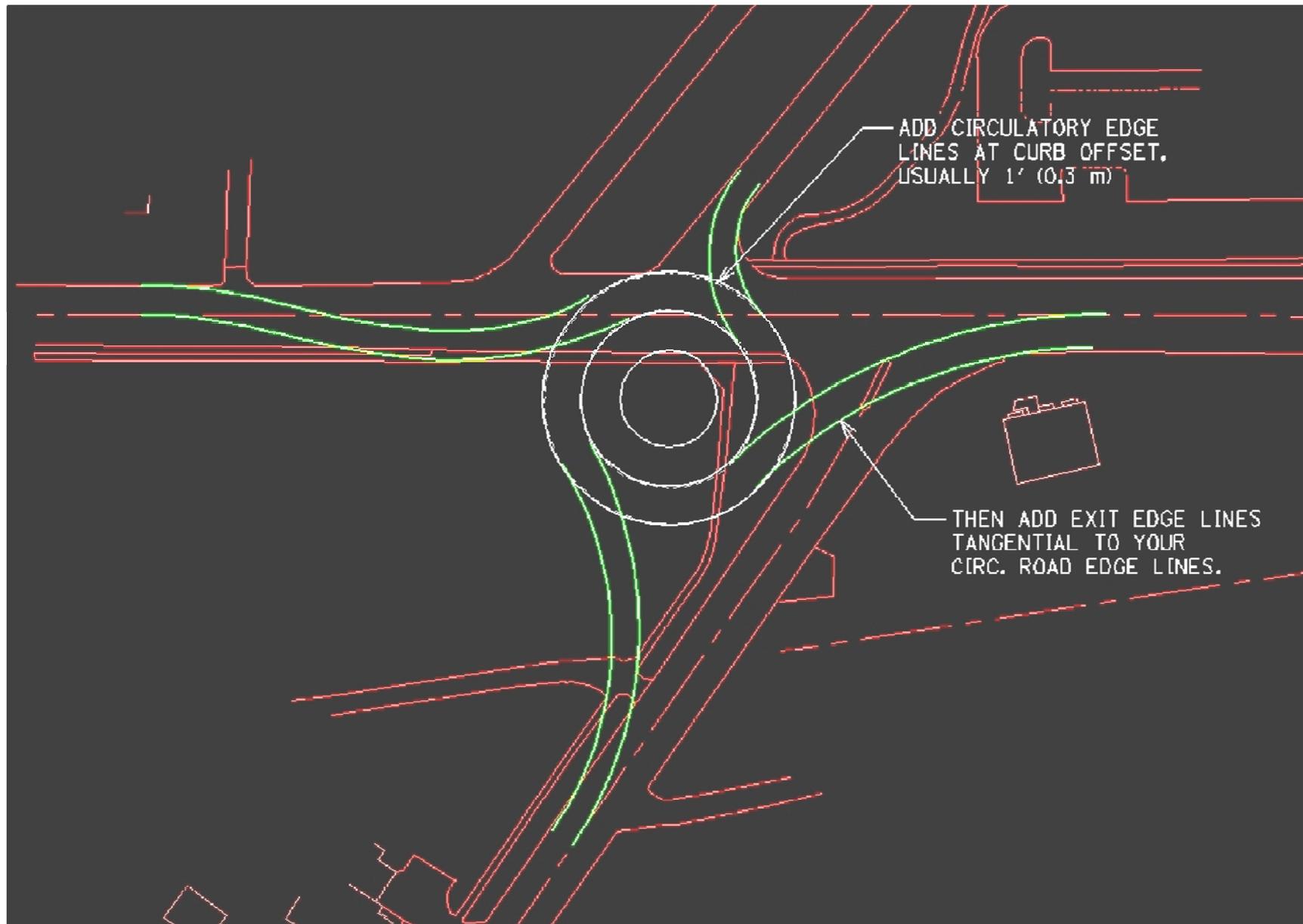
Offset Intersections, The *ugly*...



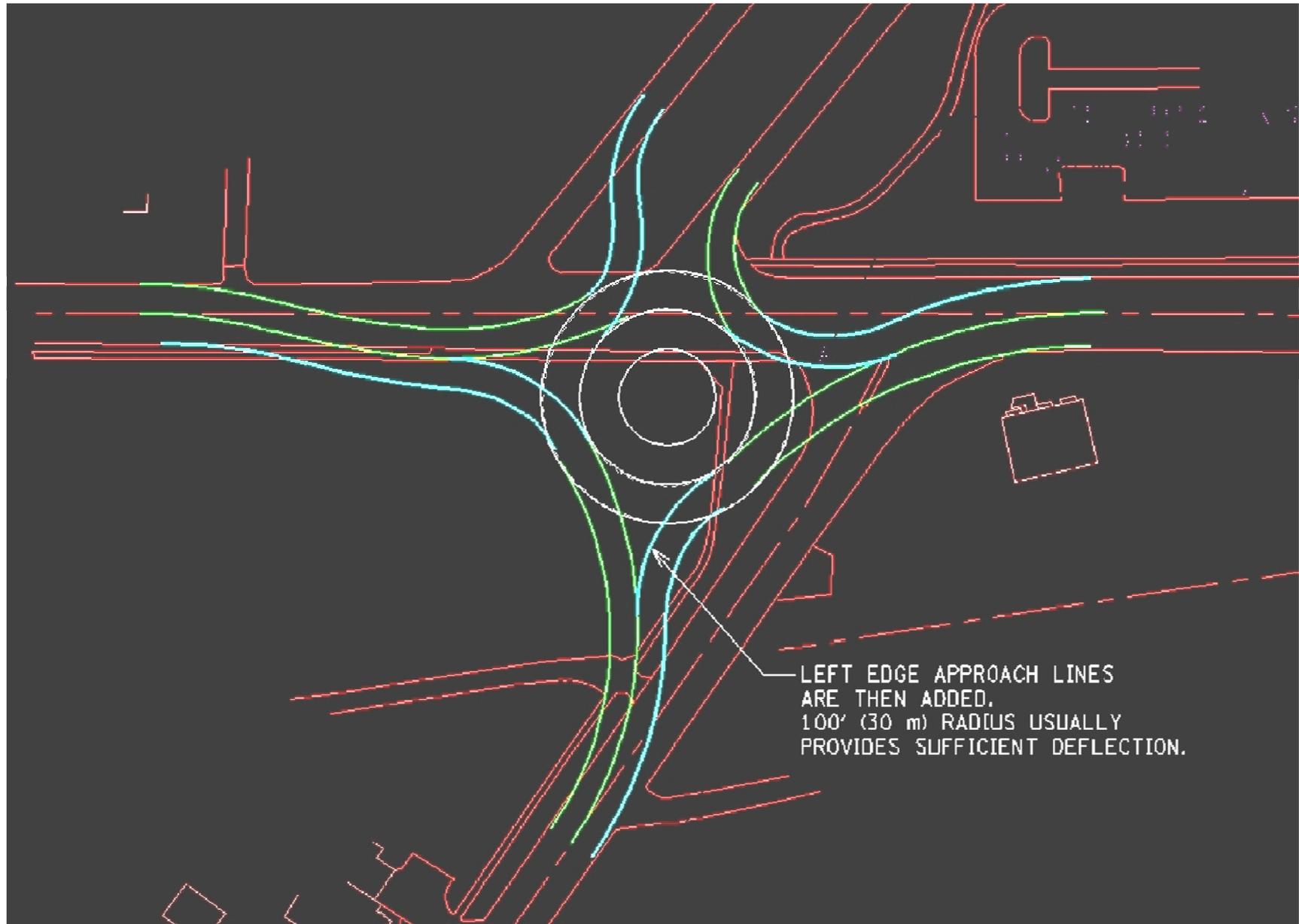
Rt. 9 at Look Park, Northampton



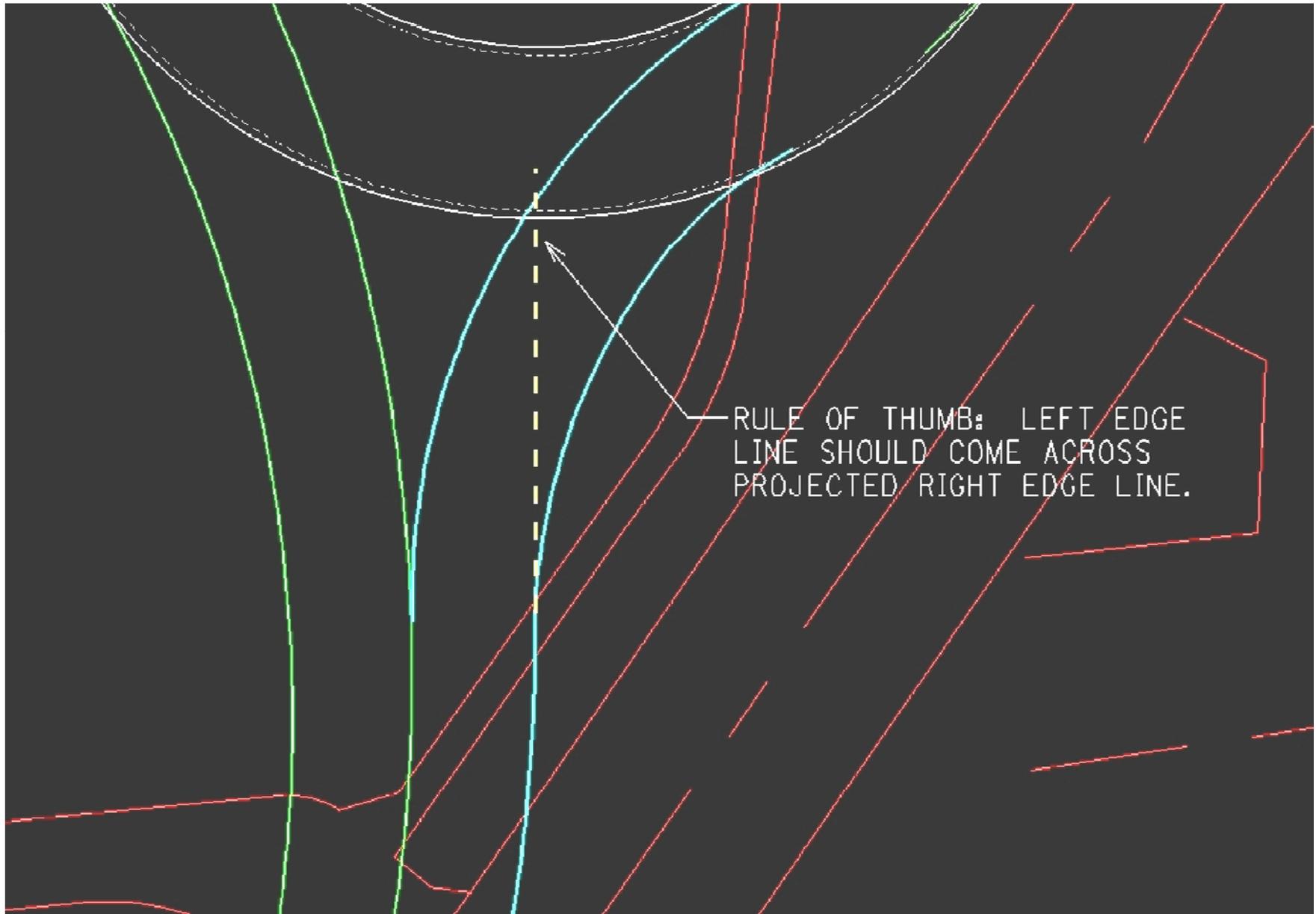
Rt. 9 at Look Park, Northampton



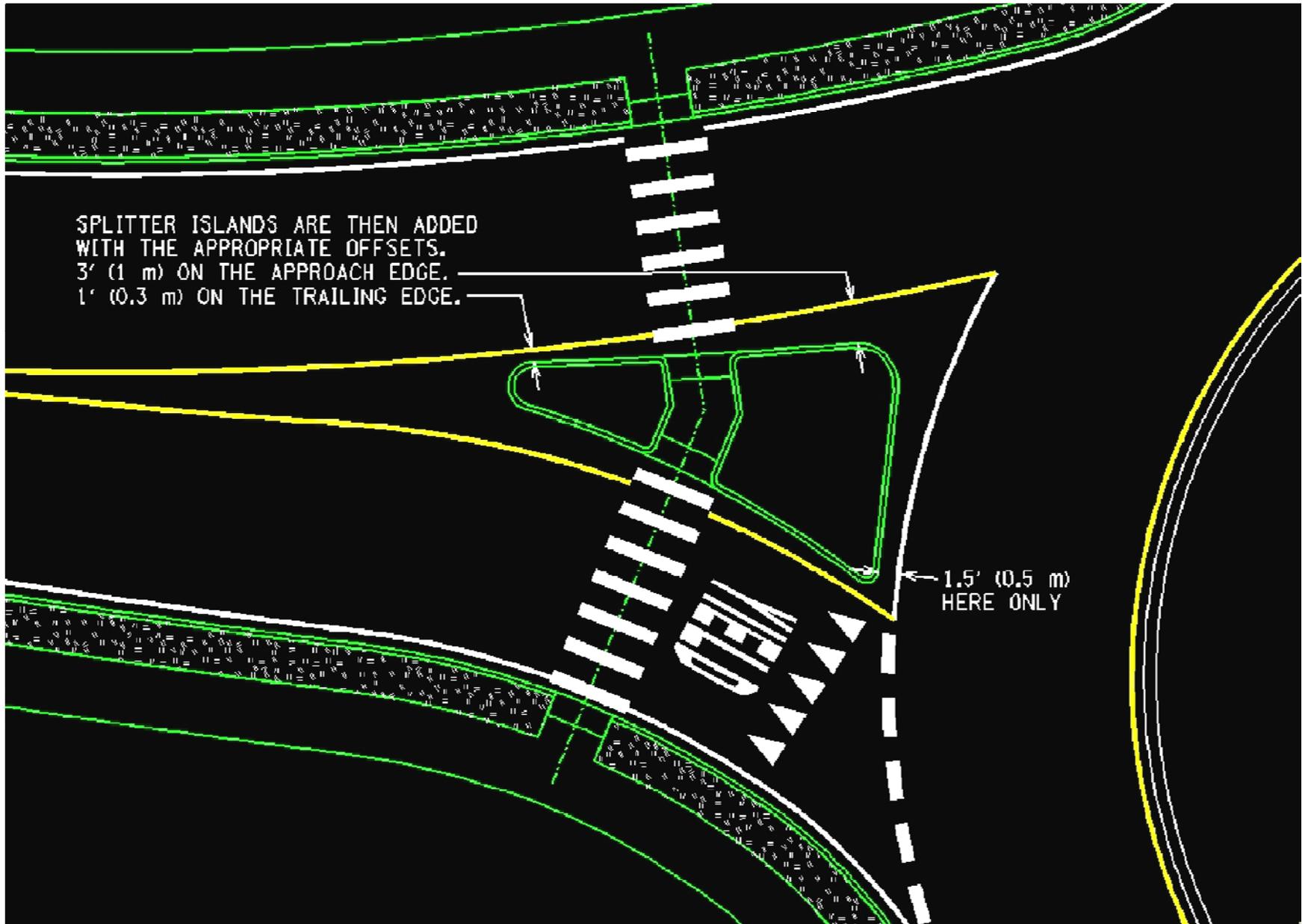
Rt. 9 at Look Park, Northampton



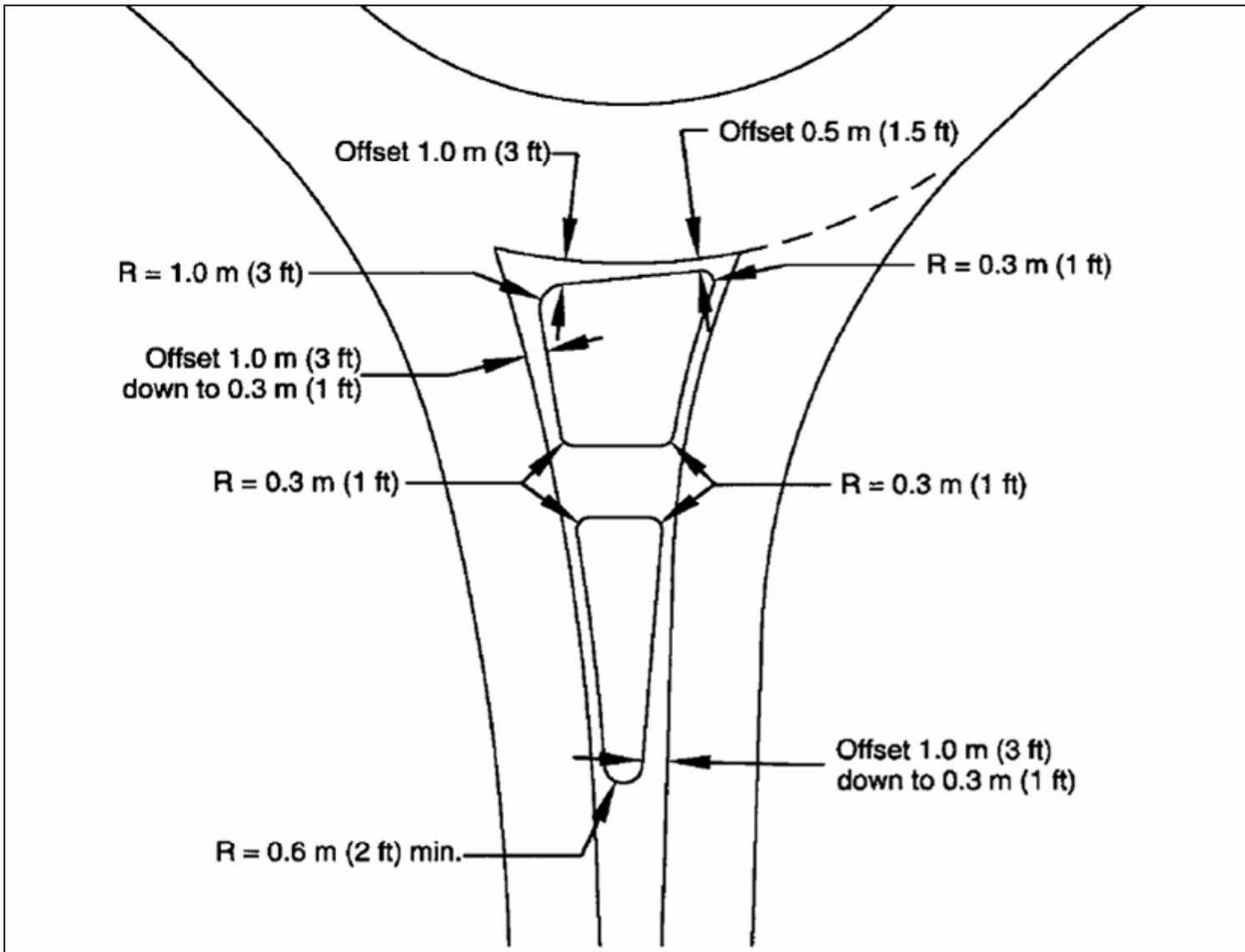
Rt. 9 at Look Park, Northampton



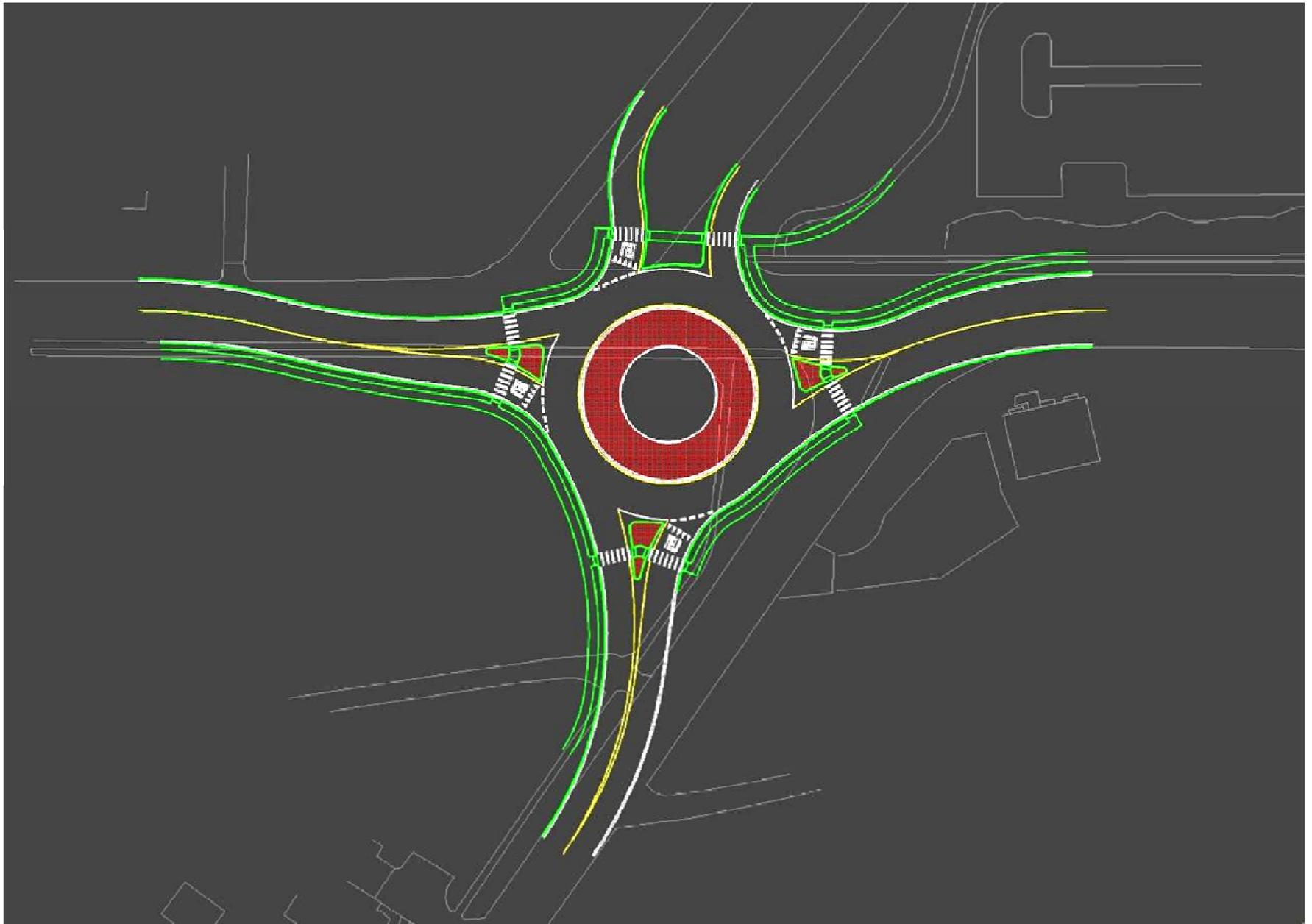
Rt. 9 at Look Park, Northampton



Splitter Island Offsets



Rt. 9 at Look Park, Northampton



Residential access

- Provide turn around.
- Use standard driveway details:
- Only one way access within splitter extents.
- Two way access achieved three possible ways...

Residential access



- Just outside of circulatory roadway, on exit.
- Within circulatory roadway.
- Just outside of splitter.

Commercial access



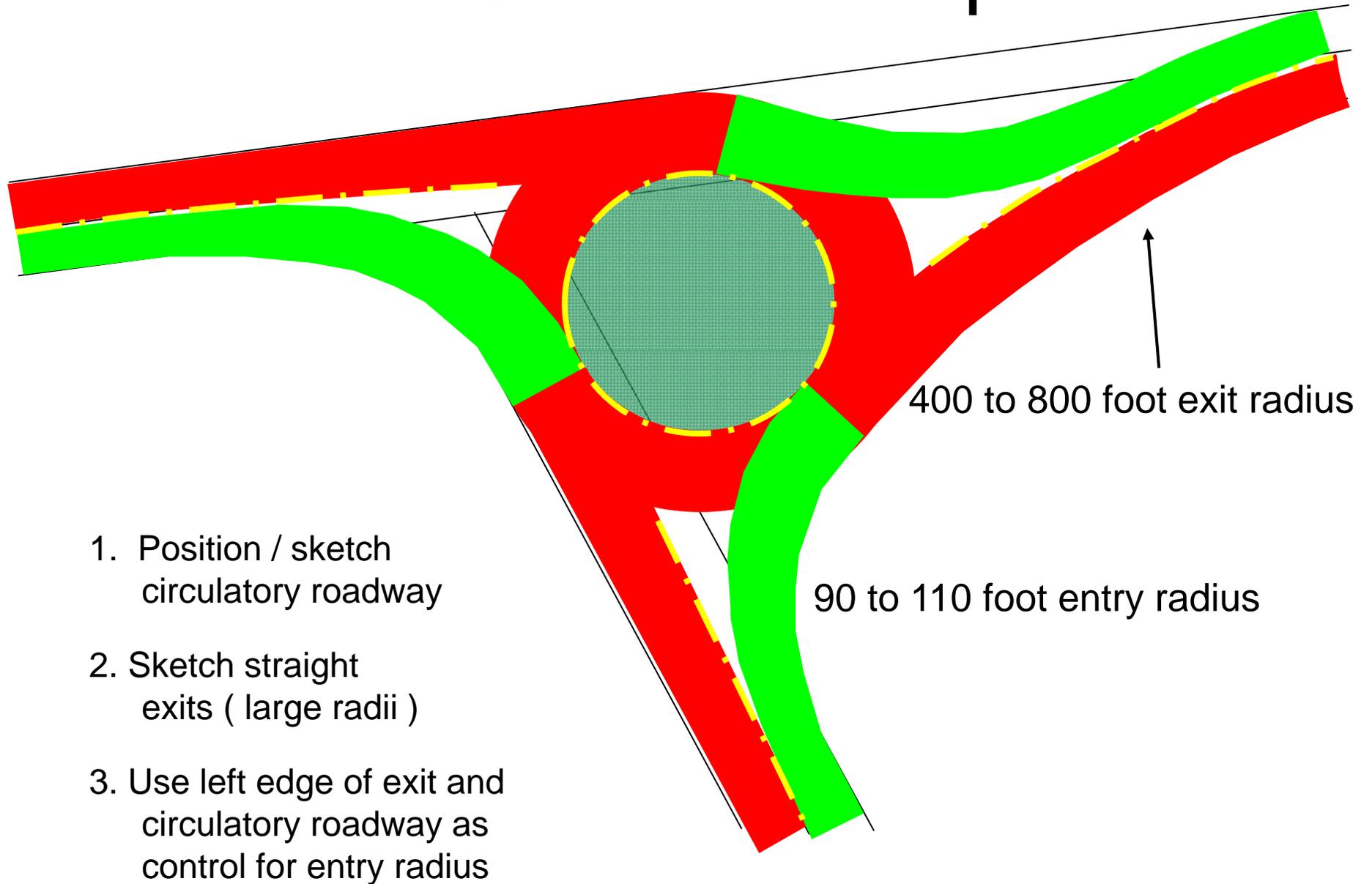
Given approach to roundabout

Right in,
right out

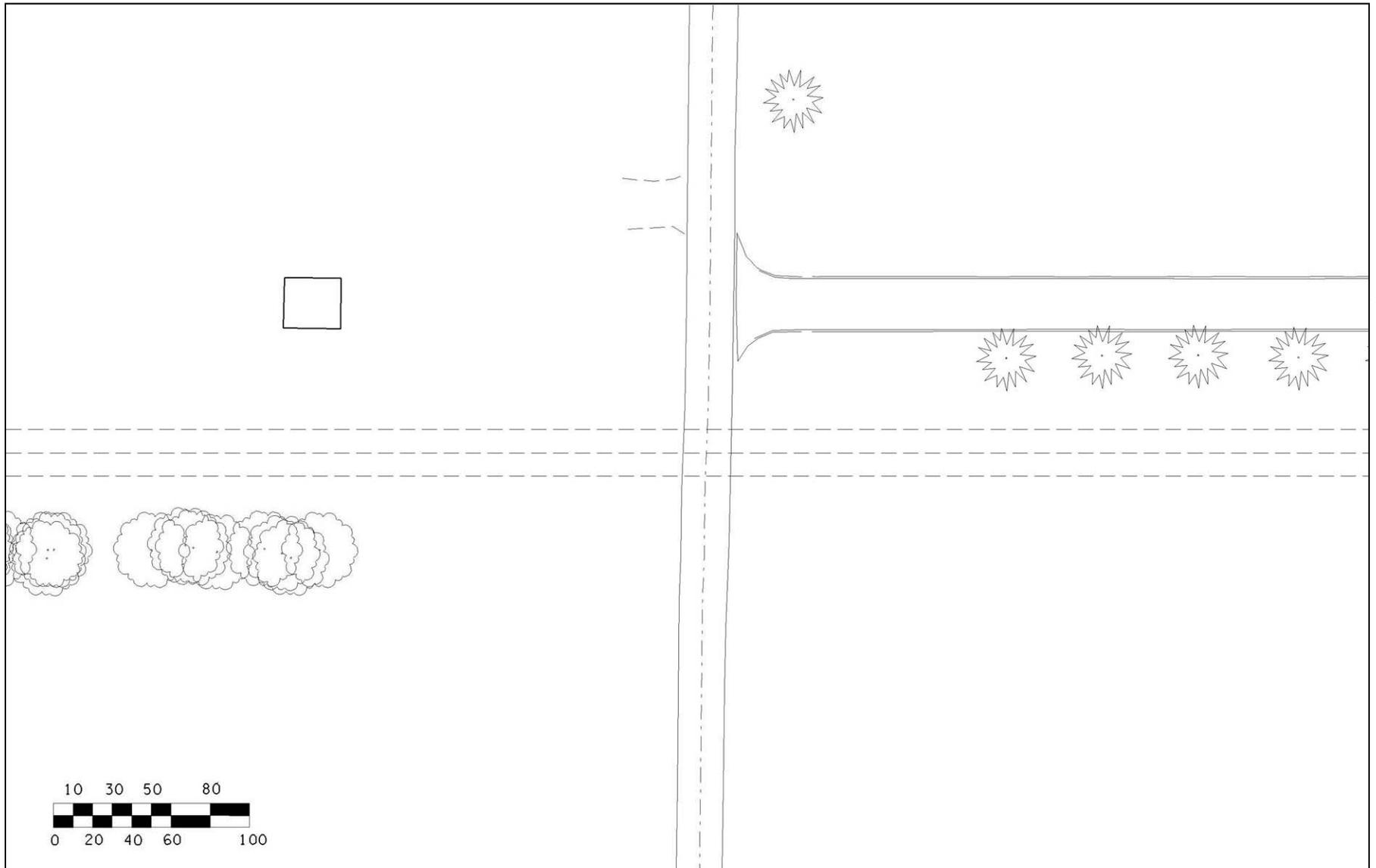
*Let's look over a
few...*

*After we review the
3 sketch principles*

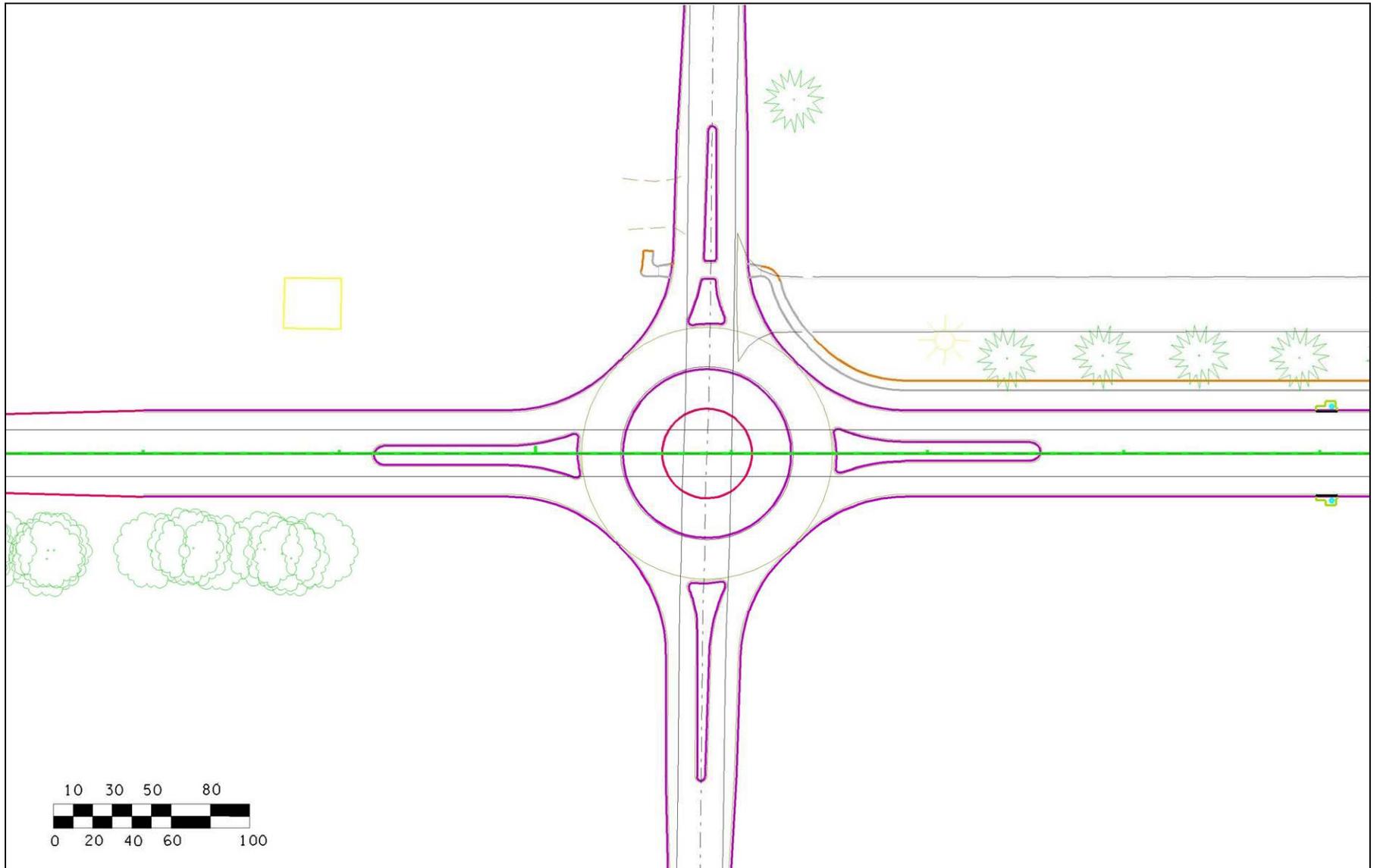
Three Sketch Principles



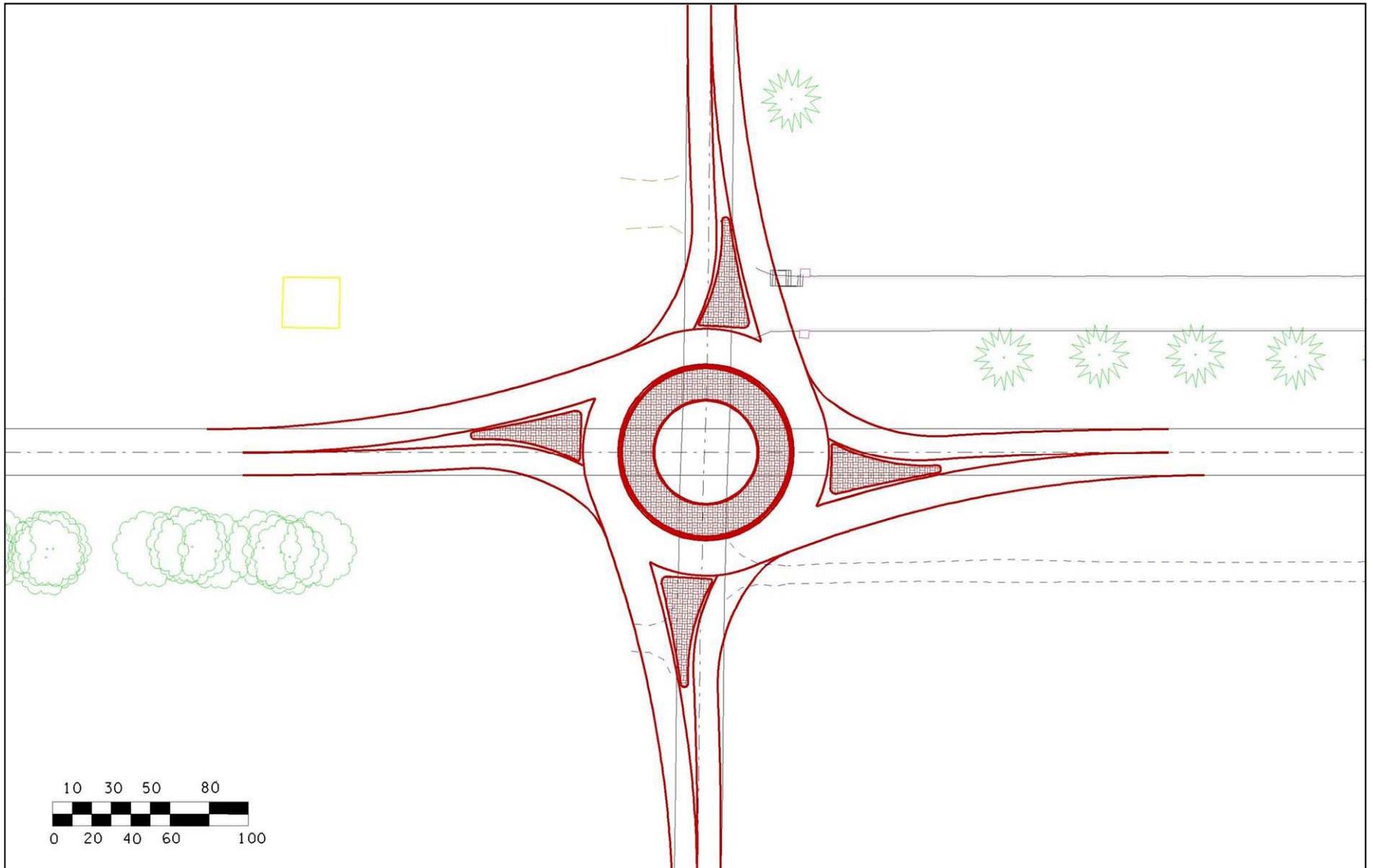
Central City Roundabout 1 of 2



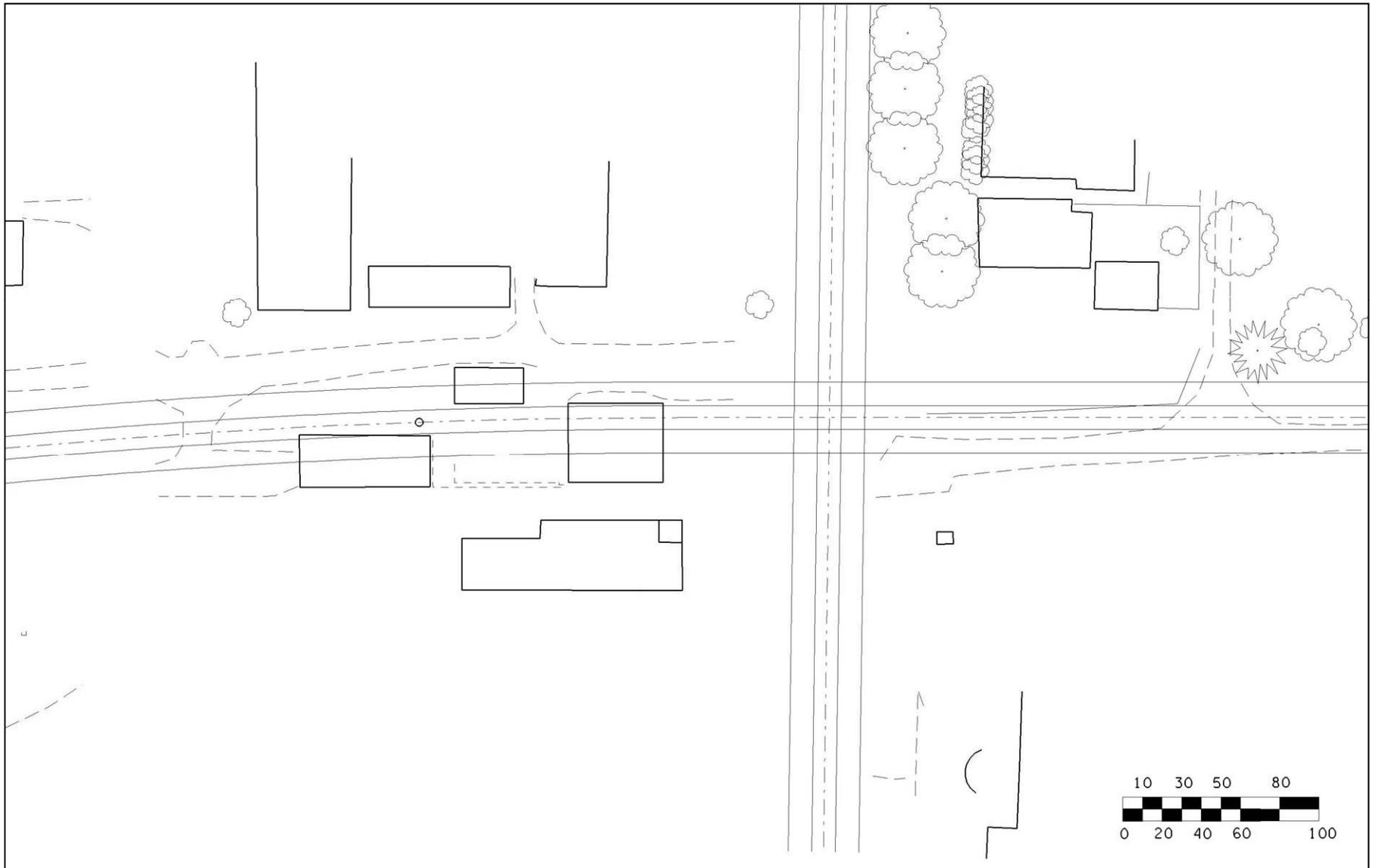
Central City Roundabout 1 of 2



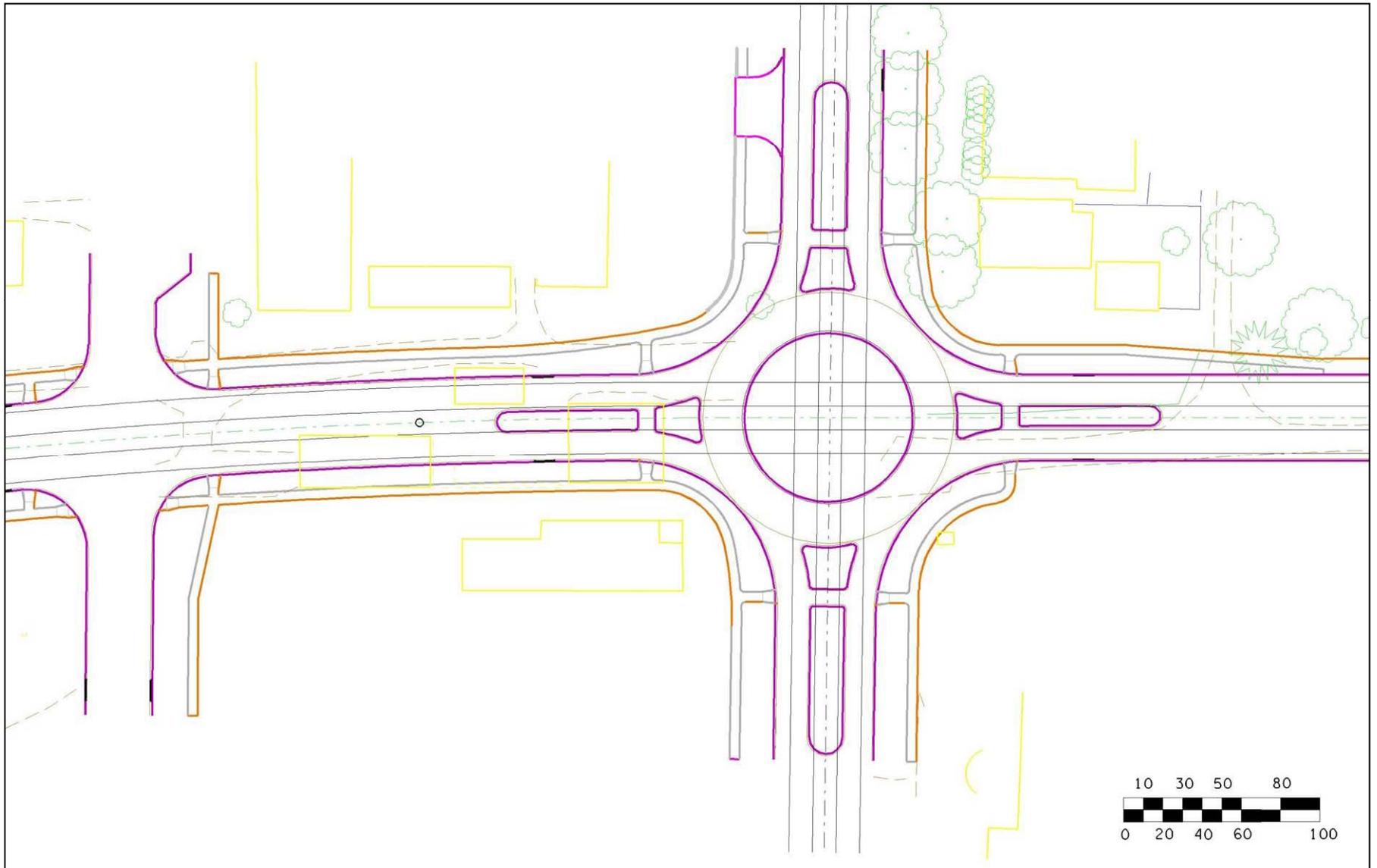
Central City Roundabout 1 of 2



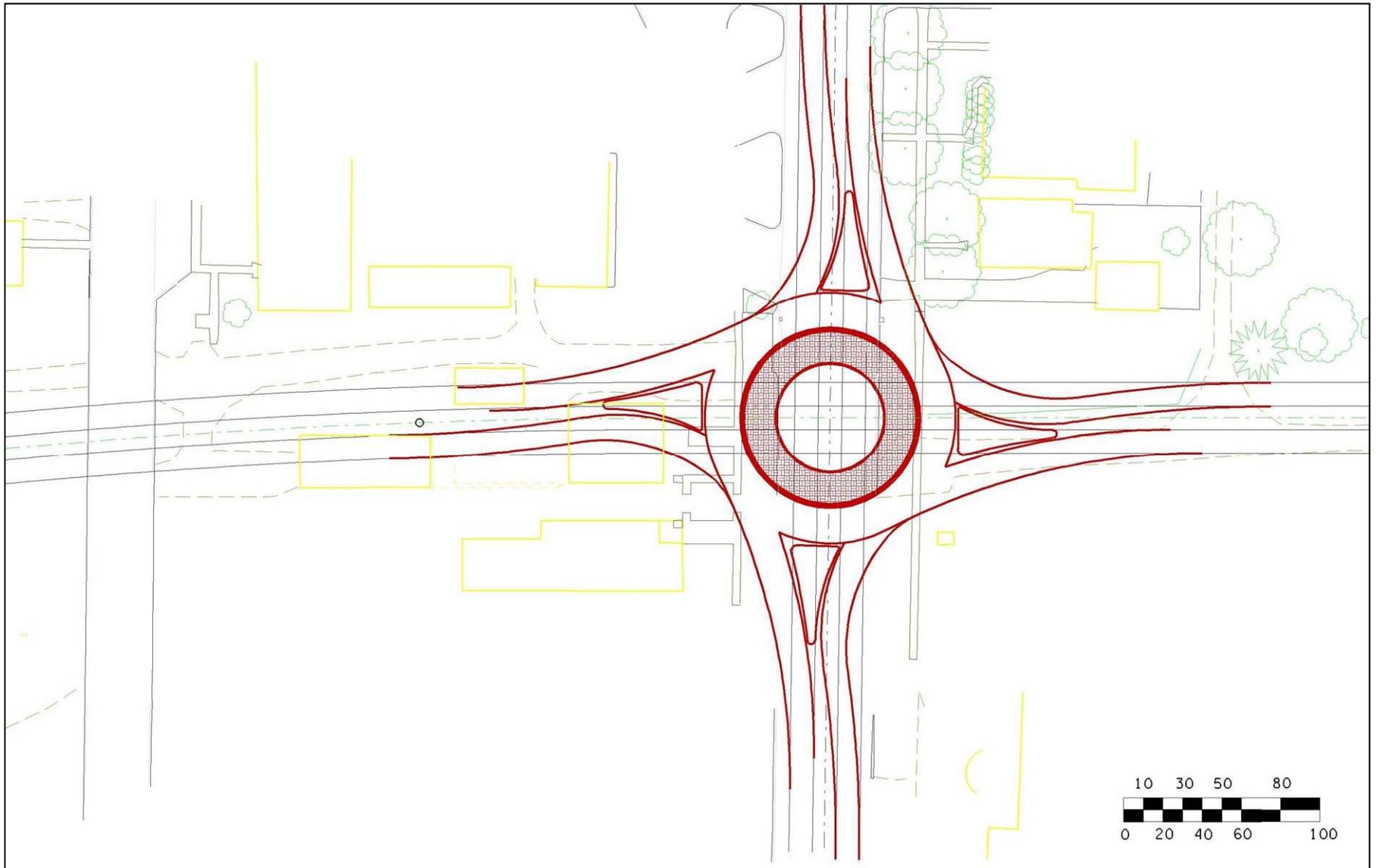
Central City Roundabout 2 of 2



Central City Roundabout 2 of 2

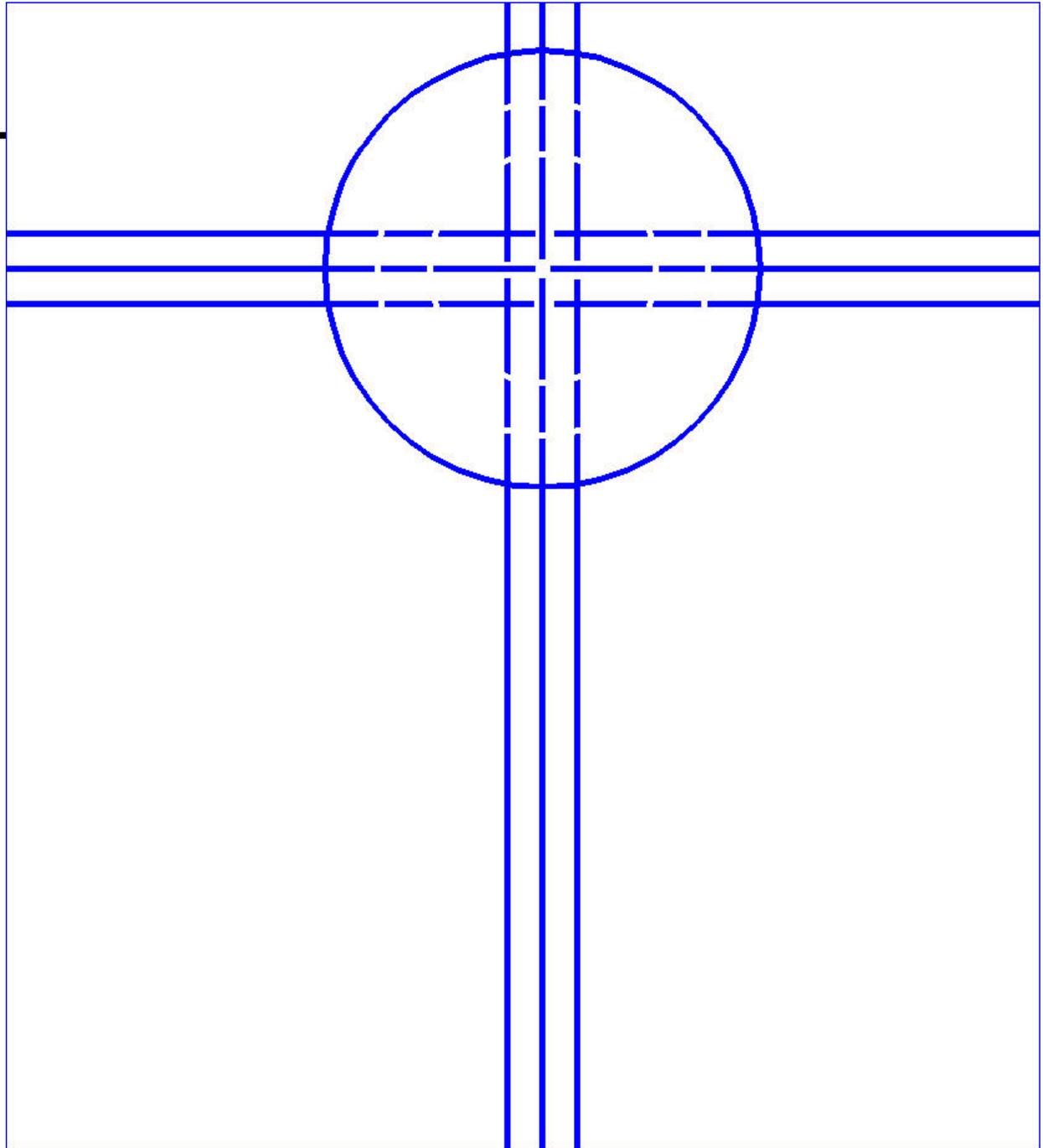


Central City Roundabout 2 of 2



Design Steps

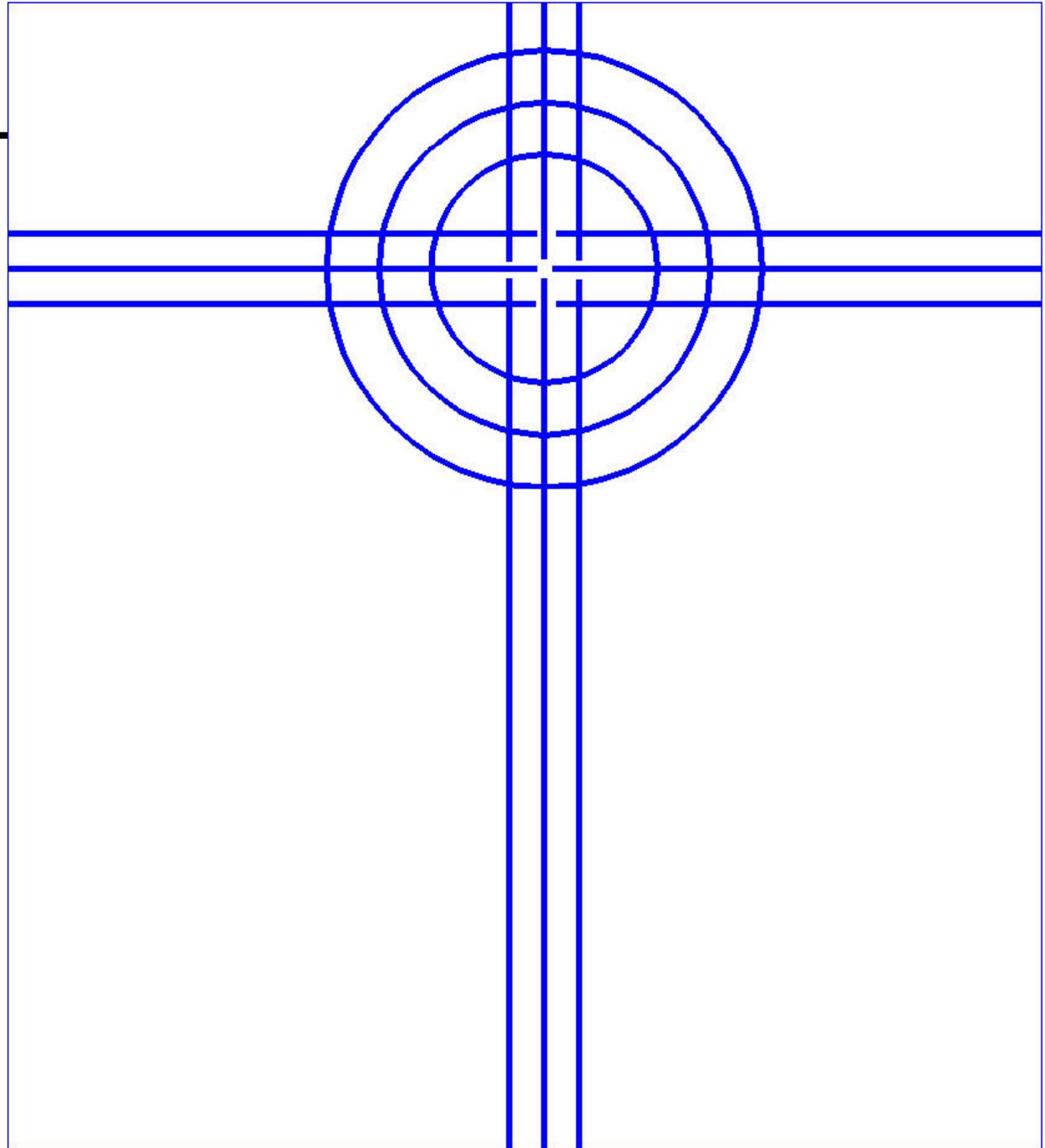
1ST – place 150' diameter circle at center of existing intersection. All work being done at this point is with paint lines – curb lines are just offsets from the paint lines



Design Steps

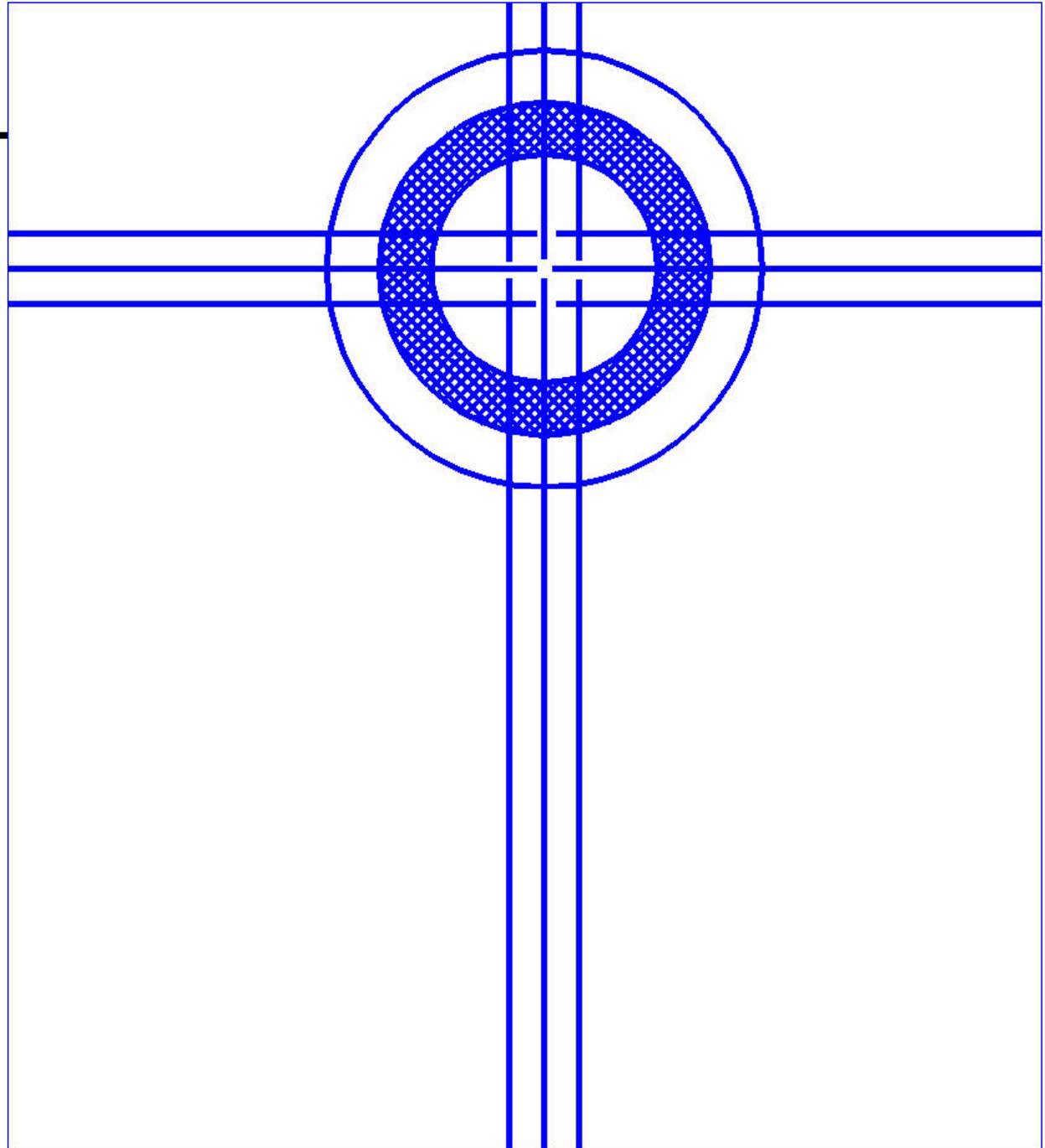
2nd – copy 150' diameter circle parallel around 18' or so twice – once for the travel lane and another time for the truck apron

NOTE: later you will need to check with AutoTurn, AutoTrack or a similar program



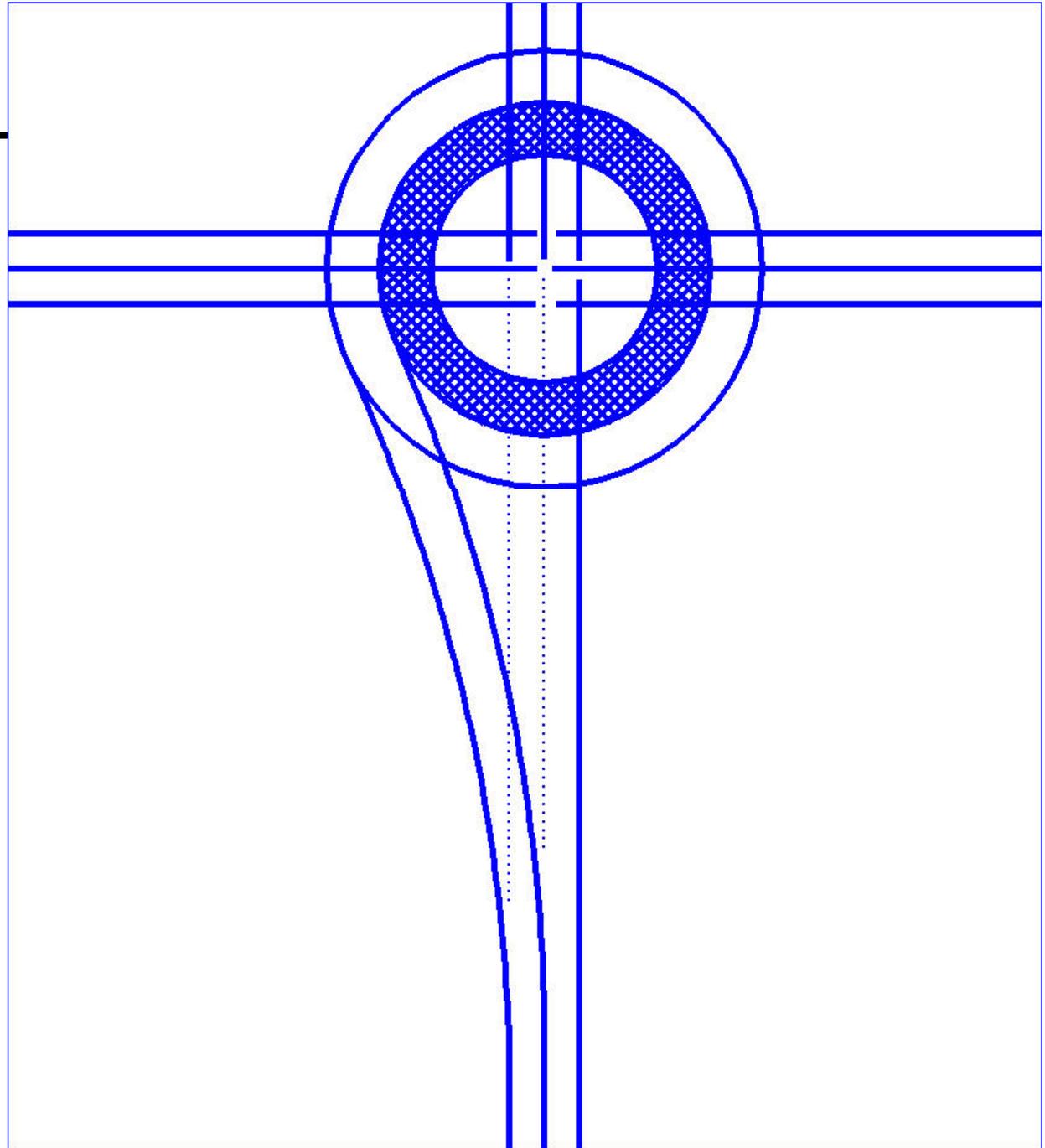
Design Steps

3rd – hatch out
the truck apron
so it is clear
what that area is
going to be
used for...



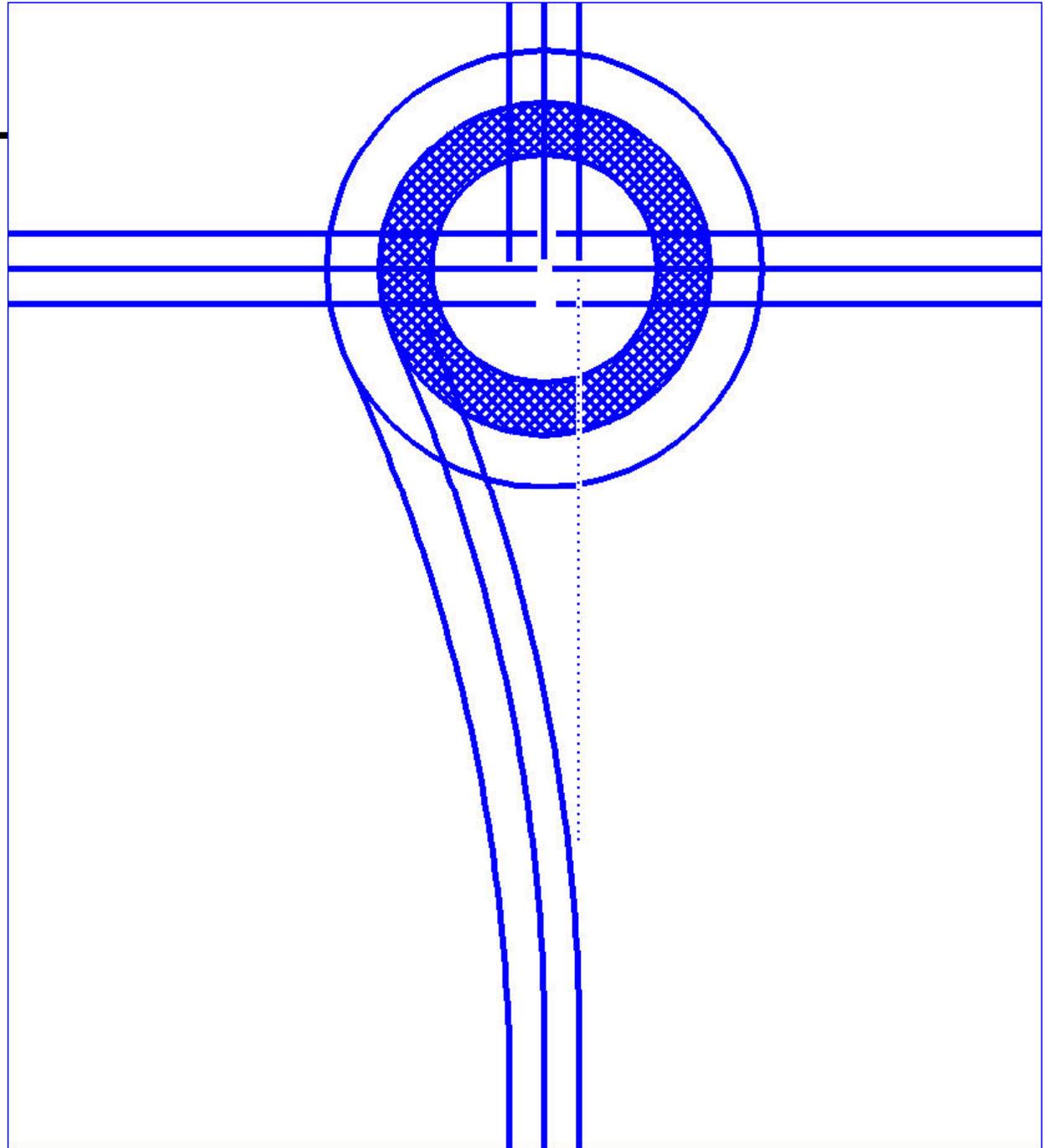
Design Steps

4th – use a 300' to 800' fillet to tie the center line to the exit side of the truck apron and the left edge line to the outside of the roundabout – use the same radius to let CAD worry about the taper..



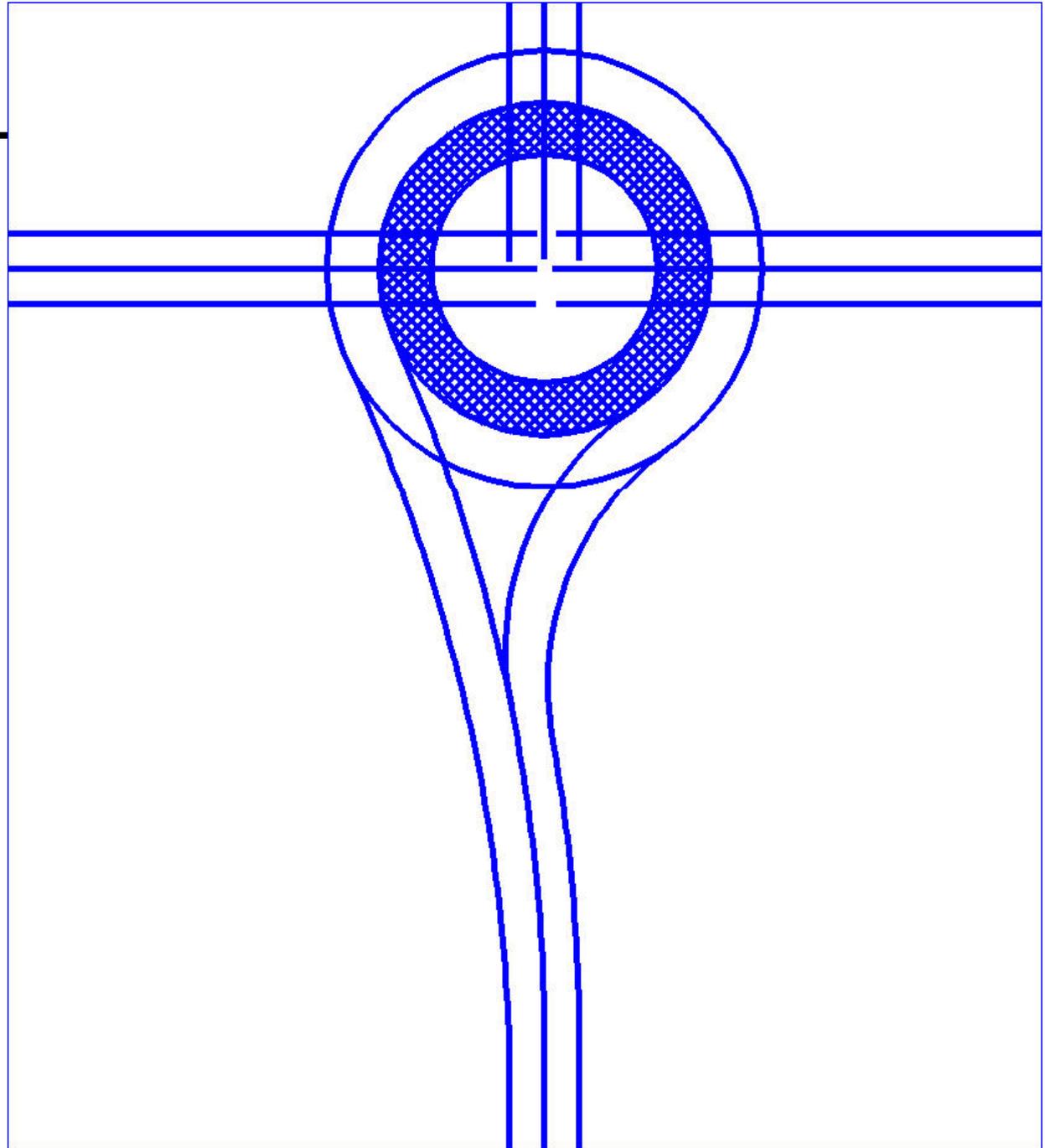
Design Steps

5th – copy the new center line over 12' for your new right edge line



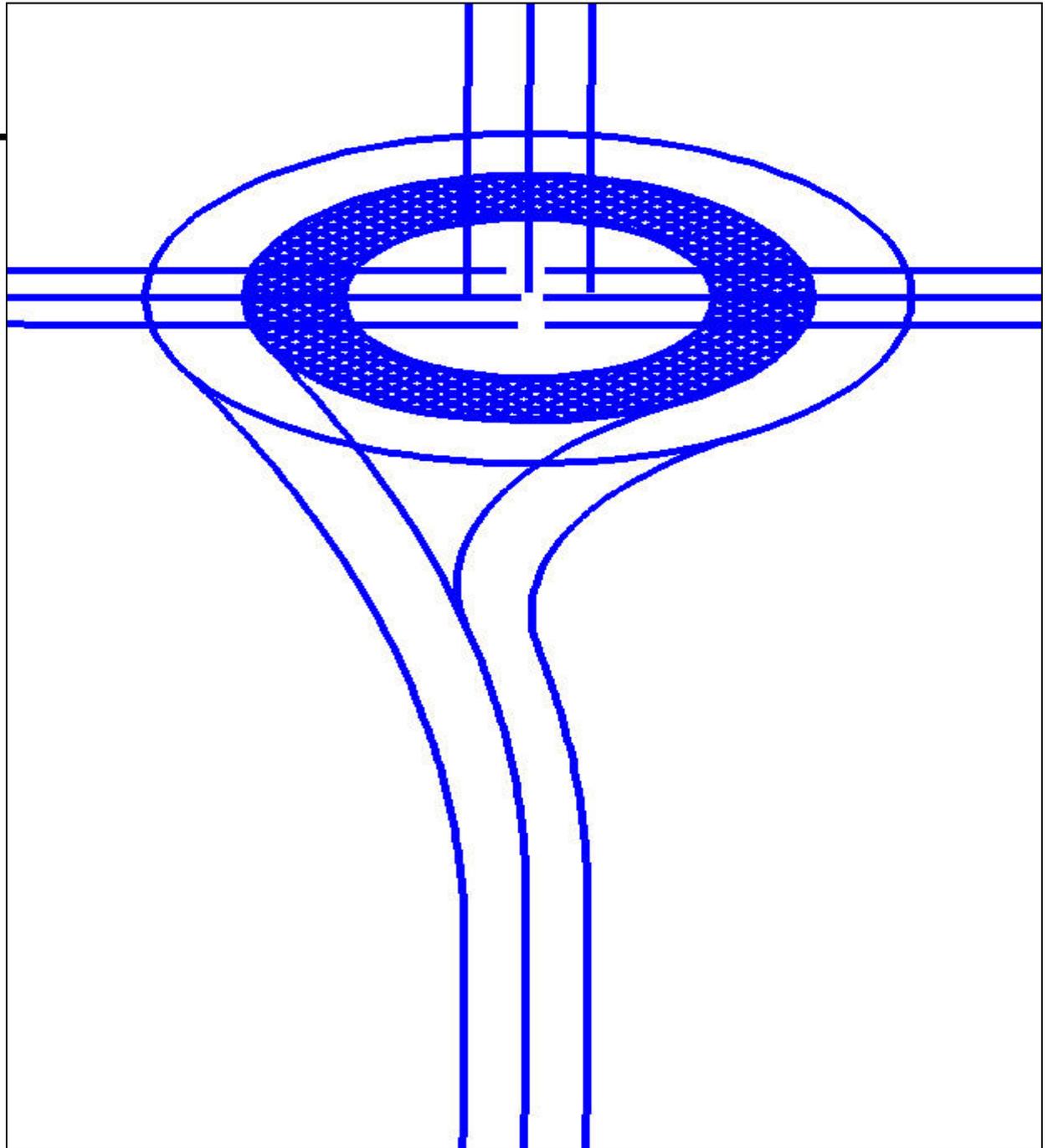
Design Steps

6th – use a 90' to 110' fillet to tie in the approach.
Use the same radius on both sides – let CAD take care of the taper...



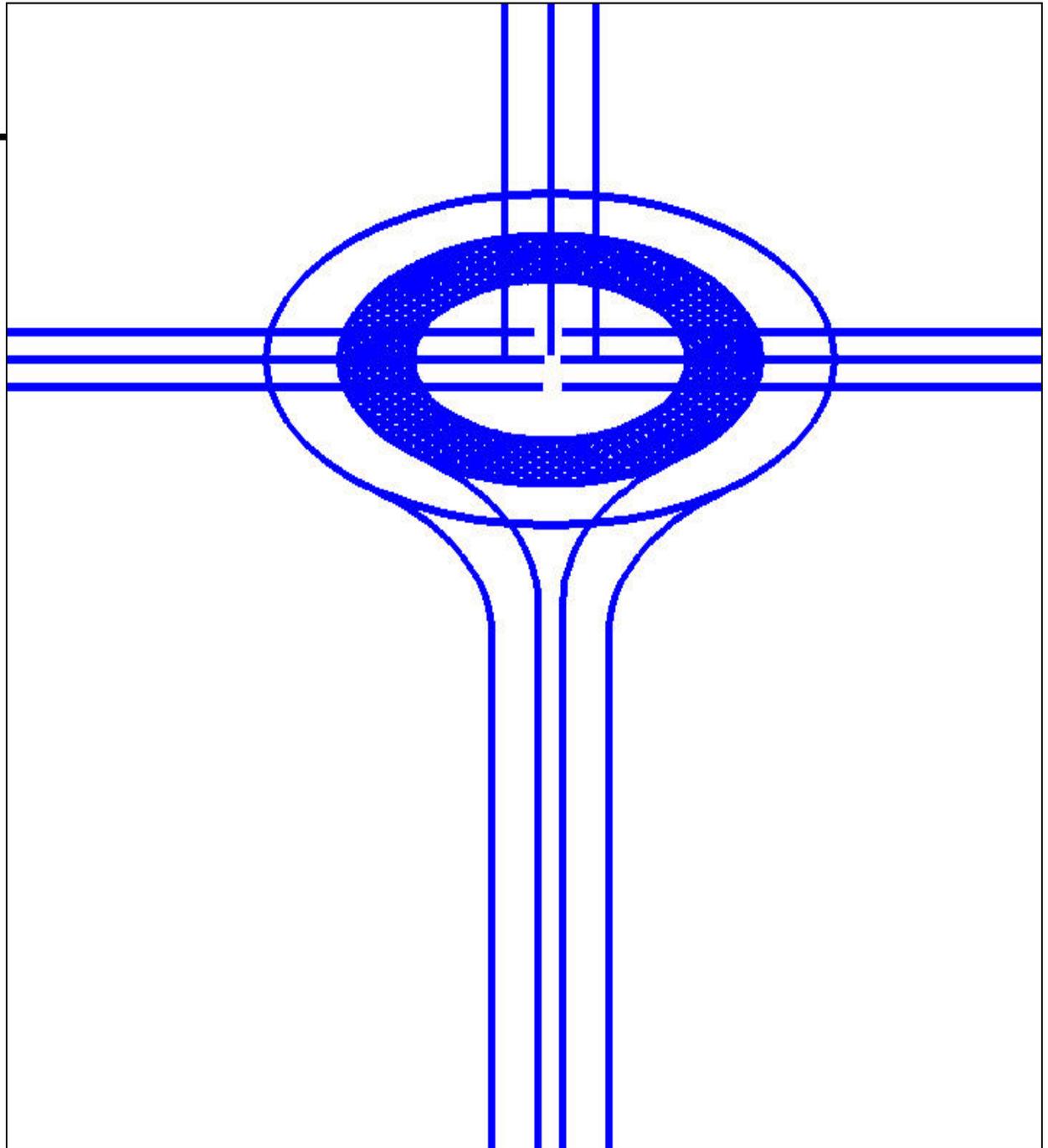
RESULT

One leg is done – you now have an approach with geometry that requires vehicles to slow down before the yield line. This technique has 2 points of speed reduction – you have staged and staggered the speed reduction



RADIAL

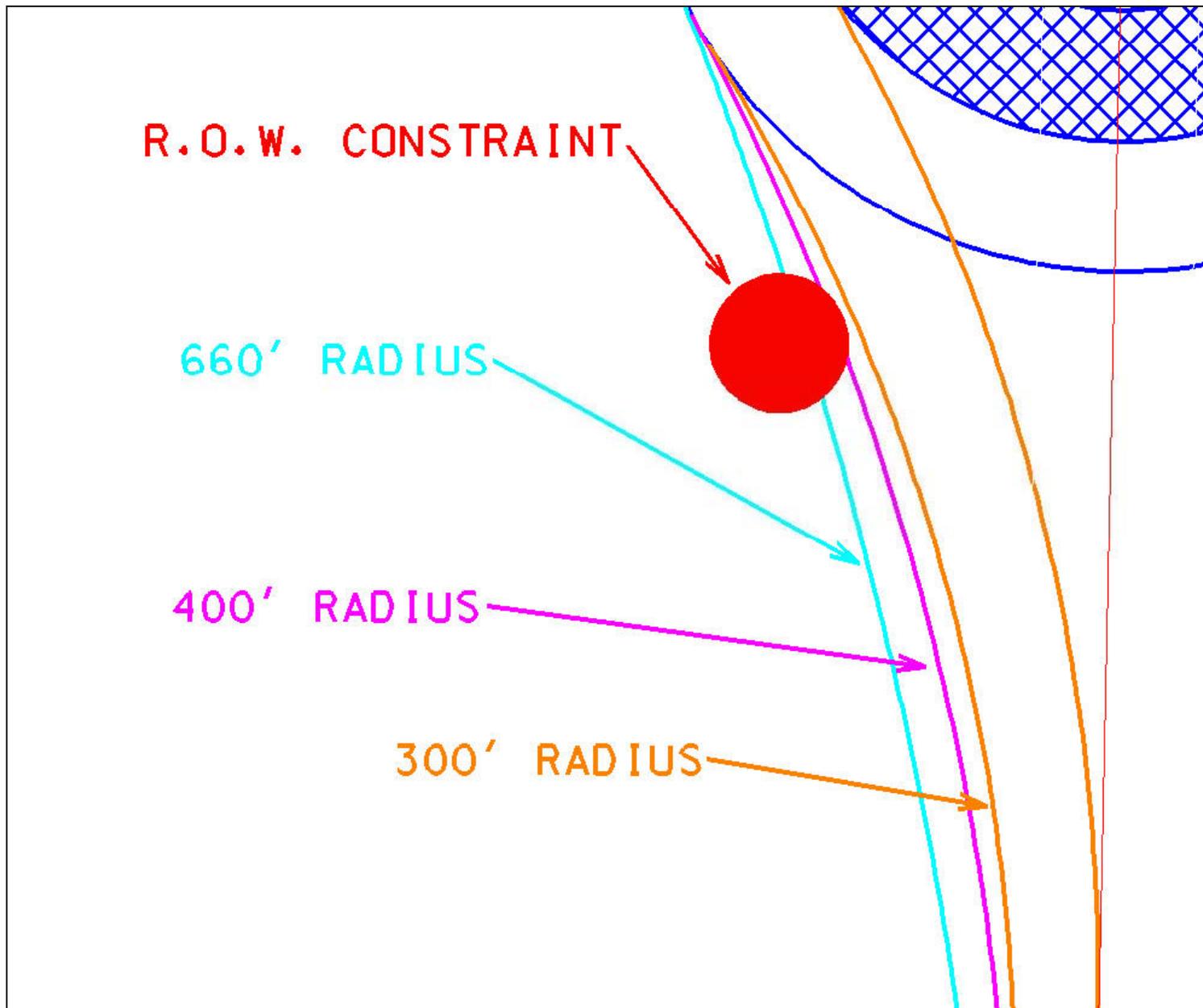
This layout technique has only 1 point of speed reduction and it is at the pedestrian and circulating vehicle conflict area. Also, the driver does have a clear view into the roundabout



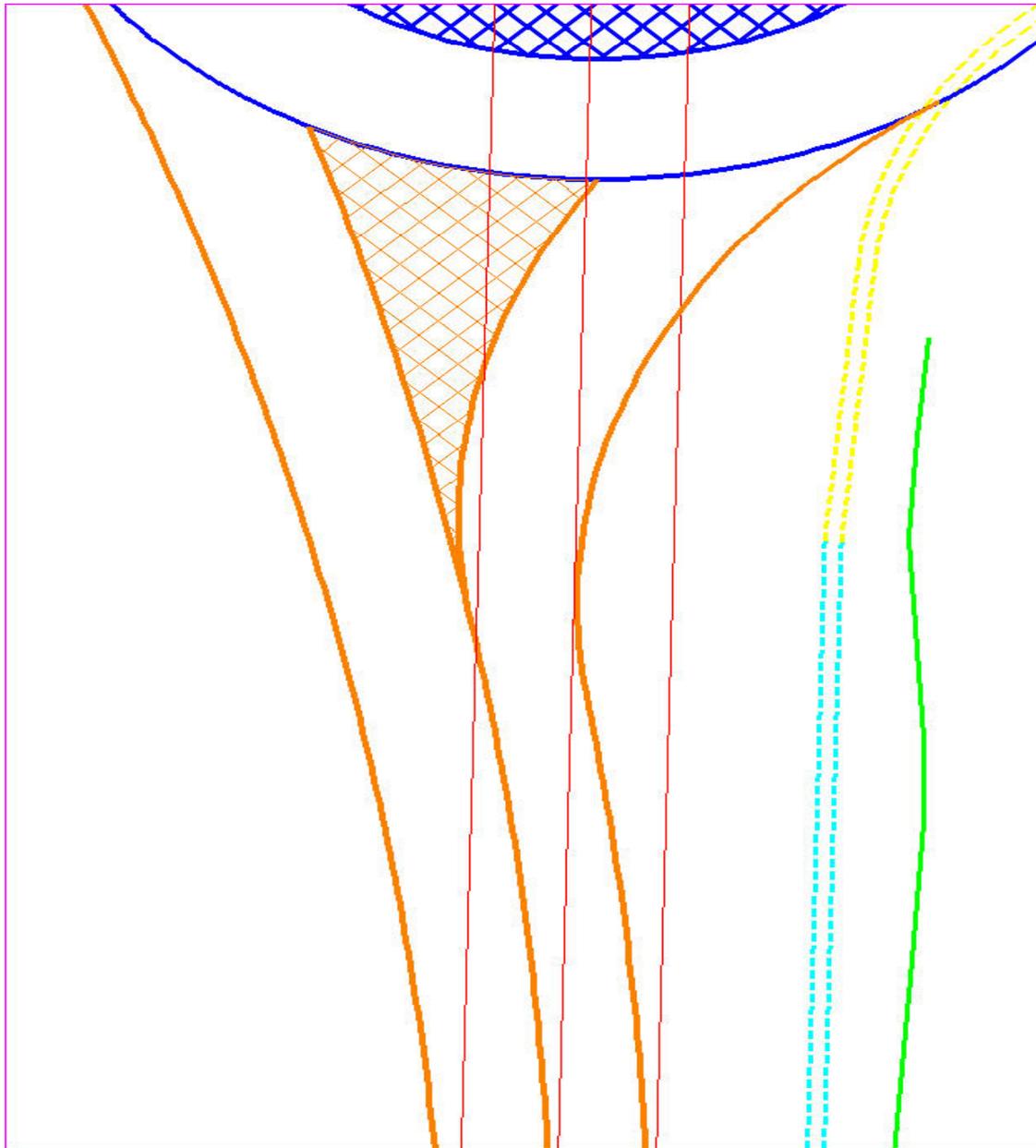
Alterations to Geometric Layout

- Decrease Exit Radii to avoid R.O.W. Impact
 - Reducing Exit Radii gets you closer and closer to “Radial” design (+/- 100’ radius)
- Run Tangent Line from Center Line to Increase Splitter Island Length and Width

Decrease Exit Radii to avoid R.O.W. Impacts

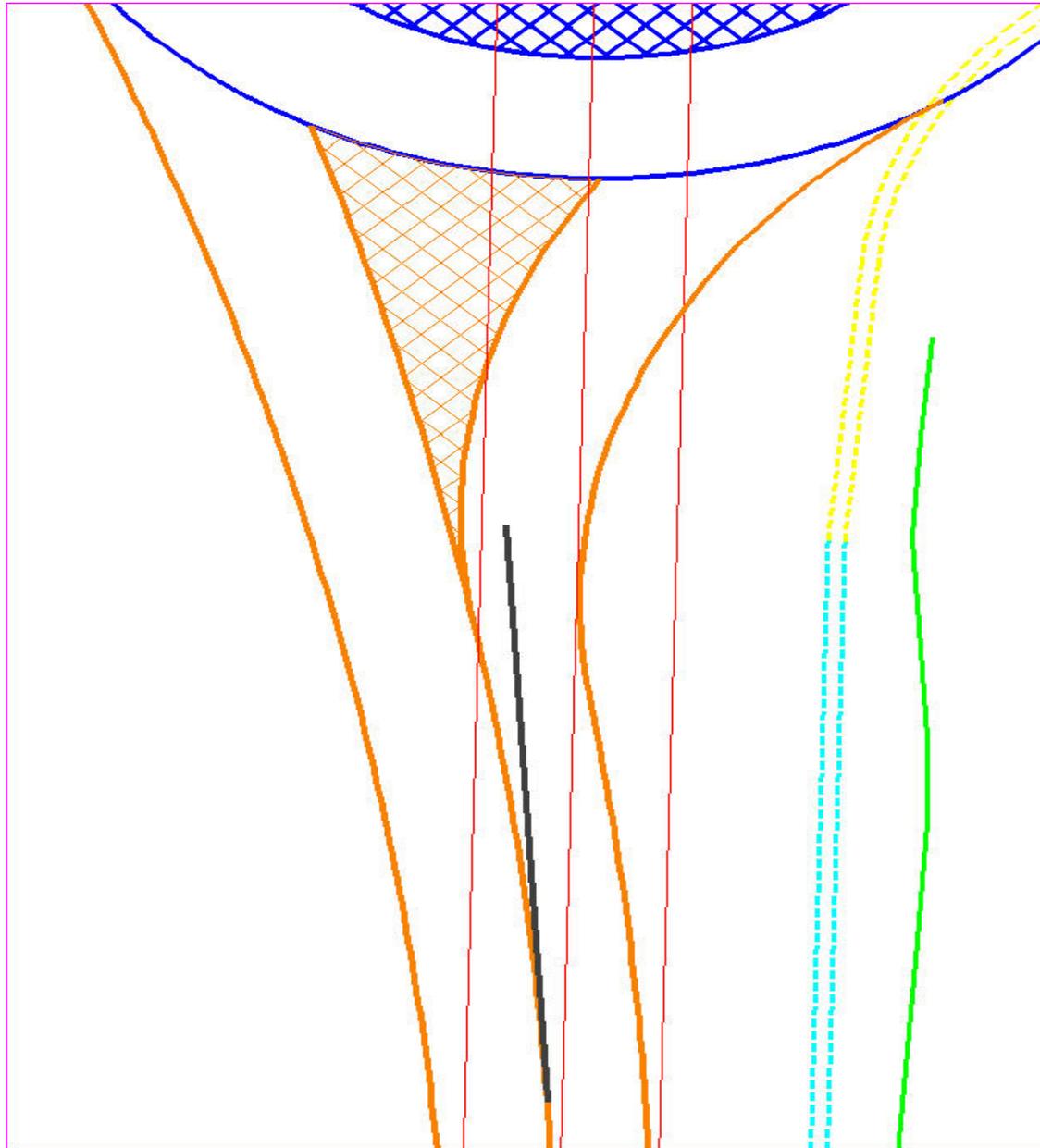


Use Tangent Line For Larger Island



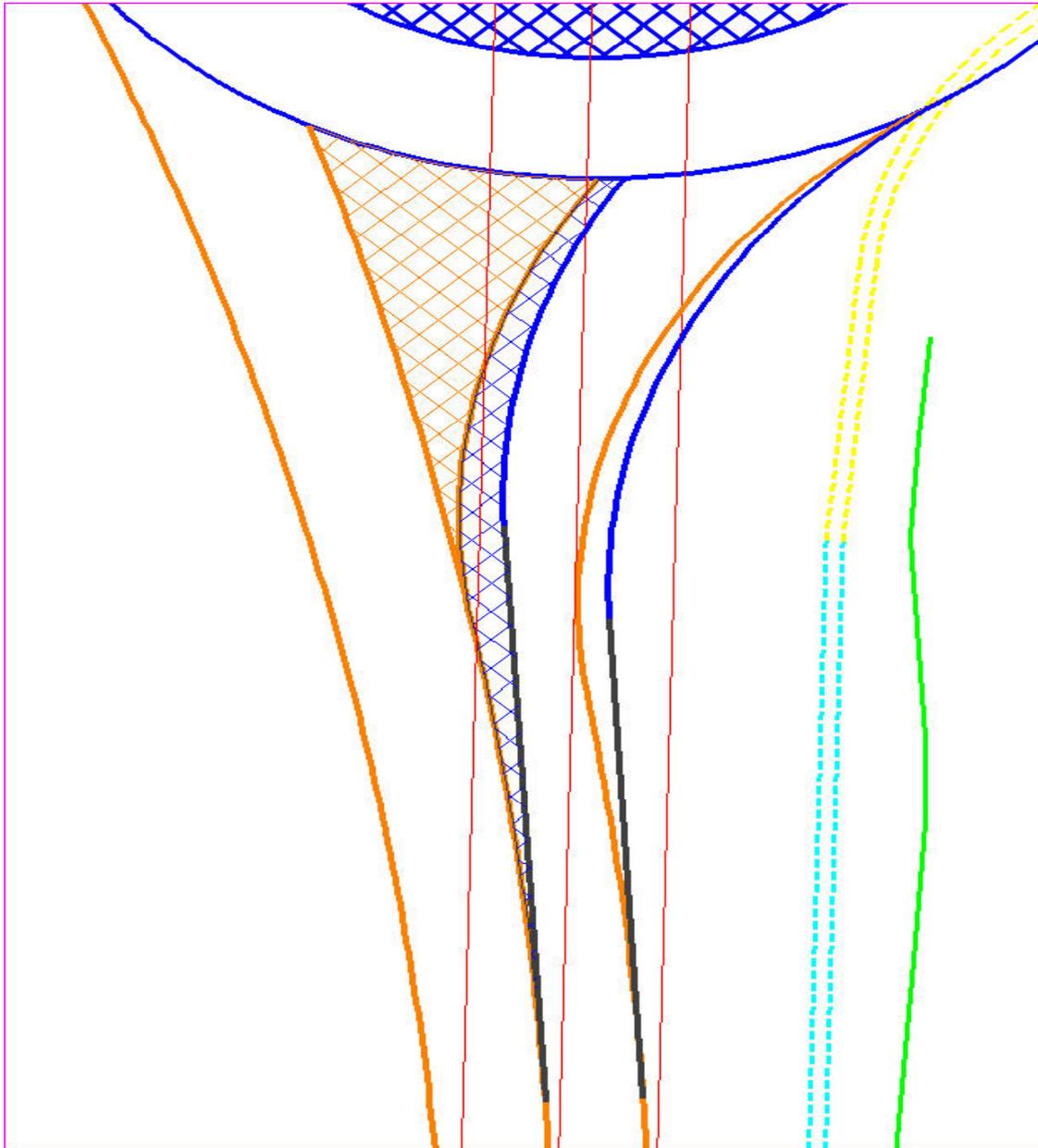
- Original Layout Shown with 660' exit radius and 100' entry radius

Use Tangent Line For Larger Island



- Tangent line, shown in black, now goes from new center line to point still left of center of roundabout

Use Tangent Line For Larger Island



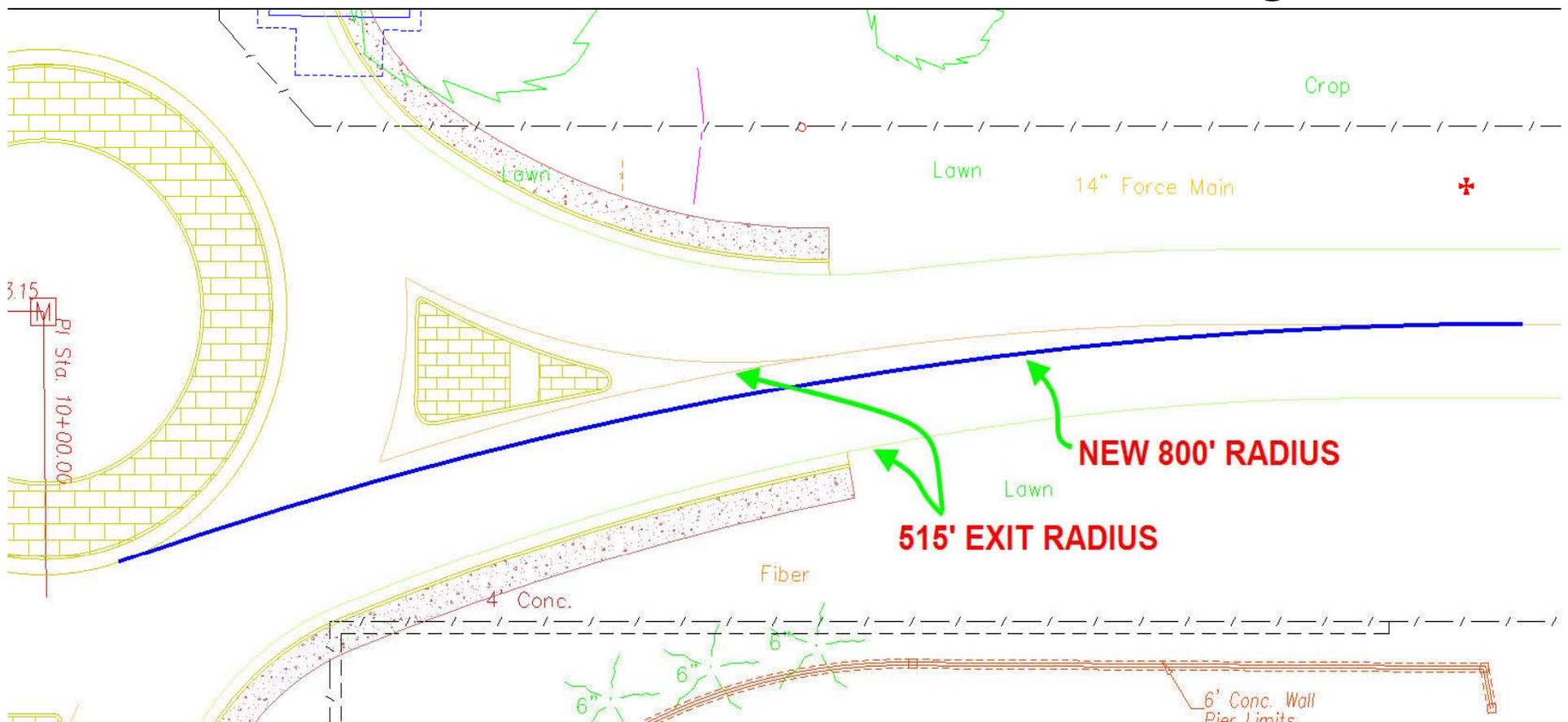
- The area hatched in blue shows extra width and length of new splitter island – still using a 660' exit radius and 100' entry radius

Additional Ways to Increase Splitter Island Length

- Hold approach where it is and increase radius for left (driver side) side of exit
- Run Tangent Line from Circulatory Roadway around 3 to 7 feet to the right of 100' or so fillet already drawn and then redo 100' fillet

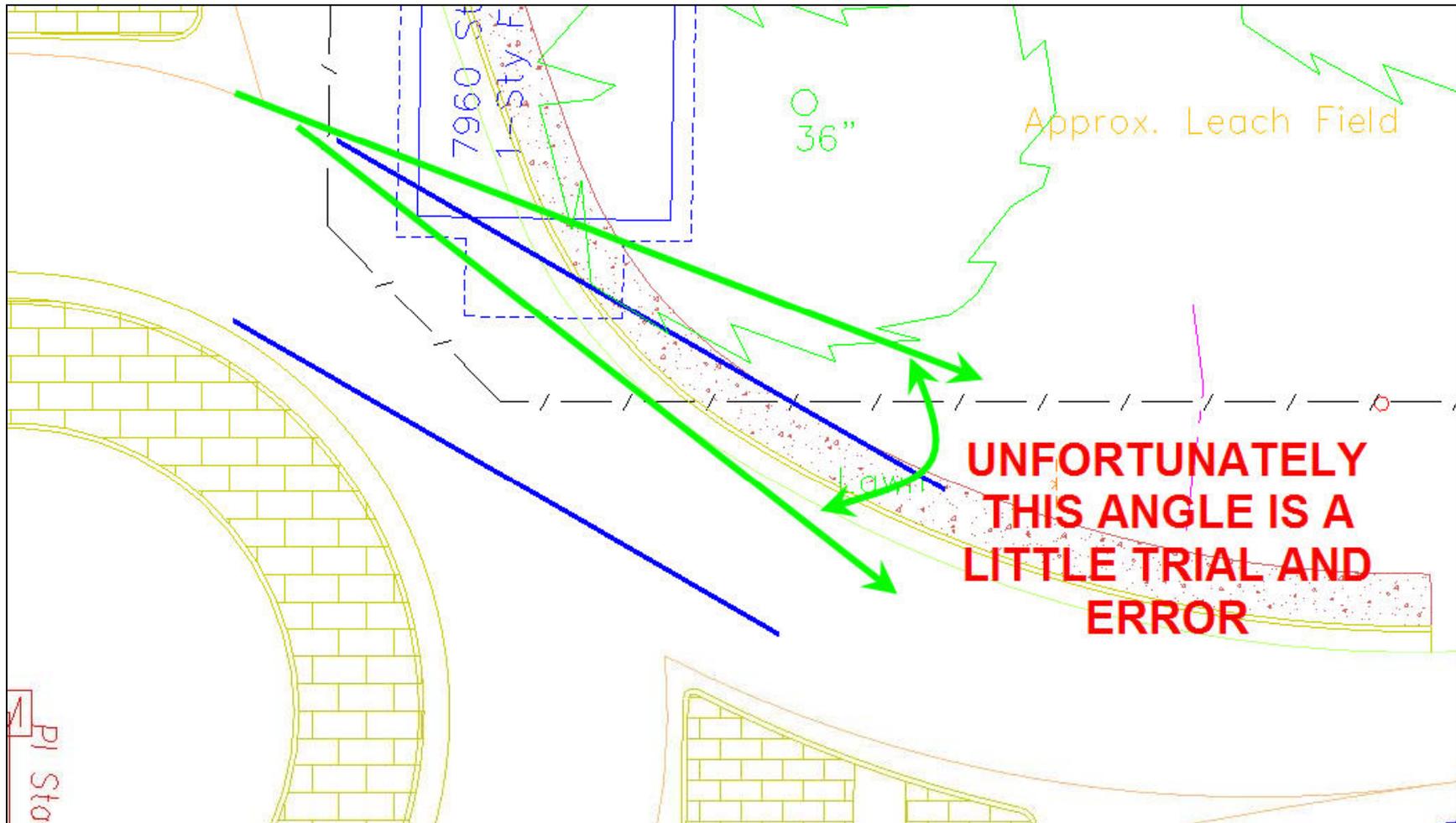
Holding Approach then Increasing Exit Radius Method

- No Additional ROW impacts but have to make sure trucks can still make the right turn



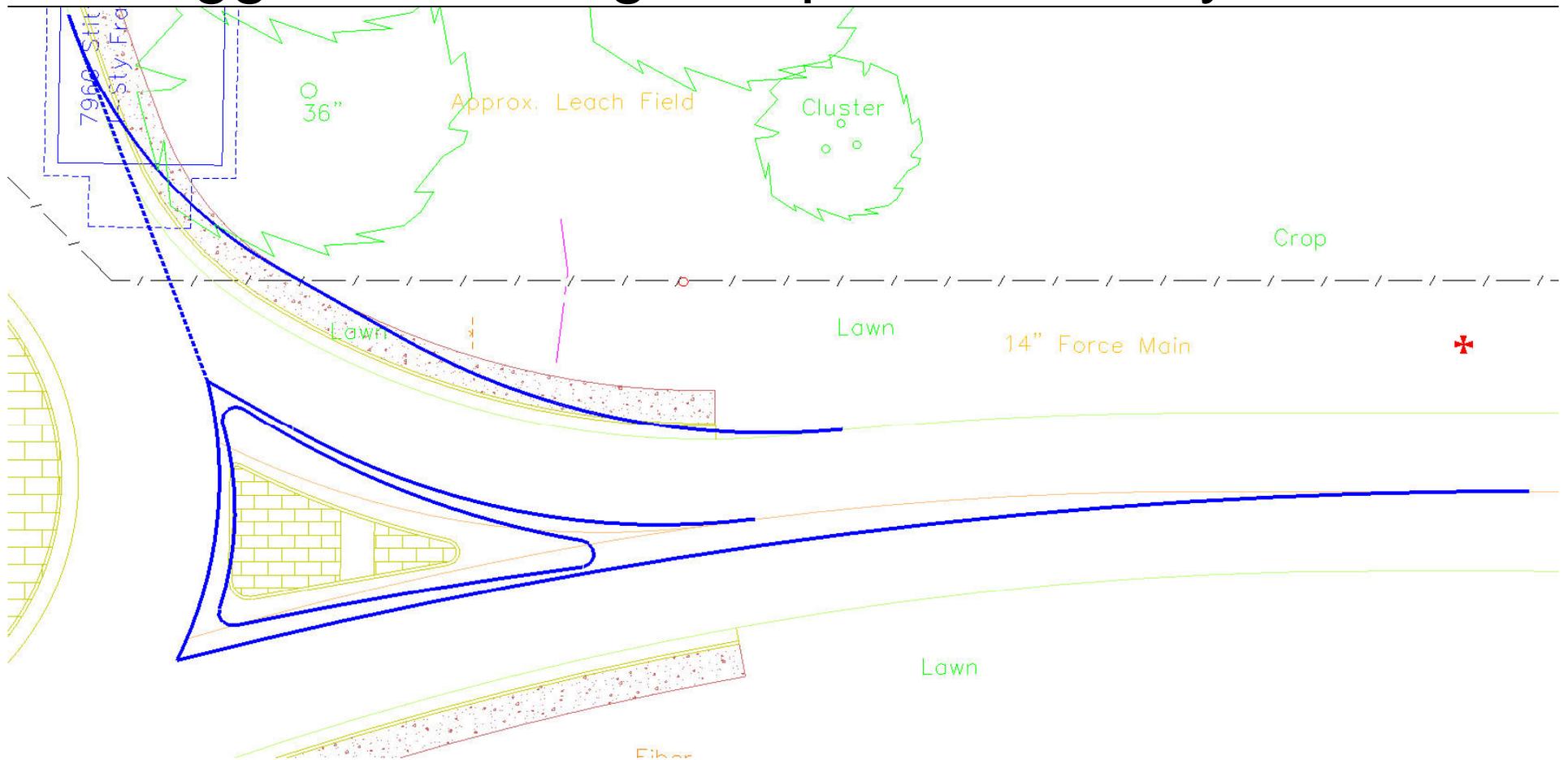
Tangents from Circulatory Roadway Method

- This will have additional ROW impacts... ☹️



Longer and Wider Splitter...

- Splitter is approximately double the size it used to be – but still not up to FHWA length suggested for higher speed roadways

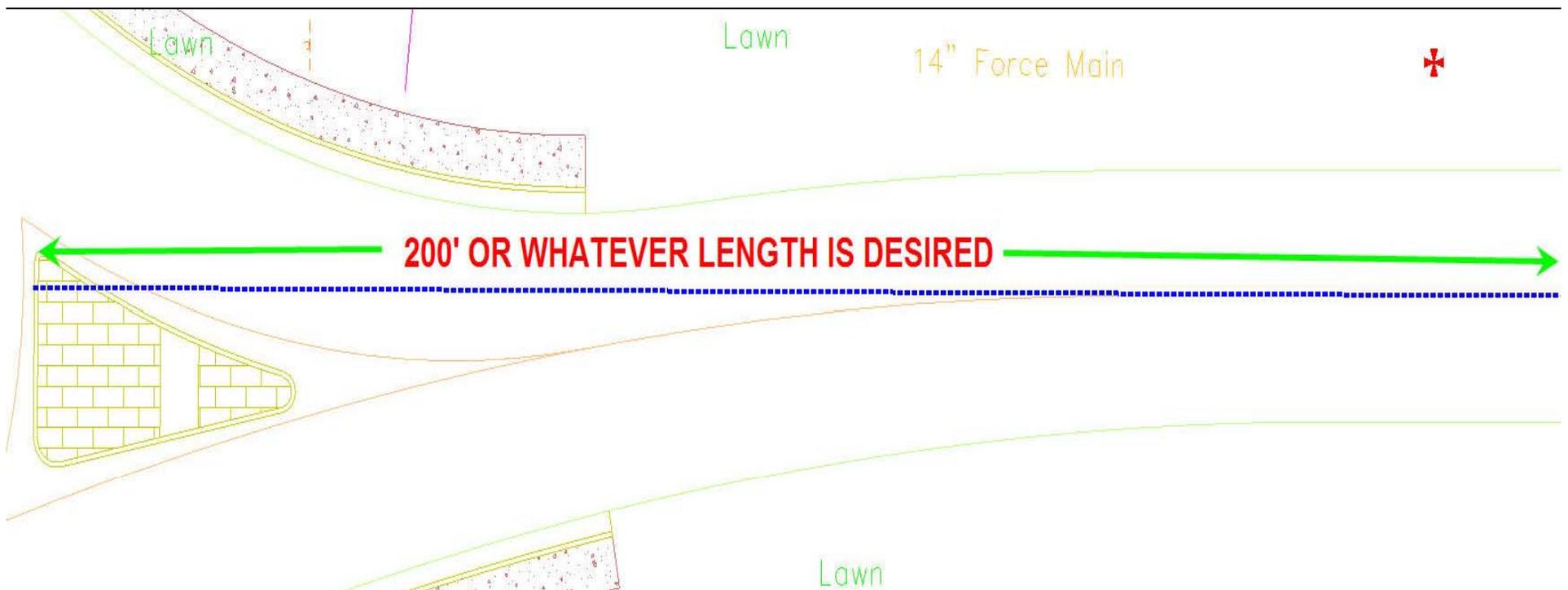


FHWA & Many Other Organizations Sometimes Want 200' + Long Splitters

- Many roundabouts currently exist on high speed roadways with 40' to 50' or so splitters and are working fine
- The additional ROW impact may or may not be worth the hassle and/or expense
- If you have to do them.....

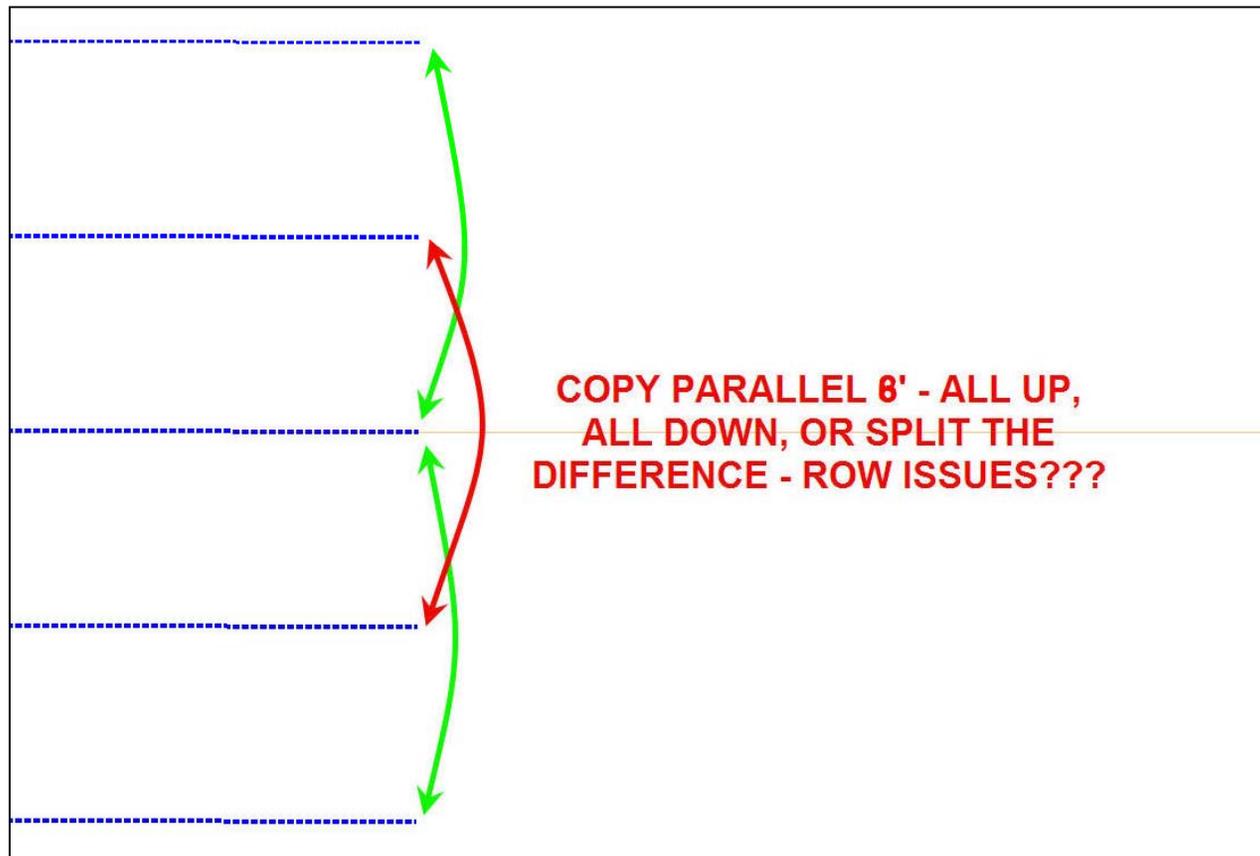
FHWA & Many Other Organizations Sometimes Want 200' + Long Splitters

- I recommend starting by drawing a line the length required



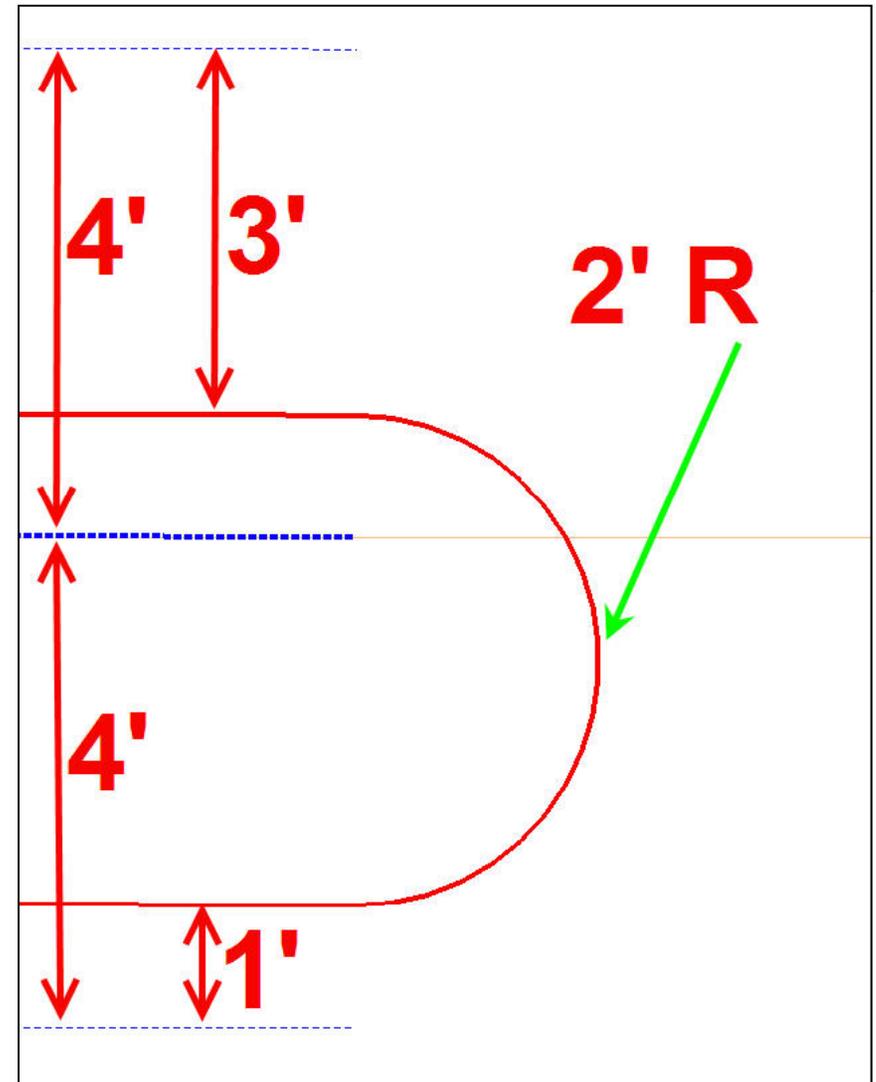
FHWA & Many Other Organizations Sometimes Want 200' + Long Splitters

- You need 8' of width for the development of the splitter nose



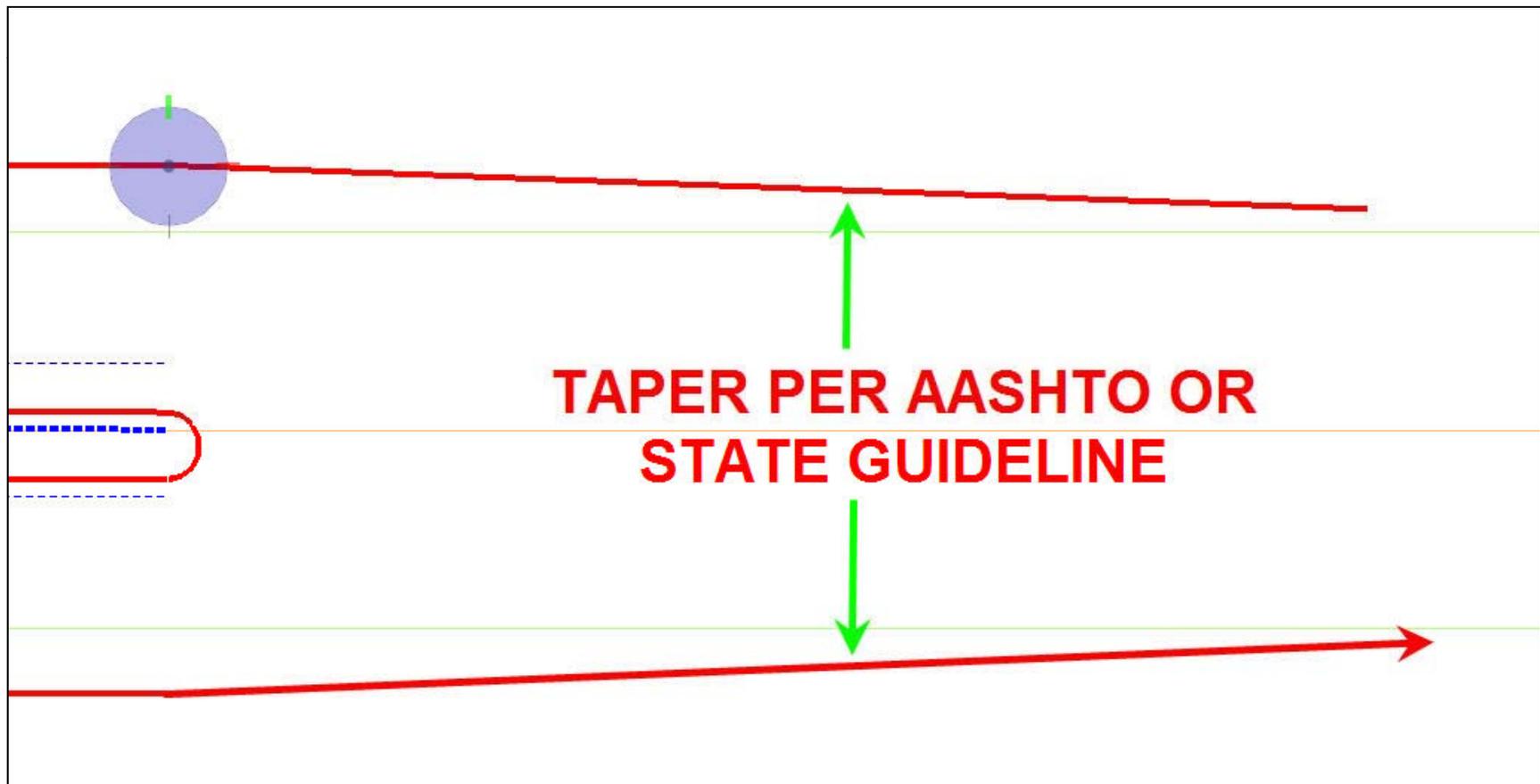
FHWA & Many Other Organizations Sometimes Want 200' + Long Splitters

- For this example I copied the centerline 4' to either side. This will have the same amount ROW impact to either side – whether or not this is best will be case by case decision.



FHWA & Many Other Organizations Sometimes Want 200' + Long Splitters

- You need to get back to original 2 lane or whatever was the existing roadway configuration



STEP 1 – PLACE EDGE LINES

The easiest way to do this is to just approximate the center line of the approach and then copy parallel your 11 or 12' lane width.

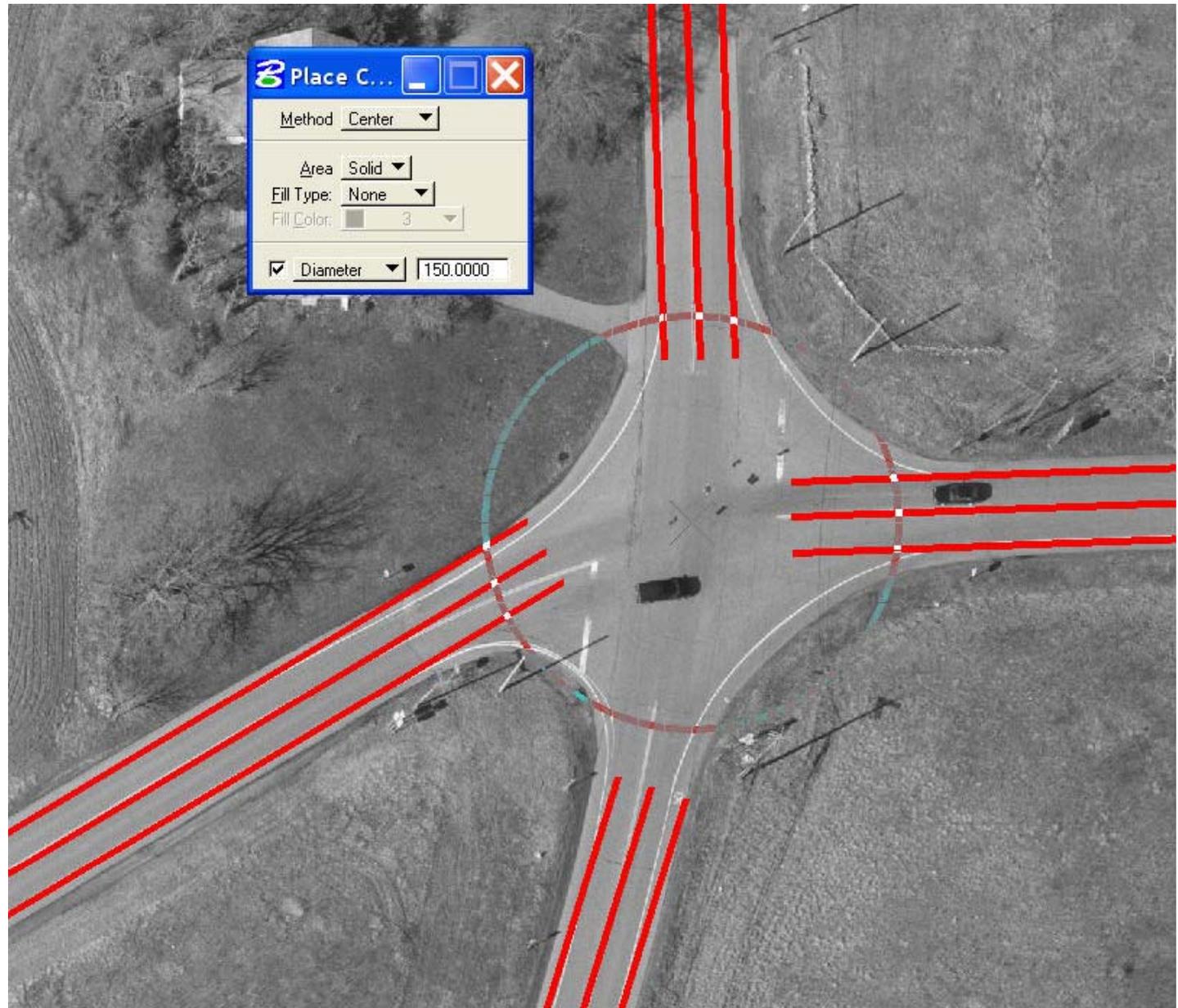
You don't need to be exact with the lines, especially very close to the intersection since the fillets will get rid of that part of the approach and exits anyway.



STEP 2 – PLACE CIRCLE AS DESIRED

The actual placement of the center of the circle is important but there isn't an absolute best spot – all long as the design principles are followed quite a few center island locations will work just as well as the others...

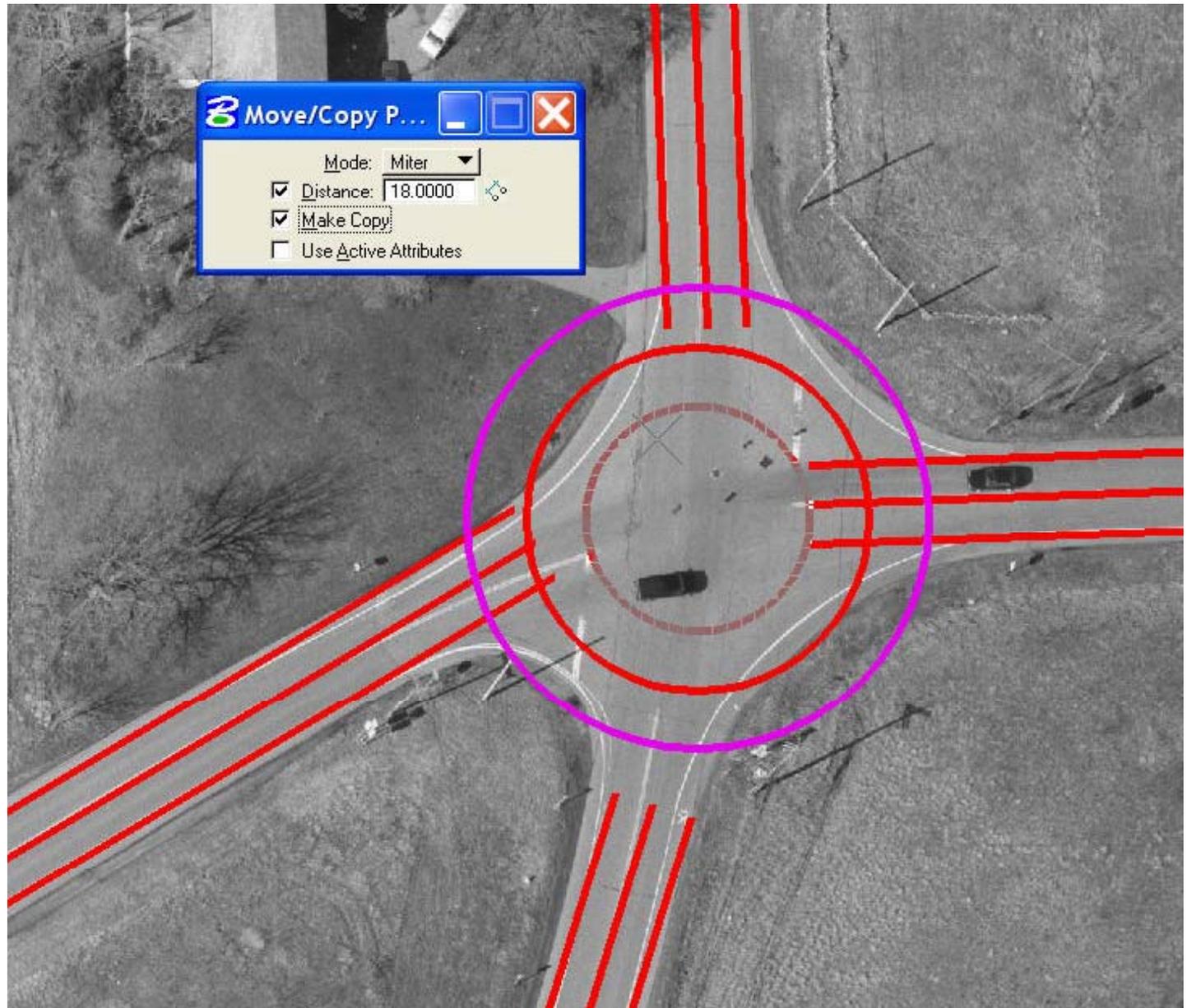
There are a few that will definitely be more challenging though... ☹



STEP 3 – COPY THE CIRCLE TWICE

Copy the circle twice – once for the truck apron and another time for the center island.

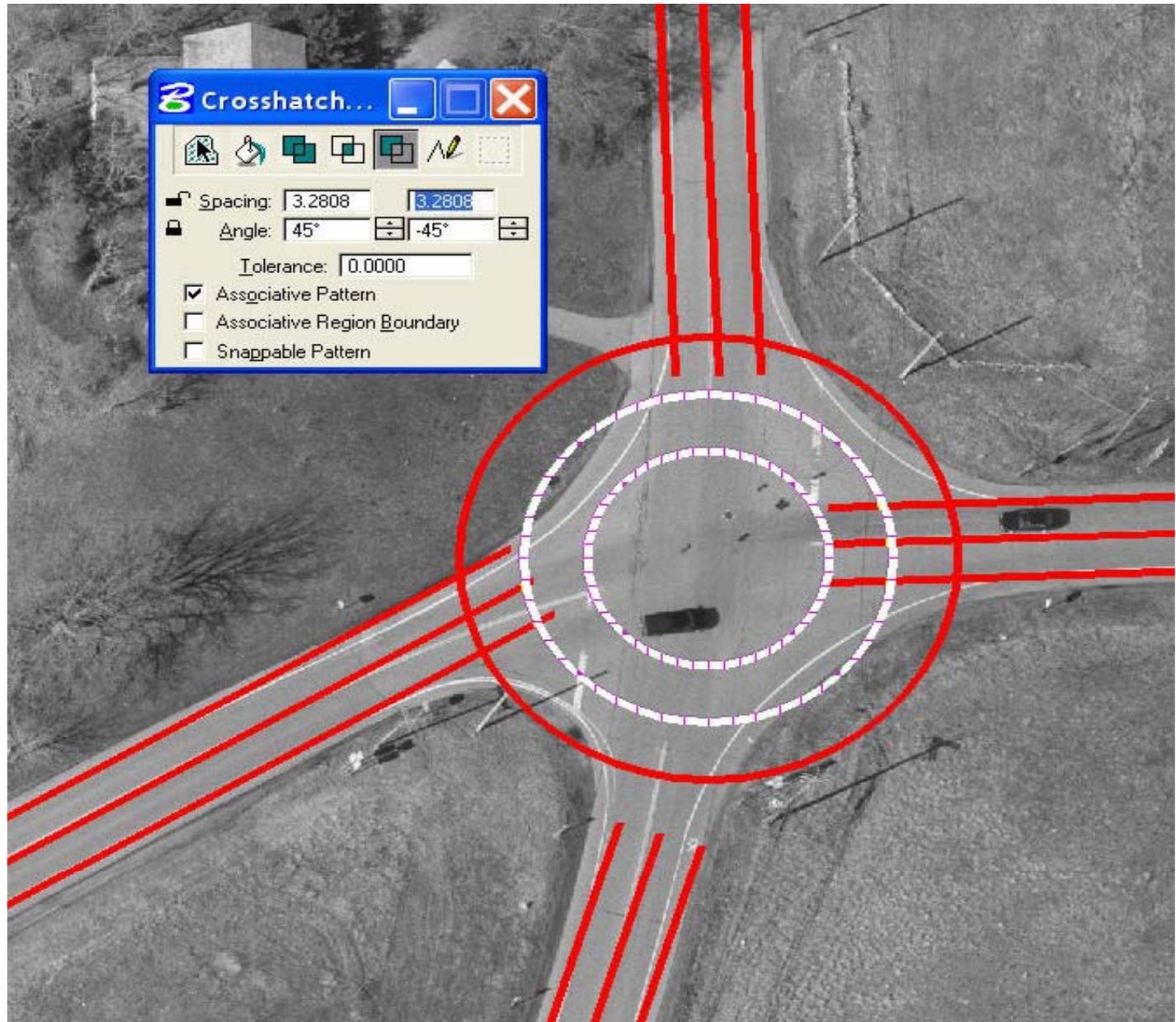
The actual width of the travel lane and truck apron will be based on vehicle tracking – running AutoTurn or AutoTrack isn't part of this course... ☹



STEP 4 – HATCH OUT THE TRUCK APRON

This will make it clearer when you start doing the fillets as to which lines go with which other lines.

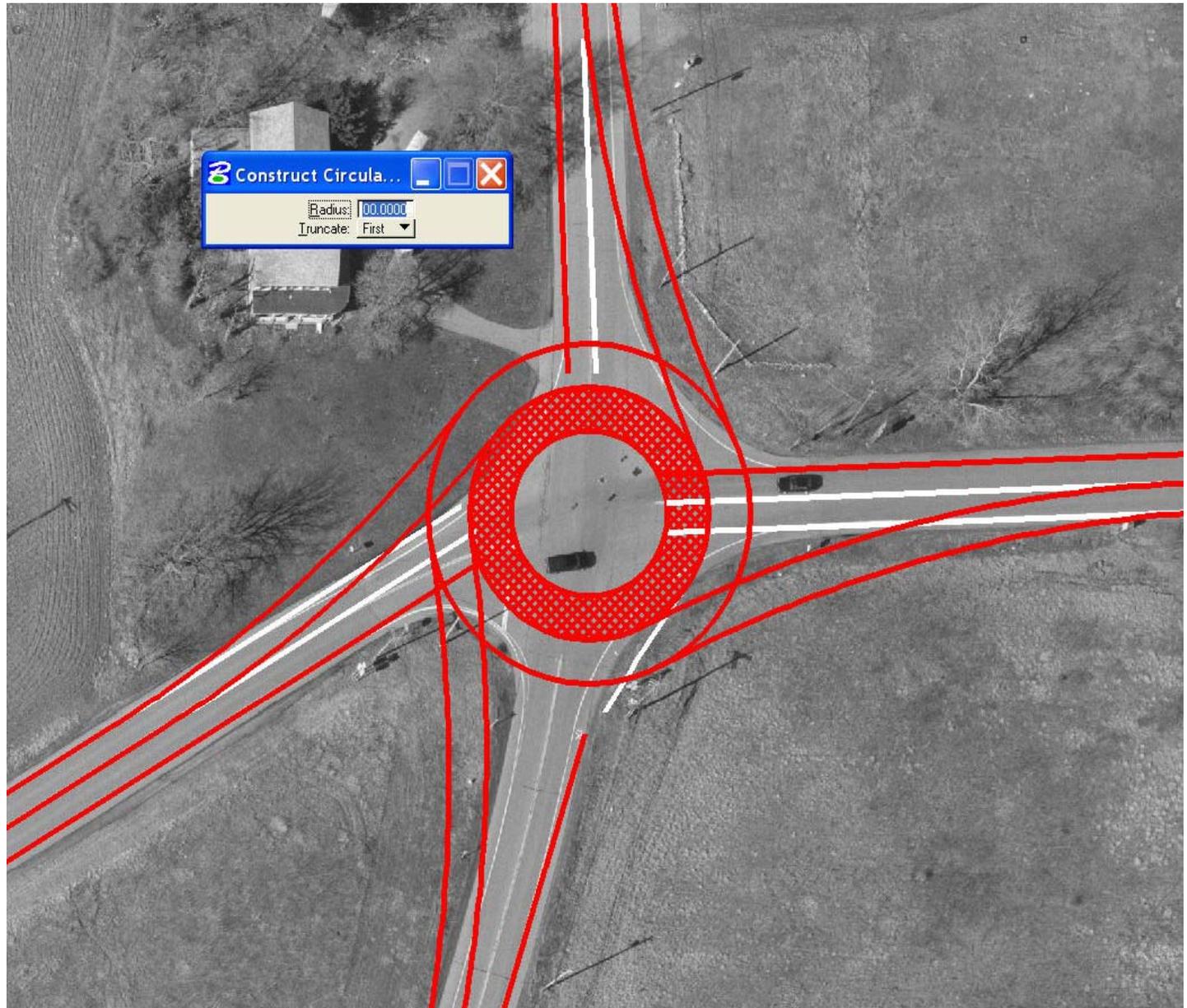
For the VISSIM layout you could make the apron a different color or even pattern as well as the center island but just hatching it for now is fine...



STEP 5 – FILLET THE EXITS

The use of larger exit radii will allow for better speed control on the approach to the roundabout.

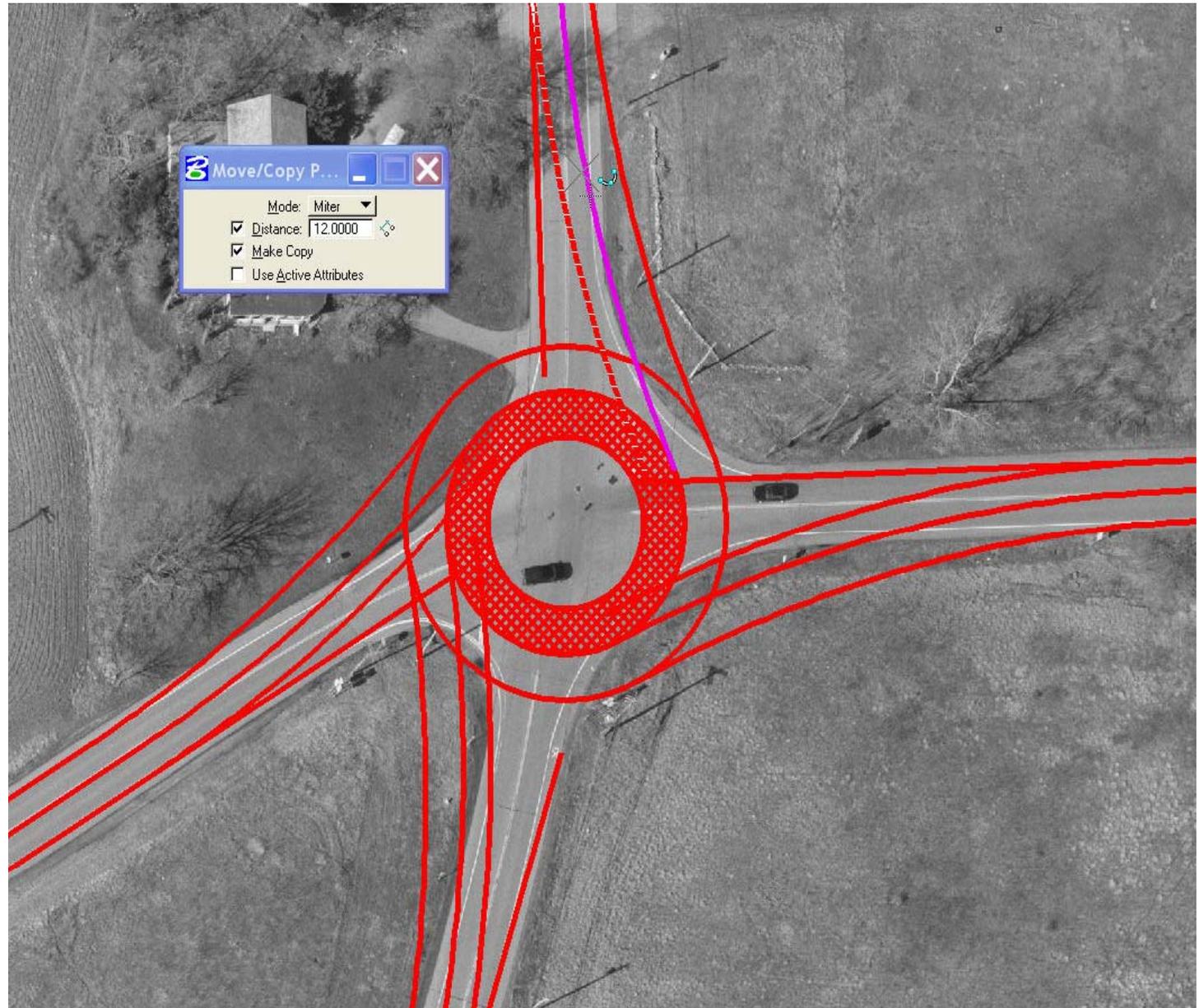
The exit speed is dictated by circulating speed plus acceleration – not just measuring the exit radii



STEP 6 – COPY CENTER LINE FOR THE APPROACH

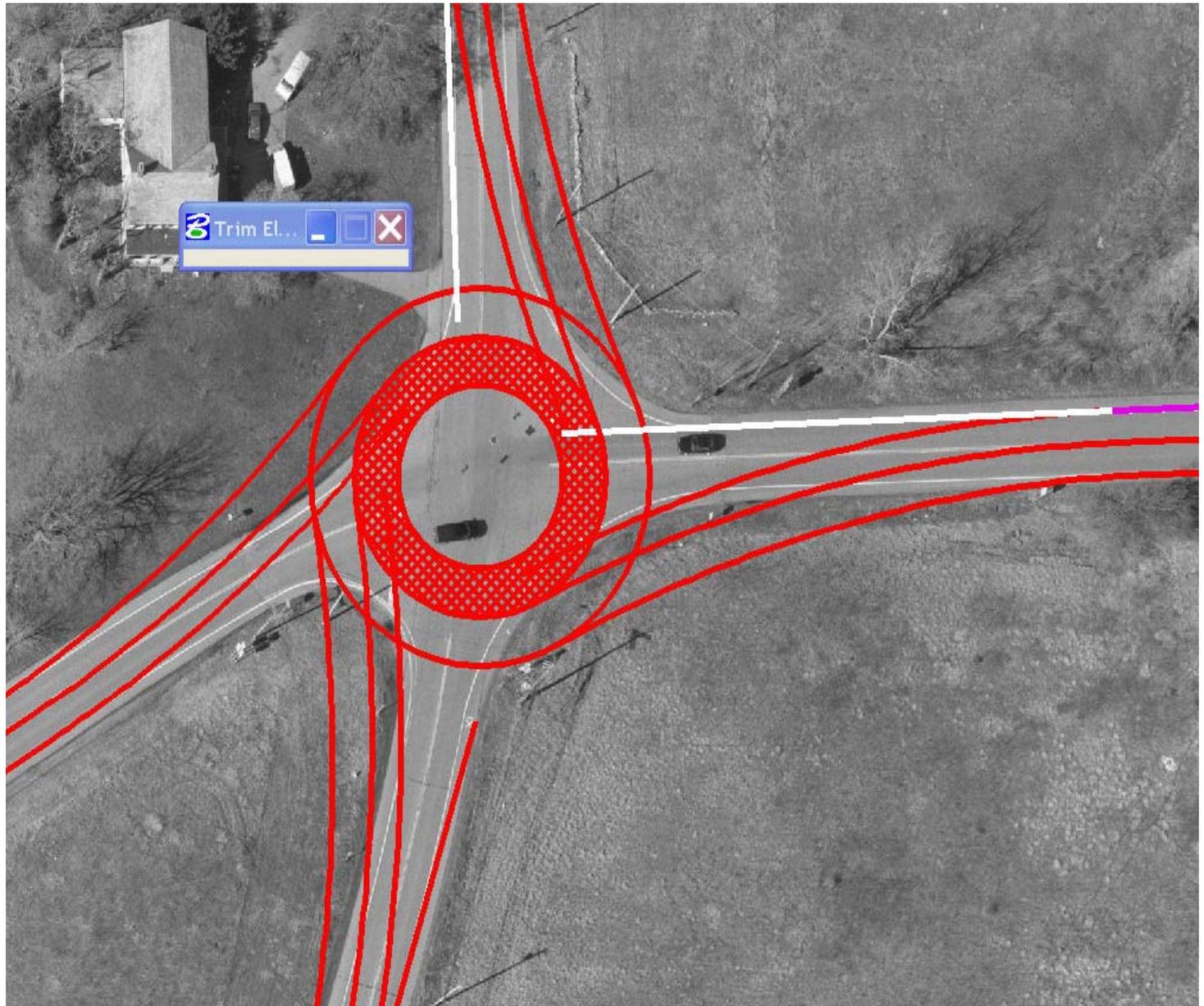
Just do another copy parallel 12' for the right side of the approach

Having the approach follow the exit radii is what will dictate the lower approach speeds



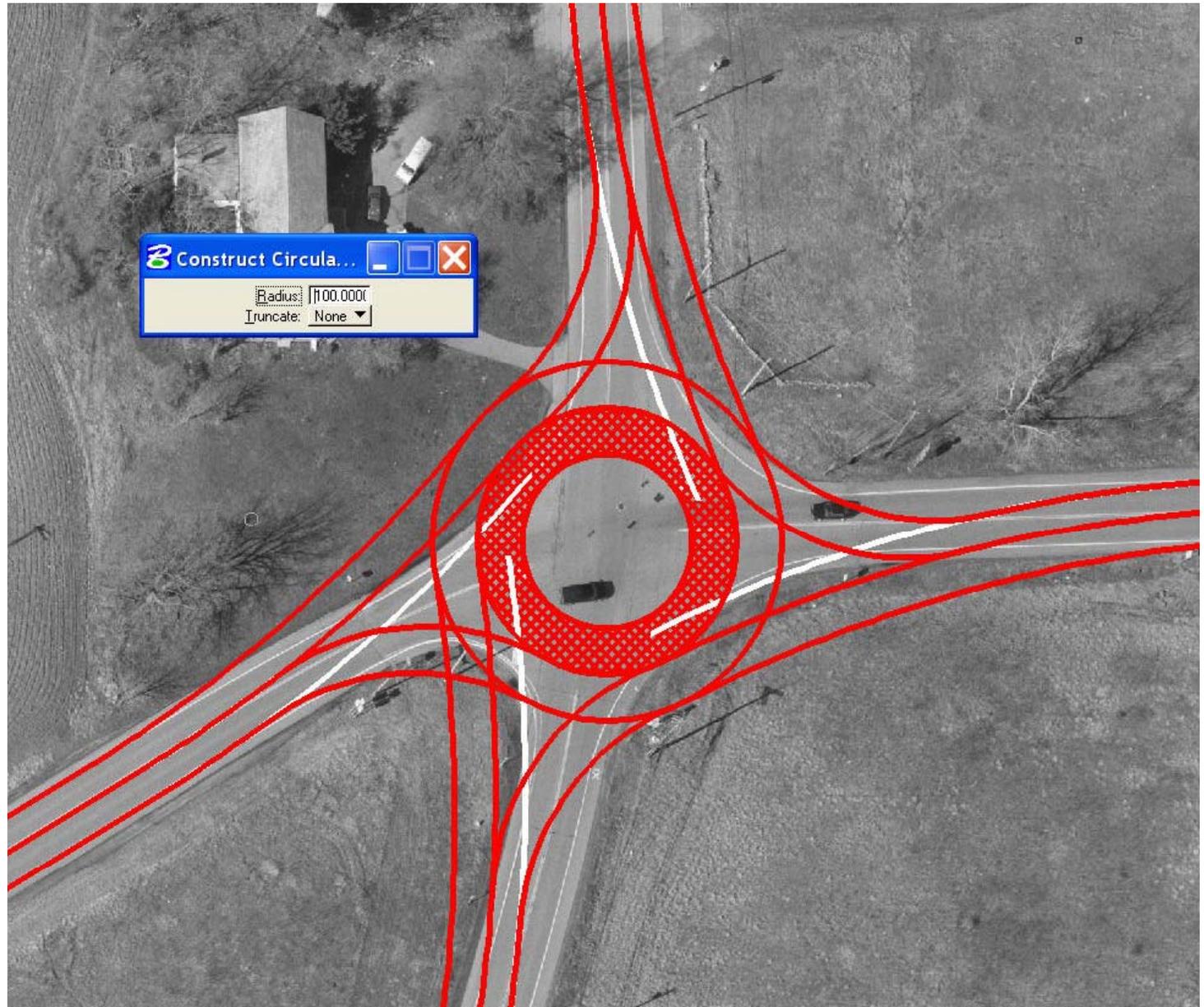
STEP 7 – TRIM THE OLD LINE ON THE APPROACH

You can either use the trim command or use the extend 2 elements to intersection command.



STEP 8 – FILLET THE APPROACH

Fillet the new right edge to the outside edge of the roundabout and trim the center line to the approach side of the truck apron – you want to truncate none when doing the center line because you need it for the exit and splitter island.



STEP 9 – TRIM LINES THAT GO INTO ROUNDABOUT

Remove the part of the fillet lines that go into the circulatory roadway of the roundabout using the outside edge of the roundabout as the cutting edge.



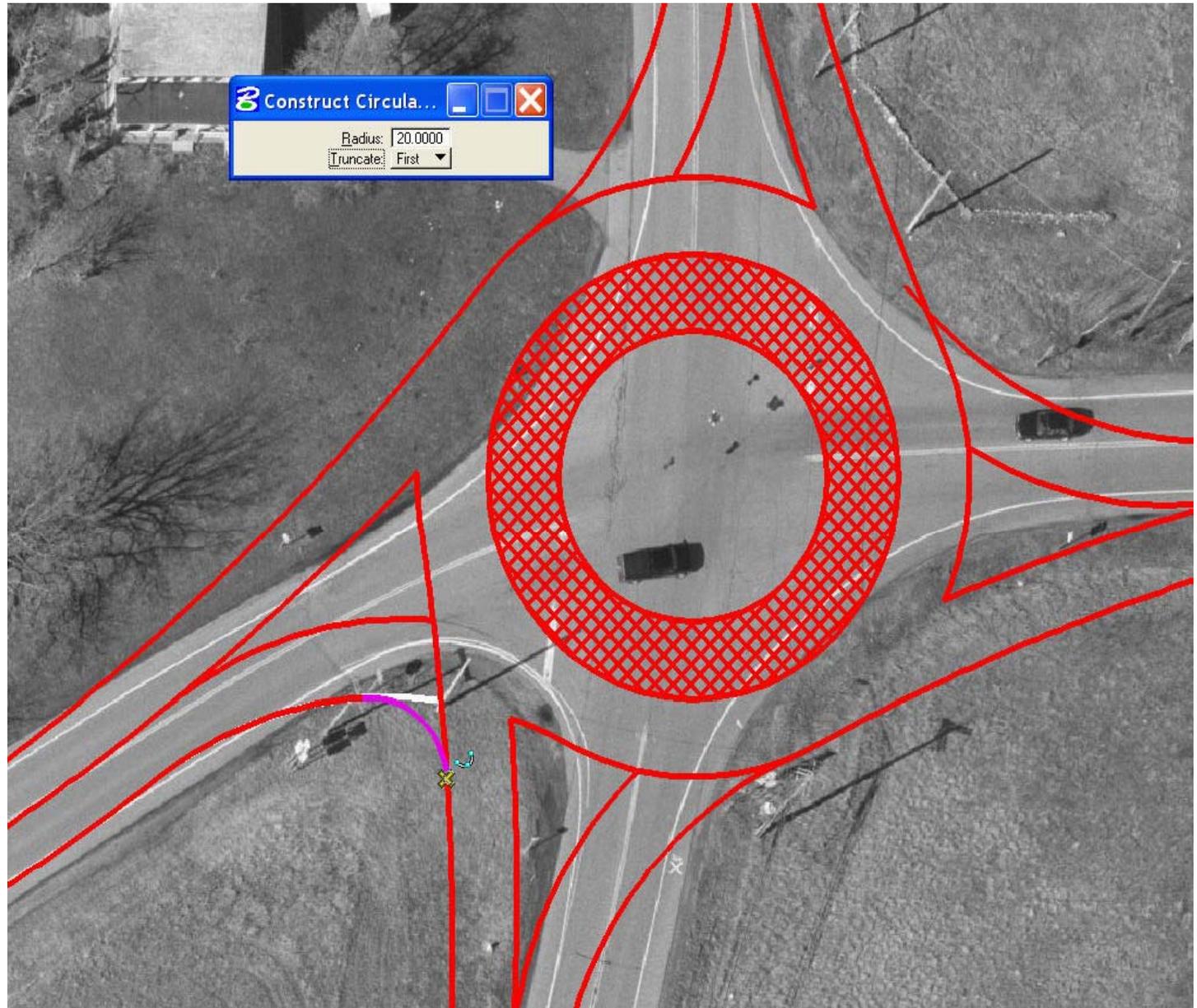
STEP 10 – TRIM LINES THAT GO ACROSS EXITS

Using the partial delete command you can get rid of any lines that aren't going to appear in the final layout – especially the lines across the exits.



STEP 11 – FILLET ANY SKEWED APPROACHES

For this example the only approach that needs a fillet to not look odd is the approach from the SW. I tried a 20' radius.



STEP 12 – SNAG AN IMAGE FOR SIMULATION, REPORT..

This concludes
the 12 step
program for
CAD

Hopefully this is
one of the
easier 12 step
programs to
complete... 😊



What about a truck turning right from the west?

OPTIONS:

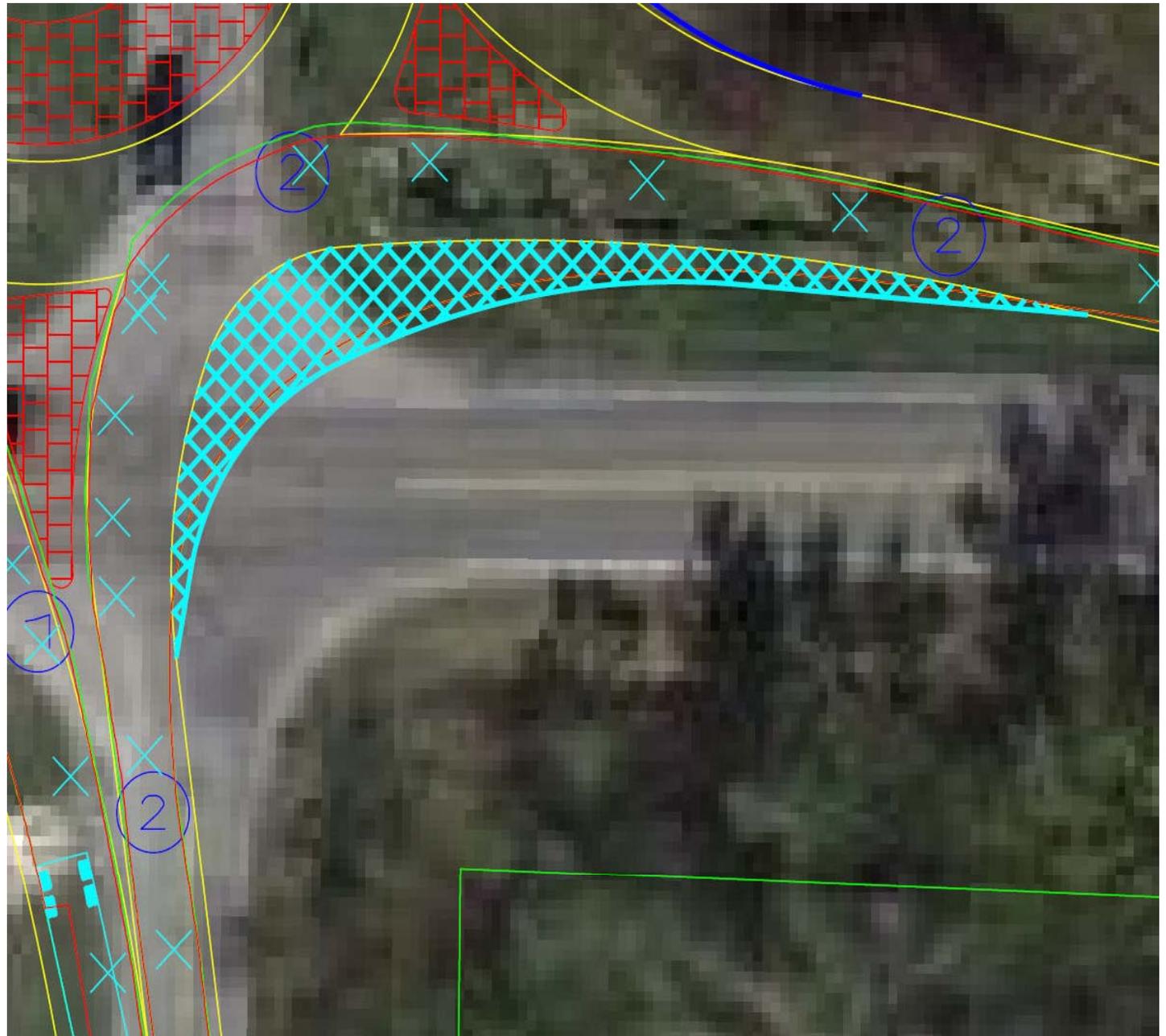
- 1) Do the loop if it is a minor move
– signs required?
- 2) Outer slip lane
– could have ROW impacts
- 3) Outside Truck Apron – peds may be difficult
- 4) Make exit wider by shaving into splitter island
- 5) Make approach a little wider
- 6) Major option - realignment



Option 3 Example

OPTIONS:

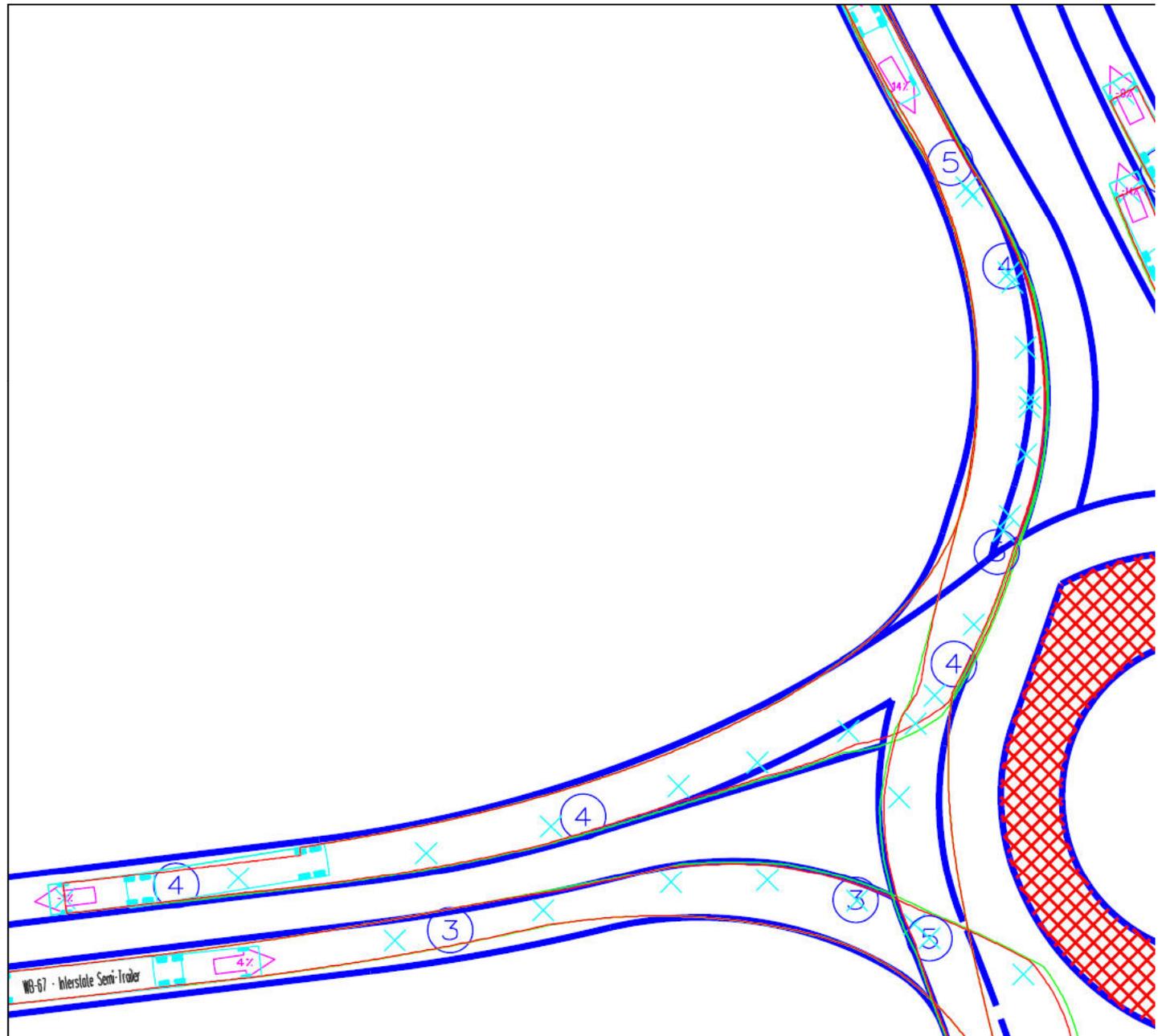
- 1) Do the loop if it is a minor move – signs required?
- 2) Outer slip lane – could have ROW impacts
- 3) **Outside Truck Apron – peds may be difficult**
- 4) Make exit wider by shaving into splitter island
- 5) Make approach a little wider
- 6) Major option - realignment



Option 4 Example

OPTIONS:

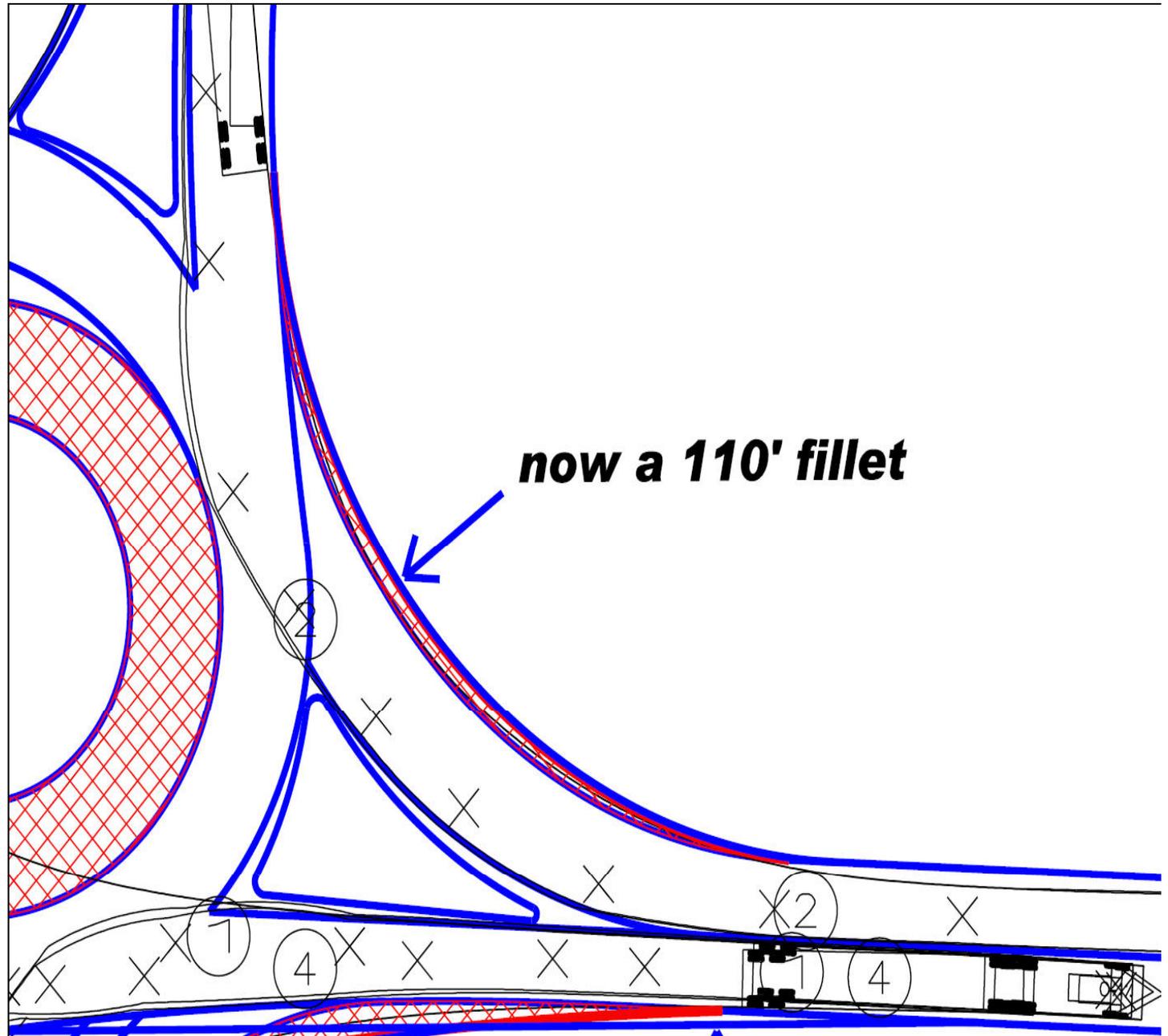
- 1) Do the loop if it is a minor move
– signs required?
- 2) Outer slip lane
– could have ROW impacts
- 3) Outside Truck Apron – peds may be difficult
- 4) **Make exit wider by shaving into splitter island**
- 5) Make approach a little wider
- 6) Major option - realignment



Option 5 Example

OPTIONS:

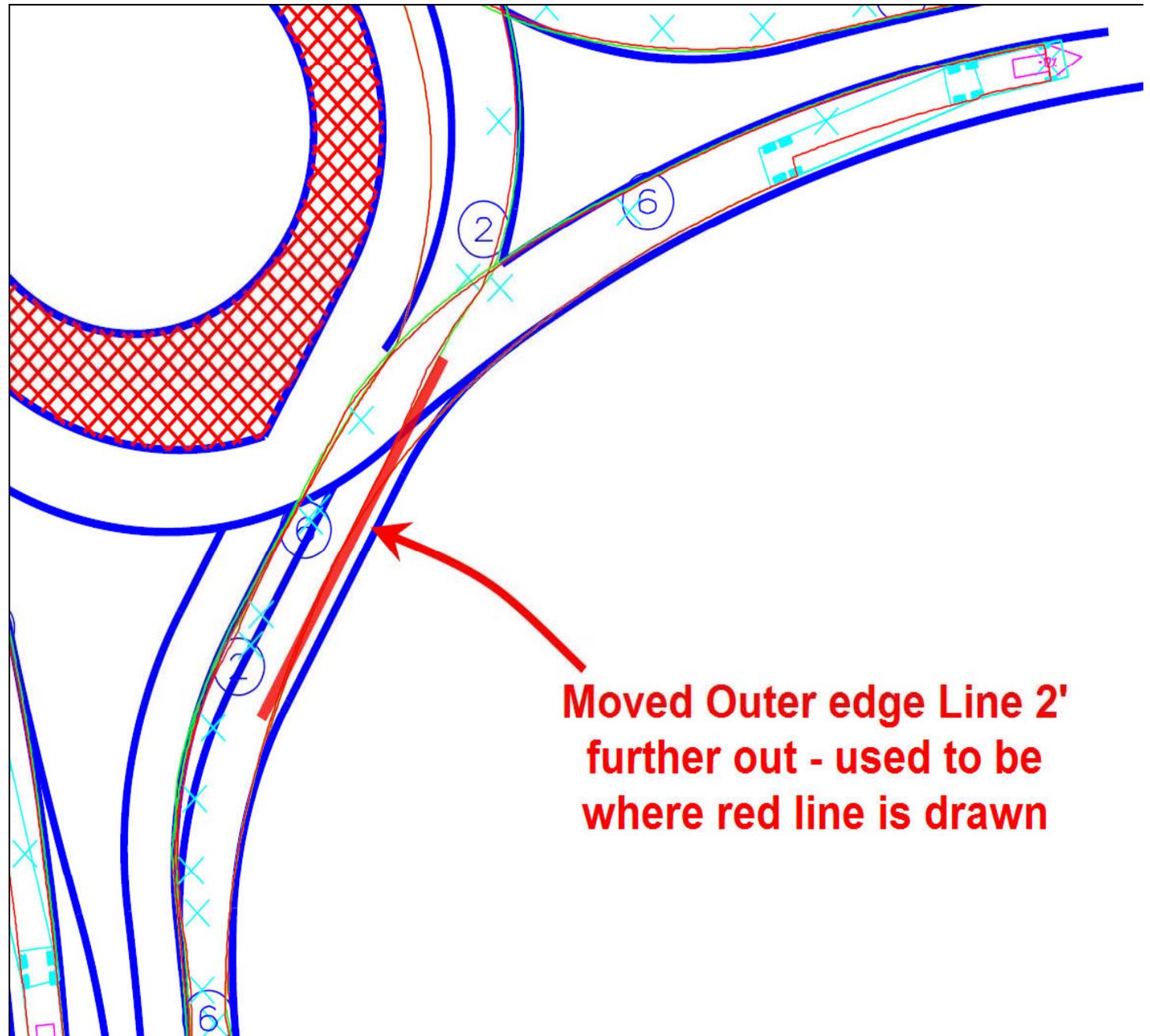
- 1) Do the loop if it is a minor move
– signs required?
- 2) Outer slip lane
– could have ROW impacts
- 3) Outside Truck Apron – peds may be difficult
- 4) Make exit wider by shaving into splitter island
- 5) Make approach a little wider
- 6) Major option - realignment



Another Option 5 Example

OPTIONS:

- 1) Do the loop if it is a minor move – signs required?
- 2) Outer slip lane – could have ROW impacts
- 3) Outside Truck Apron – peds may be difficult
- 4) Make exit wider by shaving into splitter island
- 5) **Make approach a little wider**
- 6) Major option - realignment



Akron, Ohio Roundabout



FHWA Single Lane Roundabout Capacity Study

OBSERVATION #	CONFLICTING FLOW (veh/hr)	MAXIMUM ENTRY FLOW (veh/hr)	
		Real Data (veh/hr)	VISSIM (veh/hr)
1	120	1,020	1,250
2	300	852	930
3	480	690	700
4	600	588	550
5	720	480	400
6	900	312	290

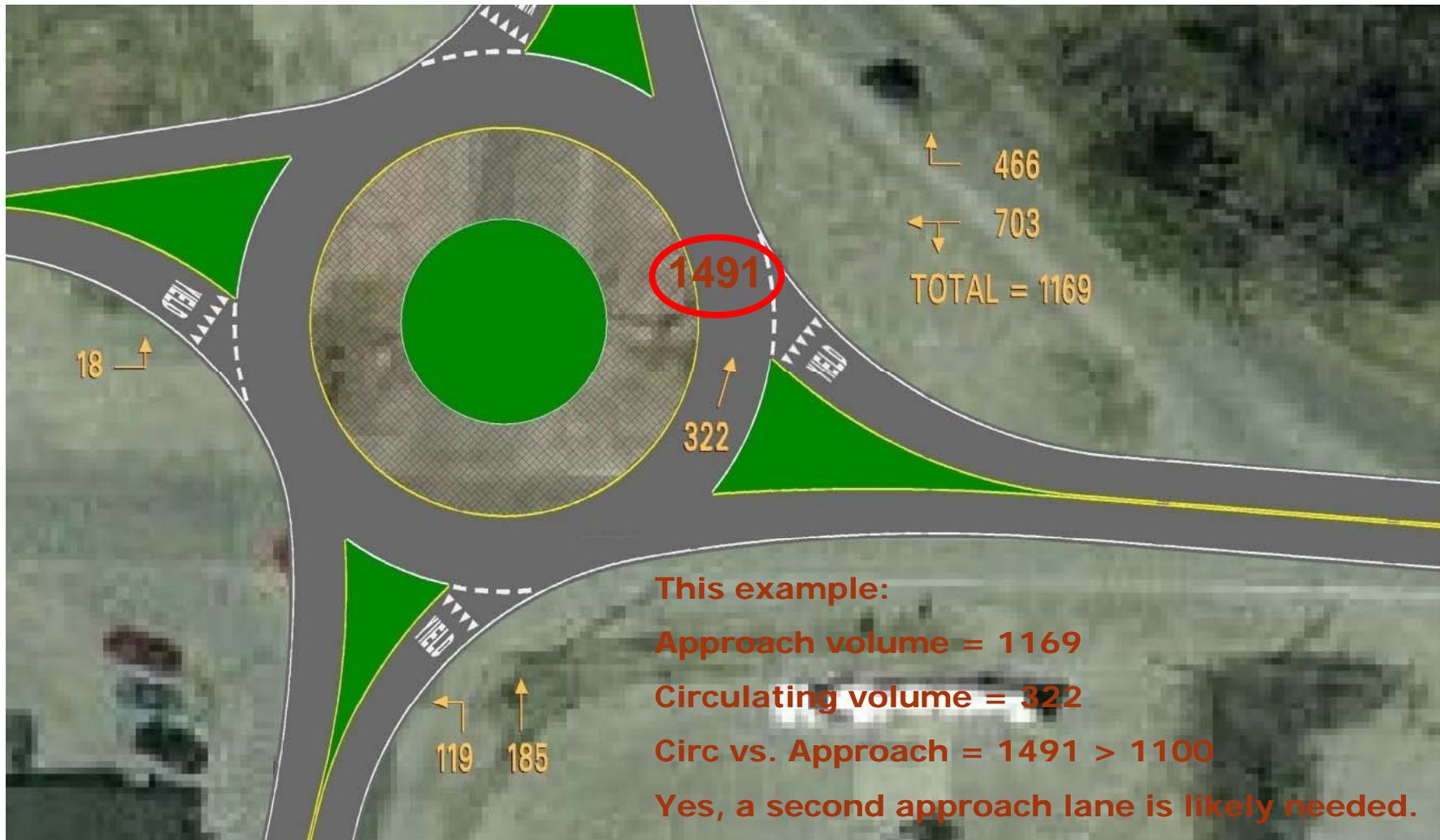
Single Lane Roundabout – Comparison of VISSIM results with real data

FHWA Two Lane Roundabout Capacity Study

OBSERVATION #	CONFLICTING FLOW (veh/hr)	MAXIMUM ENTRY FLOW (veh/hr)	
		Real Data (veh/hr)	VISSIM (veh/hr)
1	300	1620	1800
2	600	1290	1350
3	900	990	1000
4	1200	750	700
5	1500	552	450
6	1800	372	300

Approach Number of Lanes

A second approach lane may be necessary when circulating vs. approach volume sum > 1100 vphpl and most likely necessary when sum $> 1,400$ vphpl



RODEL output

When a second approach lane may be necessary

21:8:03 AIRPORT ROUNDABOUT AM 11													
E	(m)	5.00	5.00	5.00	5.00	TIME PERIOD	min	90					
L'	(m)	10.00	10.00	10.00	30.00	TIME SLICE	min	15					
U	(m)	3.00	3.00	3.00	3.30	RESULTS PERIOD	min	15	75				
RAD	(m)	20.00	20.00	20.00	20.00	TIME COST	\$/hr	15.00					
PHI	(d)	30.00	30.00	30.00	30.00	FLOW PERIOD	min	15 75					
DIA	(m)	40.00	40.00	40.00	40.00	FLOW TYPE	pcu/veh	VEH					
GRAD	SEP	0	0	0	0	FLOW PEAK	am/op/pm	PM					
LEG NAME	PCU	FLOWS (1st exit 2nd etc...U)				FLOF	CL	FLOW RATIO		FLOW TIME			
NORTH	1.02	014	062	090	0	1.00	50	0.75	1.125	0.75	15 45 75		
WEST	1.02	044	090	018	0	1.00	50	0.75	1.125	0.75	15 45 75		
SOUTH	1.02	133	185	119	0	1.00	50	0.75	1.125	0.75	15 45 75		
EAST	1.02	466	366	337	0	1.00	50	0.75	1.125	0.75	15 45 75		
MODE 2													
FLOW	veh	166	152	437	1169						AUDEL	s	50.2
CAPACITY	veh	799	983	1143	1218						L O \$	F	
AVE DELAY	mins	0.09	0.07	0.08	1.32						VEH HRS	26.8	
MAX DELAY	mins	0.12	0.09	0.11	2.78						COST	\$	402.1
AVE QUEUE	veh	0	0	1	27								
MAX QUEUE	veh	0	0	1	56								
F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc													

Rule of thumb verified...

RODEL output

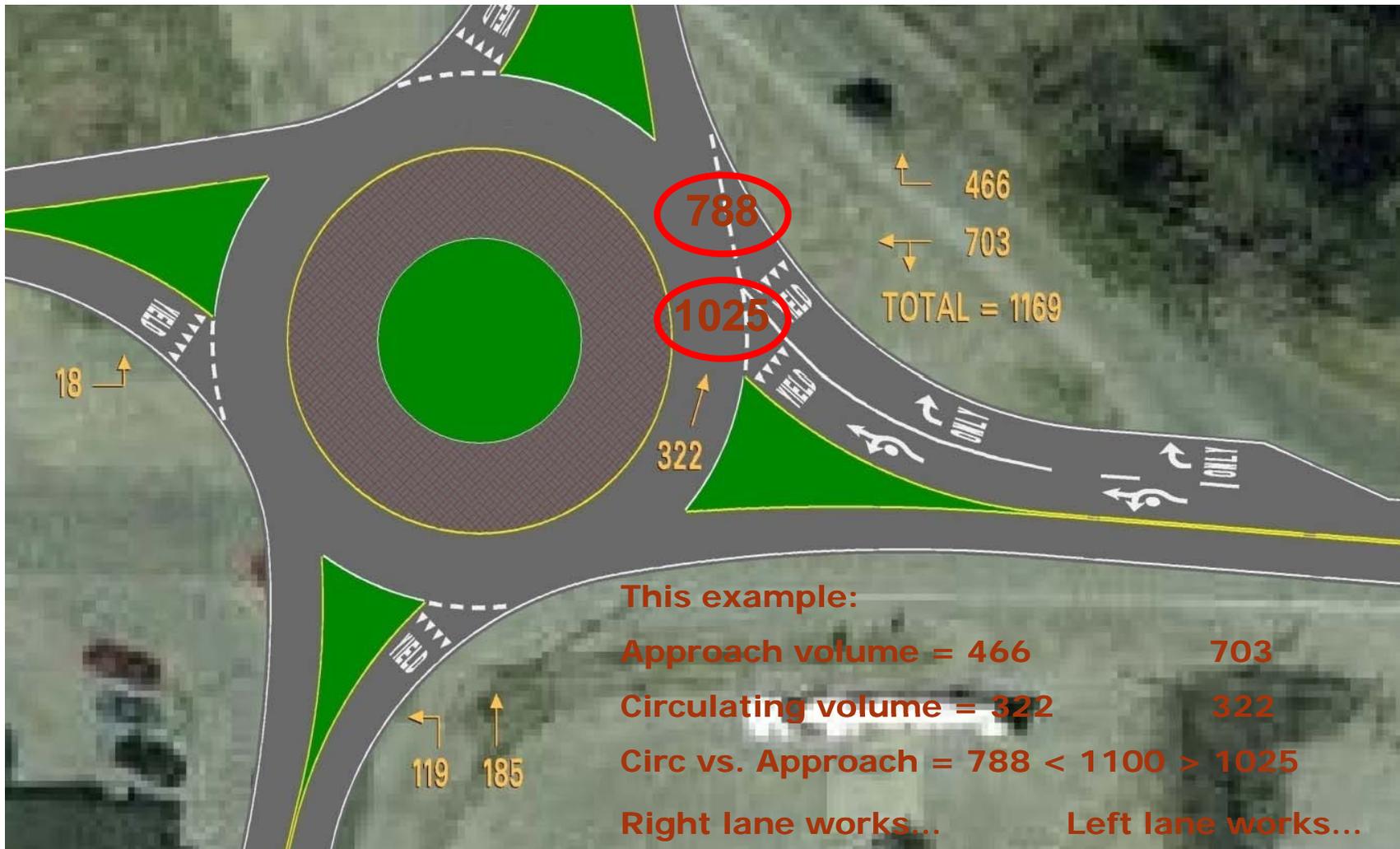
For dedicated right turn lane

RODELDEM													
21:8:03 AIRPORT ROUNDABOUT AM 13													
E (m)	5.00	5.00	5.00	4.80	TIME PERIOD	min	90						
L' (m)	10.00	10.00	10.00	30.00	TIME SLICE	min	15						
U (m)	3.00	3.00	3.00	3.30	RESULTS PERIOD	min	15 75						
RAD (m)	20.00	20.00	20.00	20.00	TIME COST	\$/hr	15.00						
PHI (d)	30.00	30.00	30.00	30.00	FLOW PERIOD	min	15 75						
DIA (m)	40.00	40.00	40.00	40.00	FLOW TYPE	pcu/veh	VEH						
GRAD SEP	0	0	0	0	FLOW PEAK	am/op/pm	PM						
LEG NAME	PCU	FLOWS (1st exit 2nd etc...U)				FLOF	CL	FLOW RATIO			FLOW TIME		
NORTH	1.02	014	062	090	0	1.00	50	0.75	1.125	0.75	15	45	75
WEST	1.02	044	090	018	0	1.00	50	0.75	1.125	0.75	15	45	75
SOUTH	1.02	133	185	119	0	1.00	50	0.75	1.125	0.75	15	45	75
EAST	1.02	466	000	000	0	1.00	50	0.75	1.125	0.75	15	45	75
MODE 2													
FLOW	veh	166	152	437	466							AVEDEL s	4.6
CAPACITY	veh	1187	1169	1143	1178							L O S	A
AVE DELAY	mins	0.06	0.06	0.08	0.08							VEH HRS	1.6
MAX DELAY	mins	0.07	0.07	0.11	0.11							COST \$	23.4
AVE QUEUE	veh	0	0	1	1								
MAX QUEUE	veh	0	0	1	1								
F1mode F2direct F3peak CtrlF3rev F4fact F6stats F8econ F9prnt F10run Esc													

Queue eliminated for right turn move...

Right Turn Lane Needed

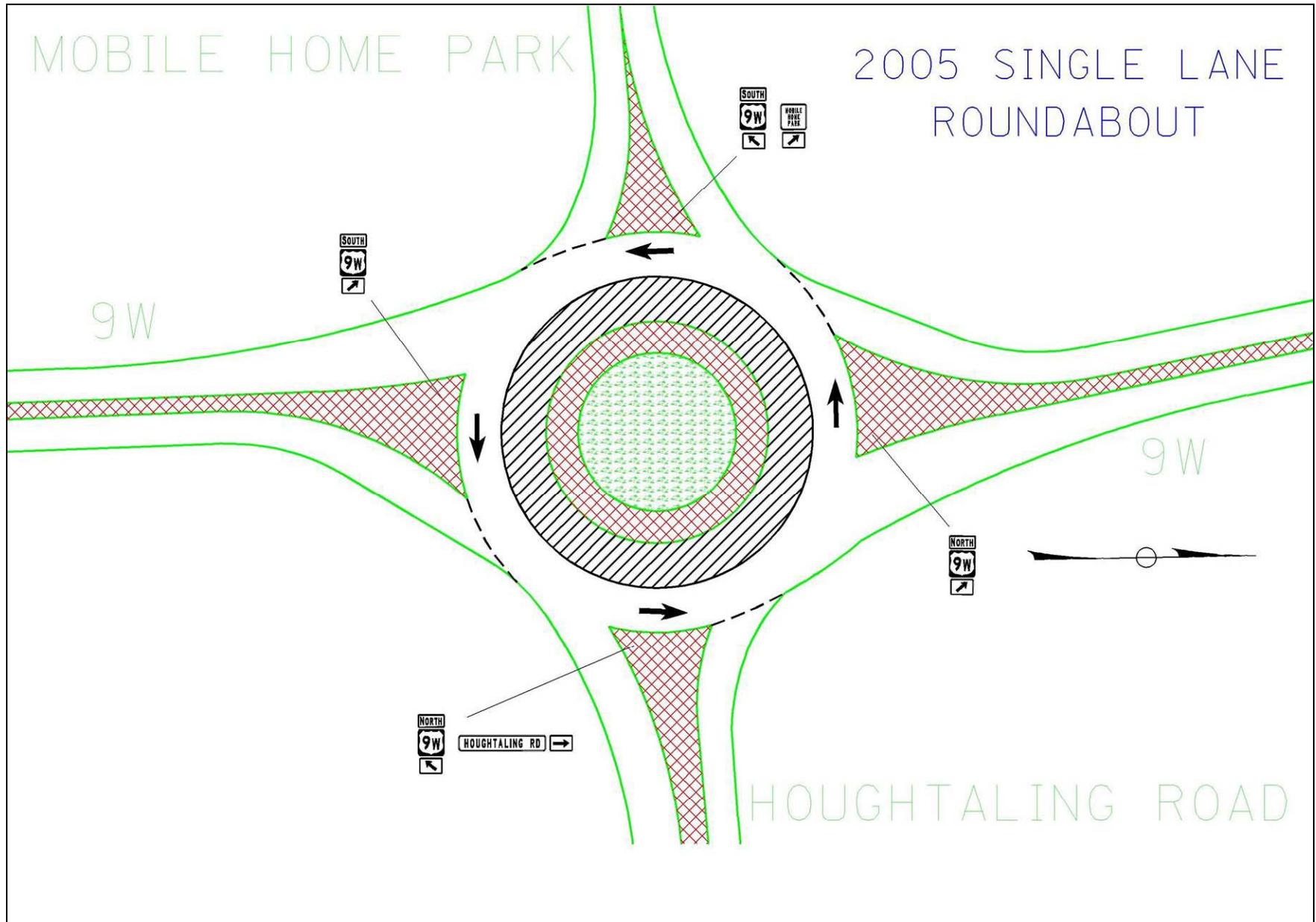
A right turn lane added layout now provided total sums of entering and circulating traffic below the 1,100 vphpl warning level and definitely well below the 1,400 vphpl maximum



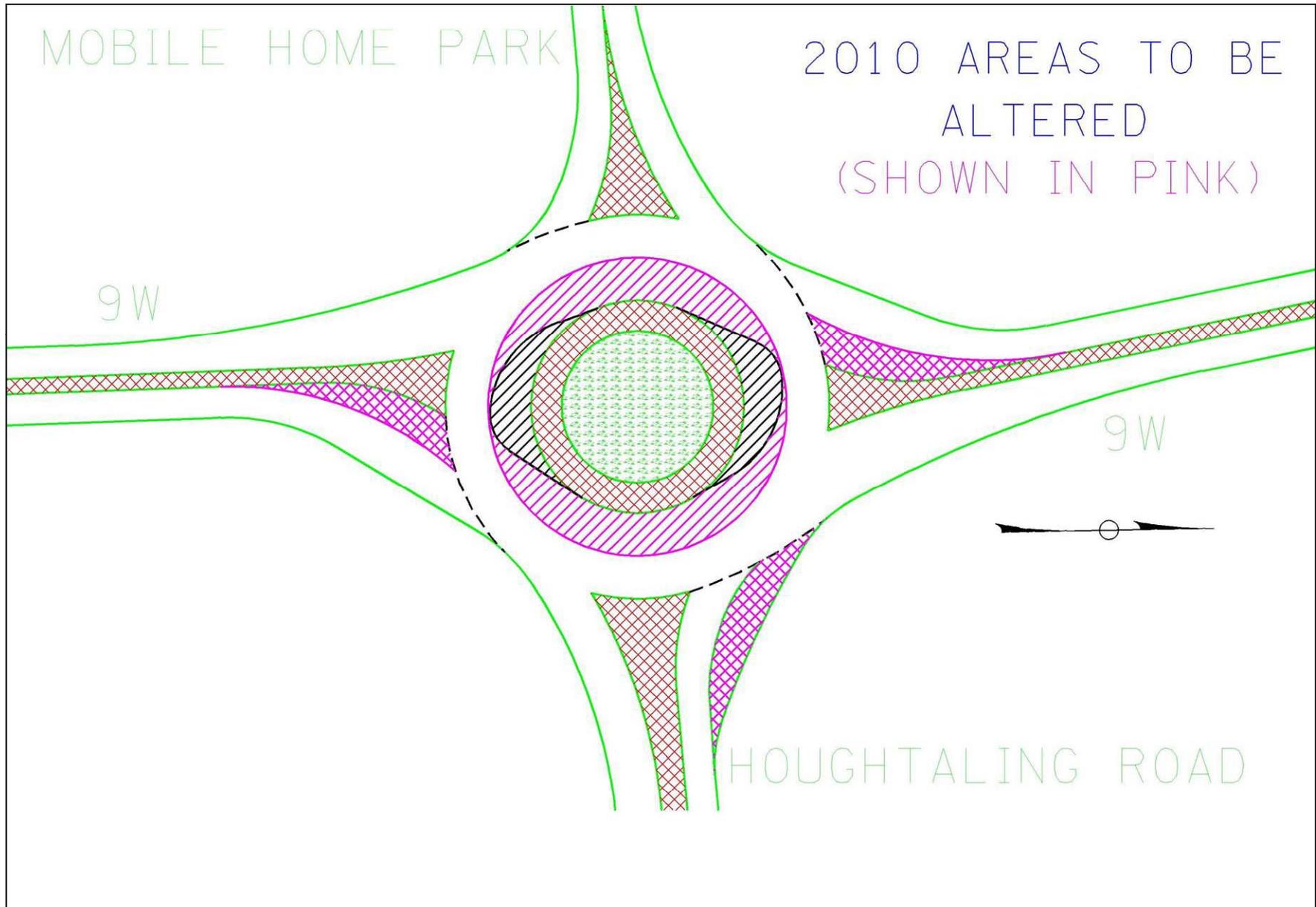
Old Wolf & Old Niskayuna Road - Colonie



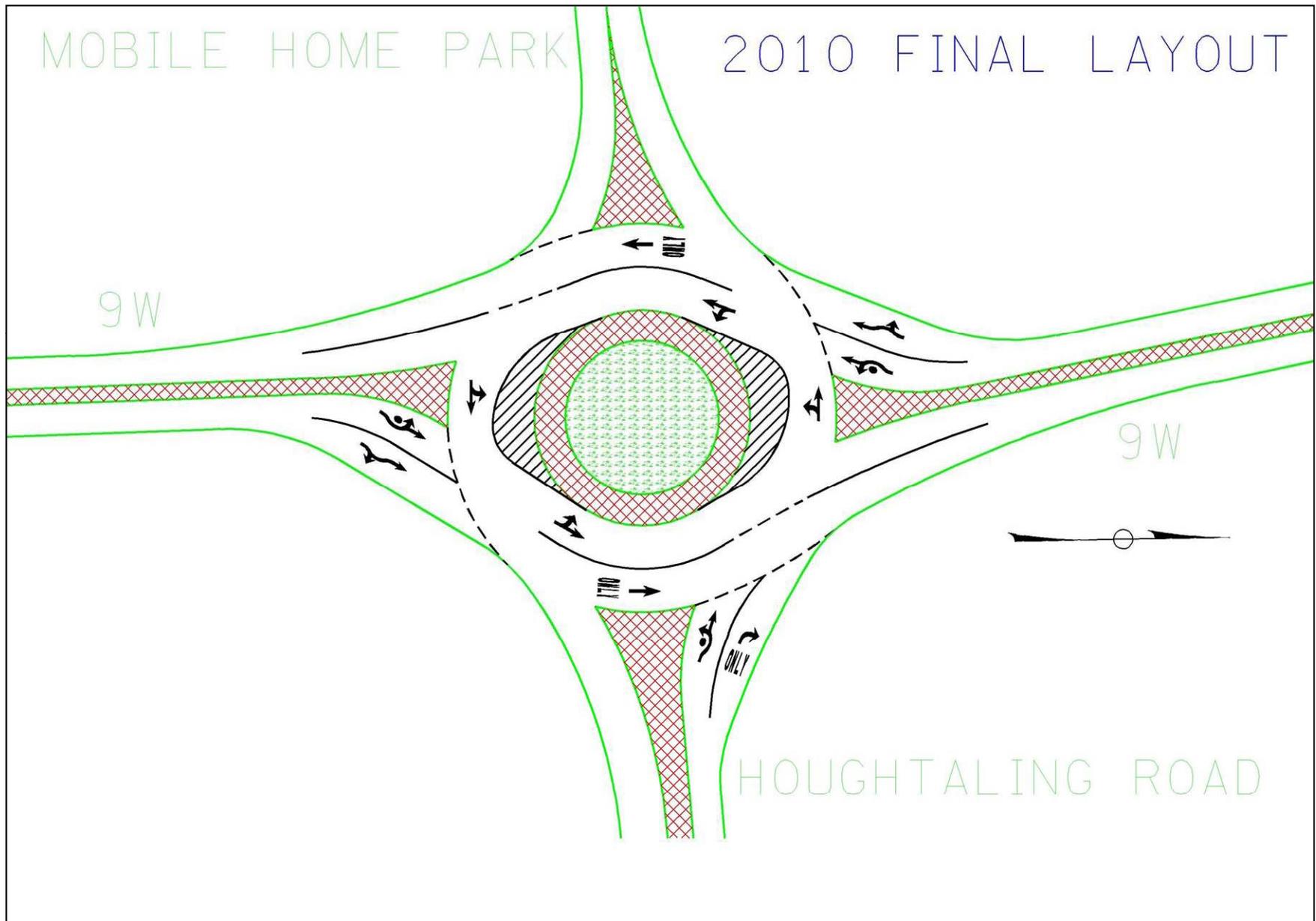
Phased in Design Steps – Phase 1



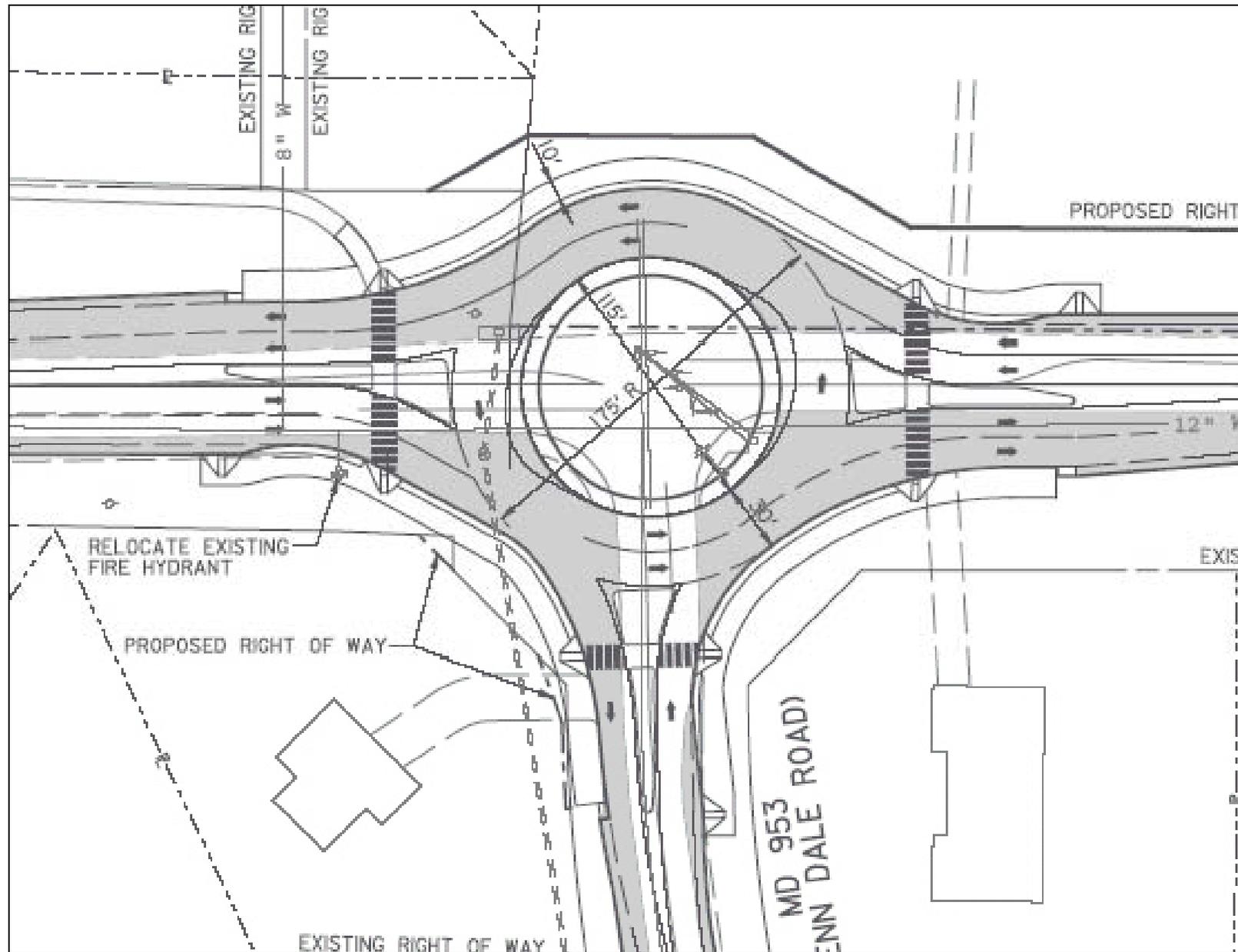
Phased in Design Steps – Phase 2



Phased in Design Steps – Final

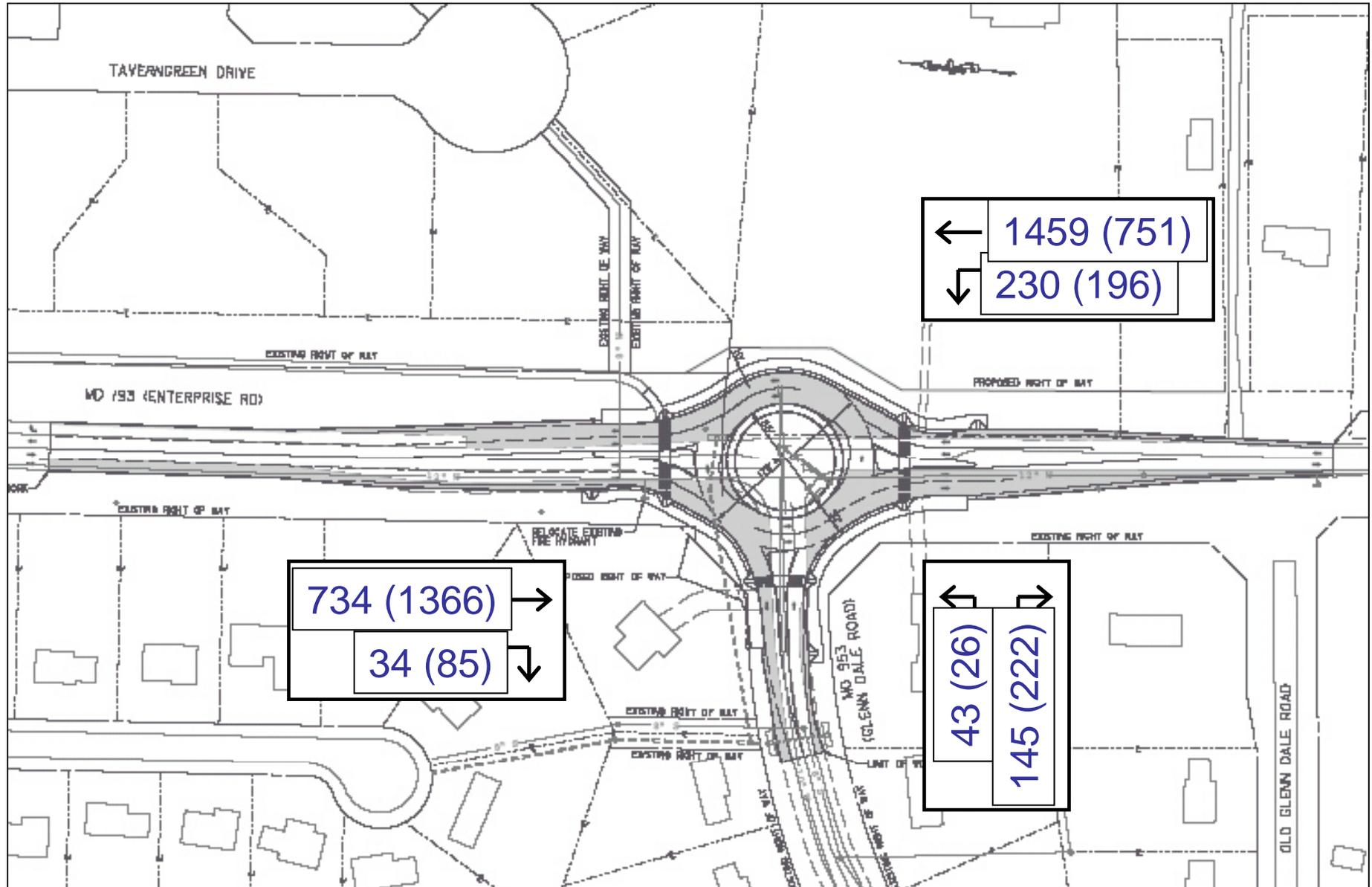


Major - Minor Roundabout



Major - Minor Roundabout

w/ 2030 AM (PM) Turn Volumes



Capacity Limits - Not Lane by Lane

If sum is 0 – 1,100 then

Single lane works

If sum is 1,100 – 1,400 then

Single lane might work

If sum is 1,400 – 1,900 then

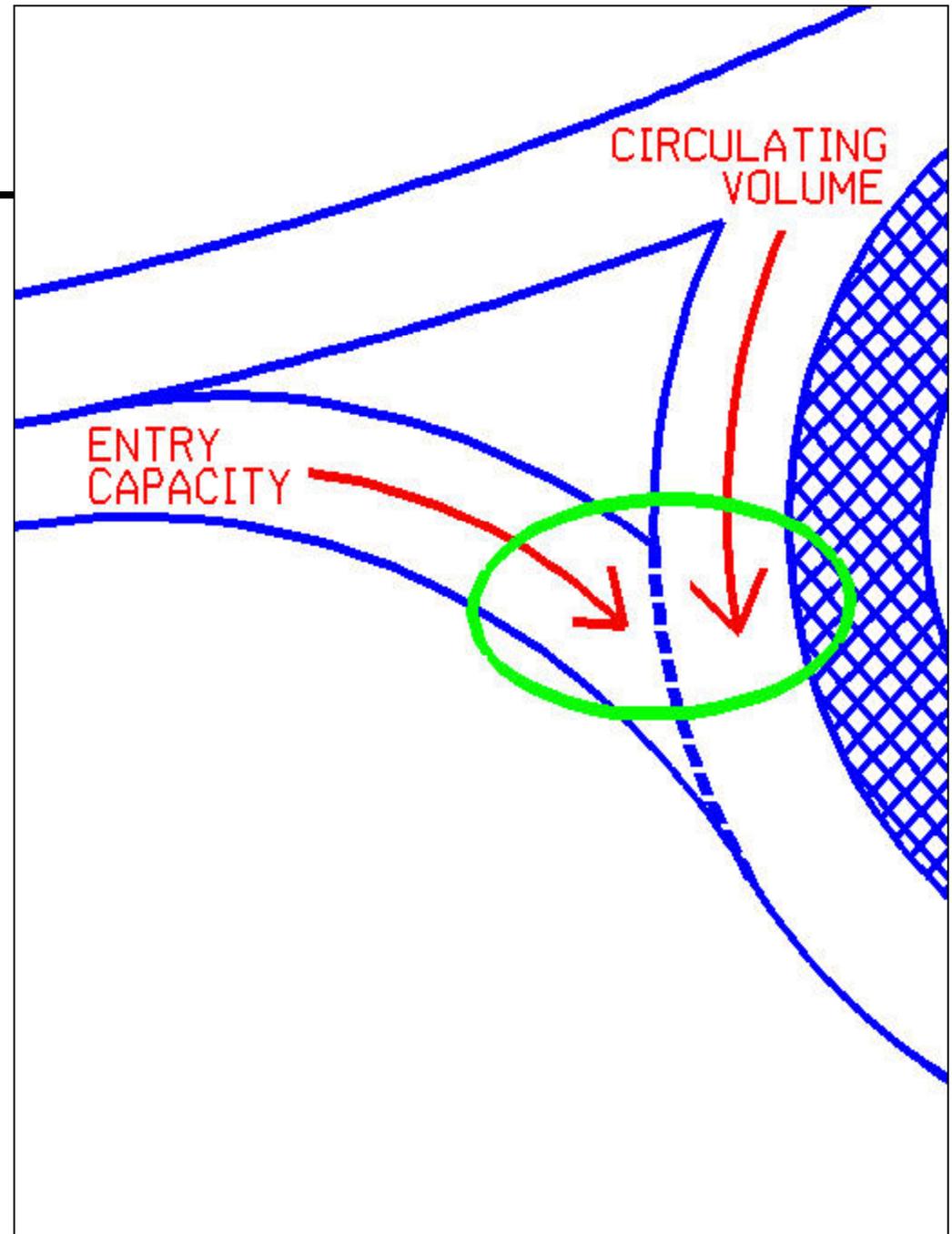
2 laner works

If sum is 1,900 – 2,300 then

2 laner might work

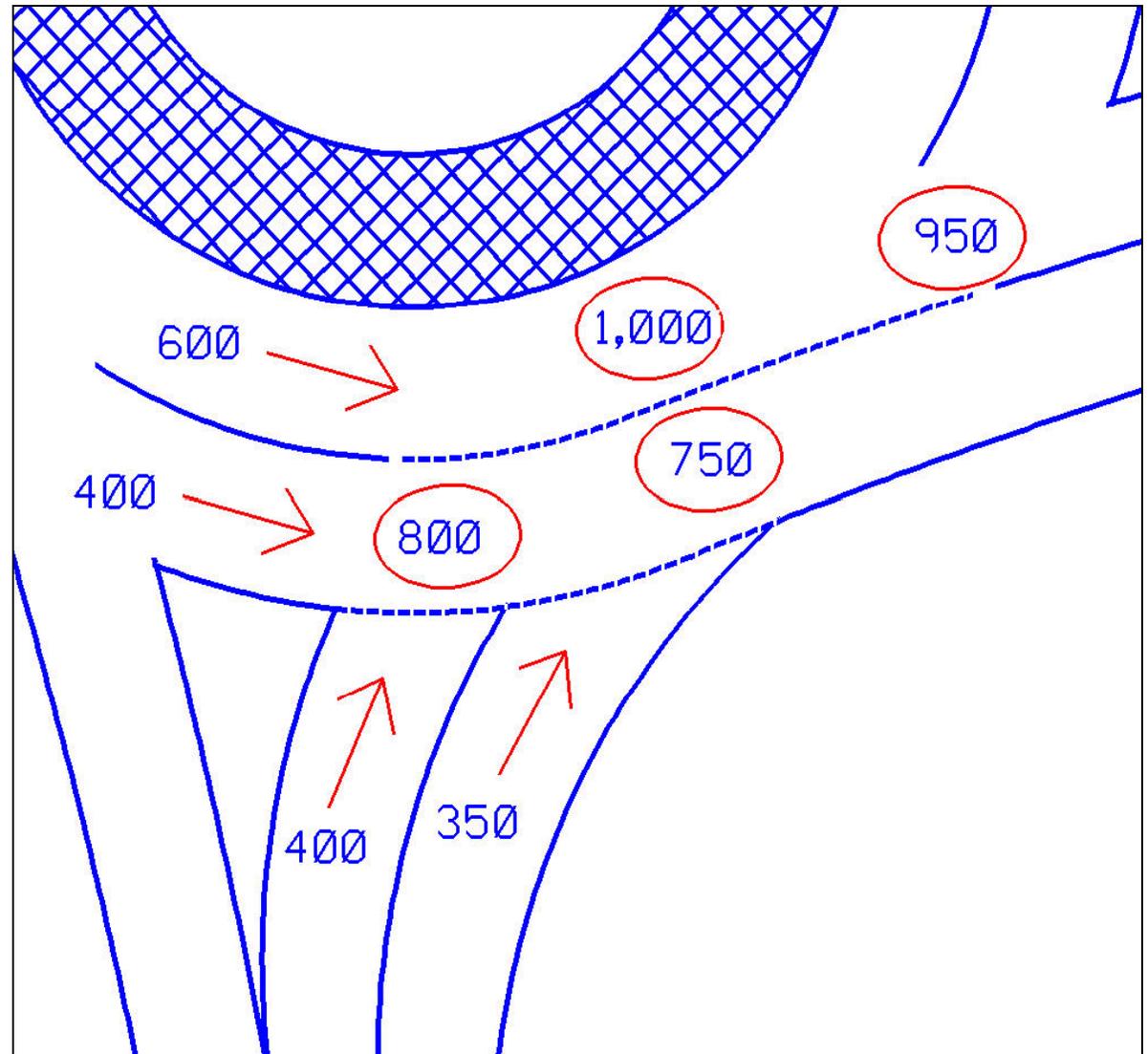
If sum is 2,300 – 2,900

3 laner might work



Capacity Limits – Still want to Check Lane by Lane – now 1,000 vphpl is limit

The 1,100 rule of thumb drops to 1,000 because entering vehicles need to find acceptable gaps in both circulating lanes at once – some gaps in the outer lane will be eliminated by the vehicles circulating in the inner lane....

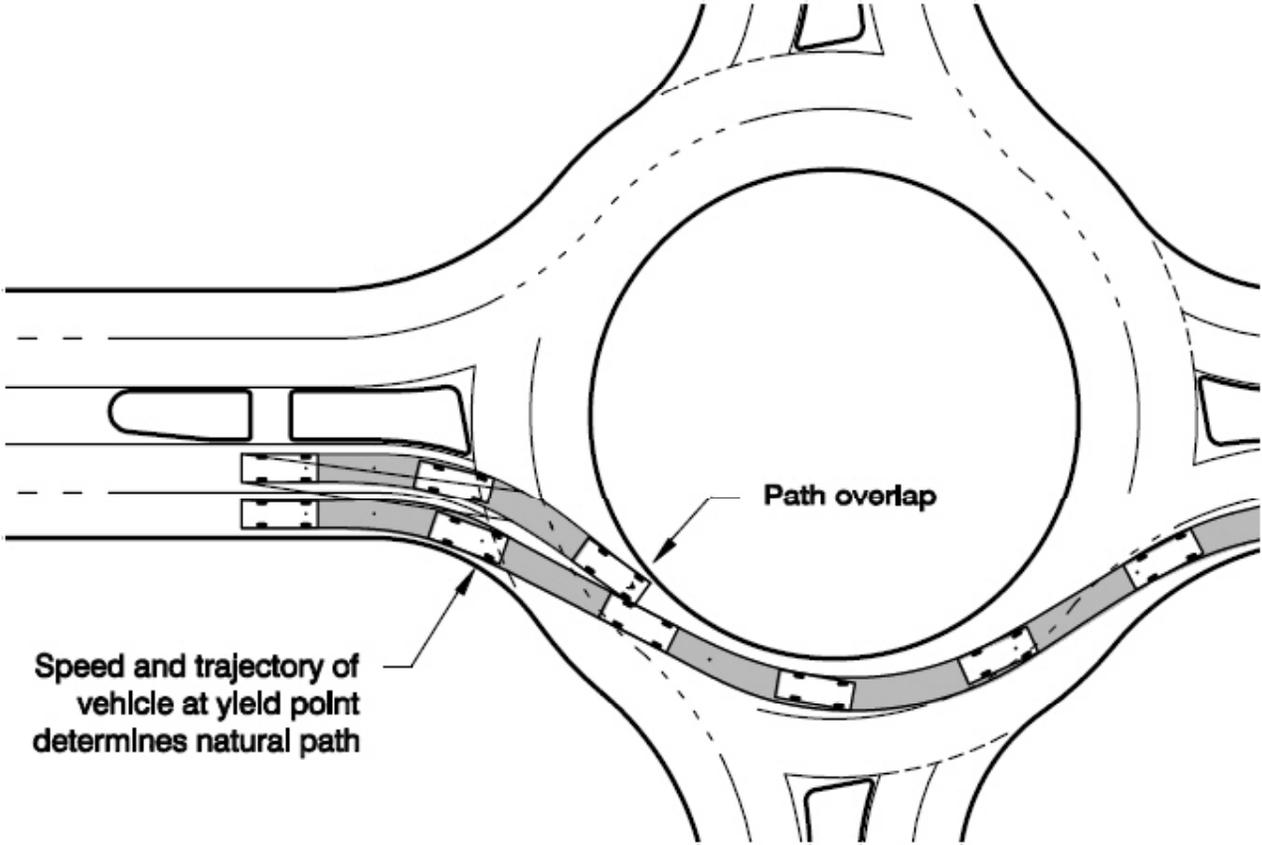


Additional 2 lane Roundabout Issues

- Entry path overlap
- Design vehicle tracking
 - On approach
 - Within circulatory roadway
- Striping crucial to achieve desired use...

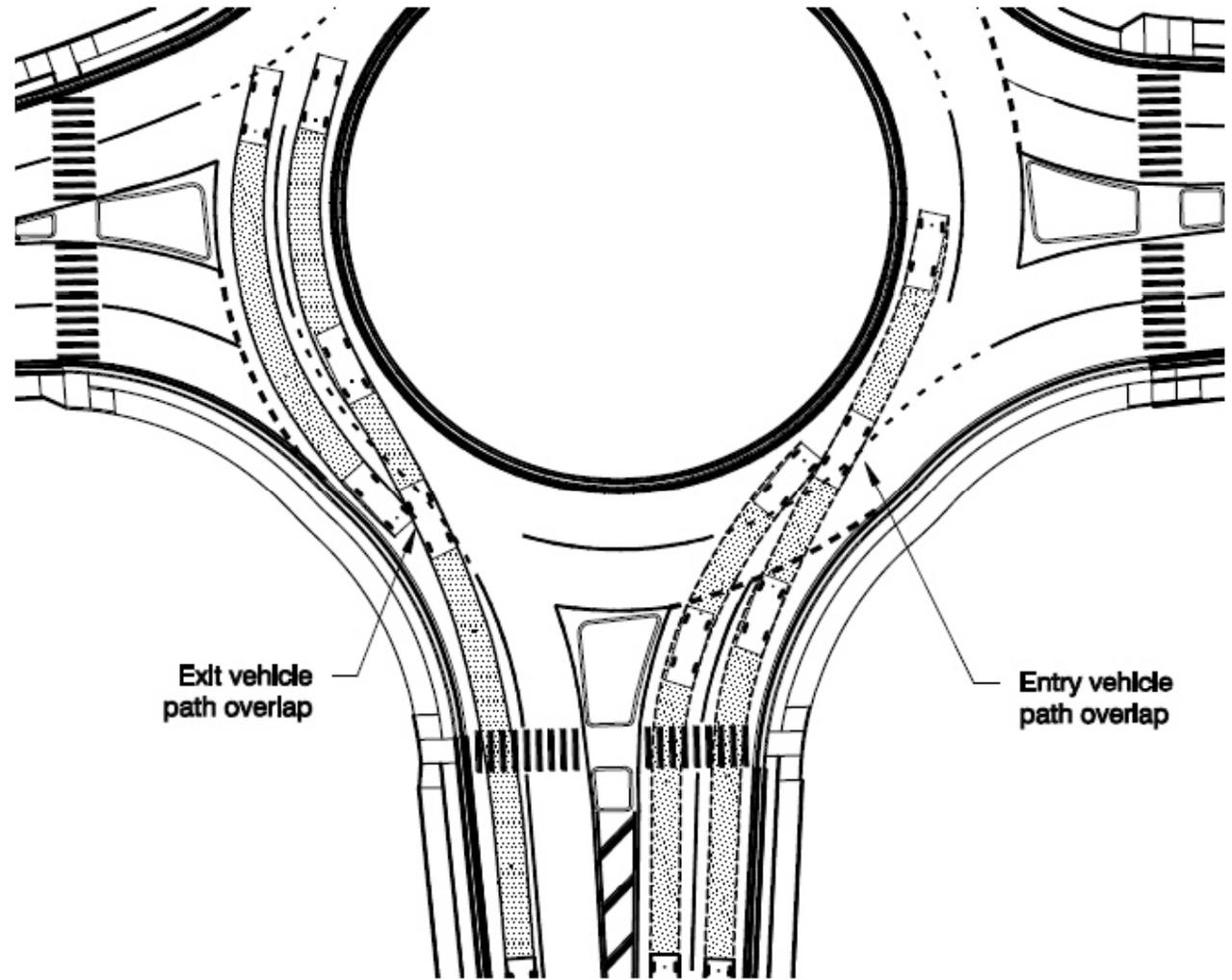
Entry Path Overlap – Per NCHRP 672

Exhibit 6-28
Entry Vehicle Path Overlap



Path Overlaps – Per NCHRP 672

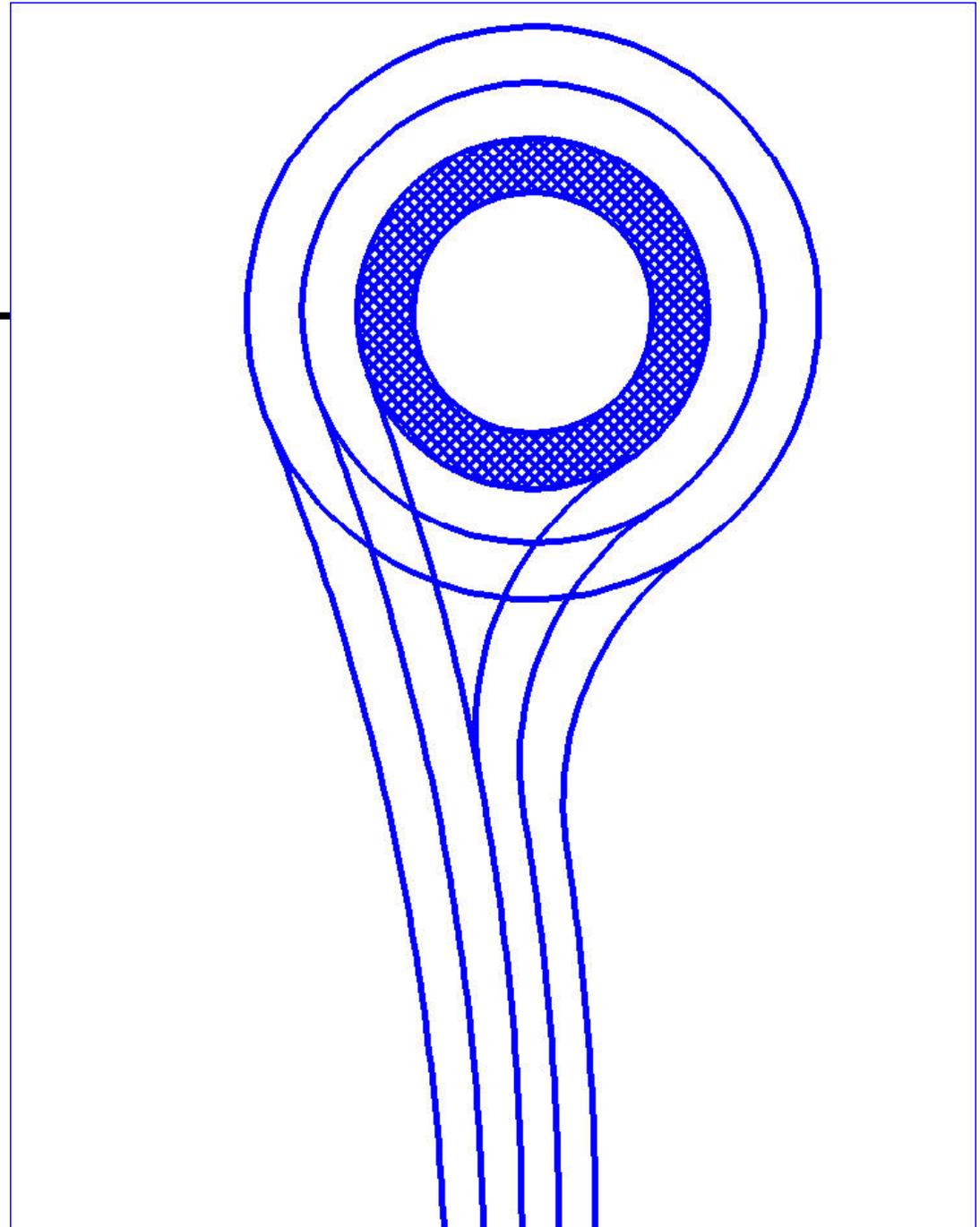
Exhibit 6-5
Path Overlap at
a Multilane Roundabout



ENTRY PATH OVERLAP

Created by using
single lane design
techniques on 2
lane roundabouts.

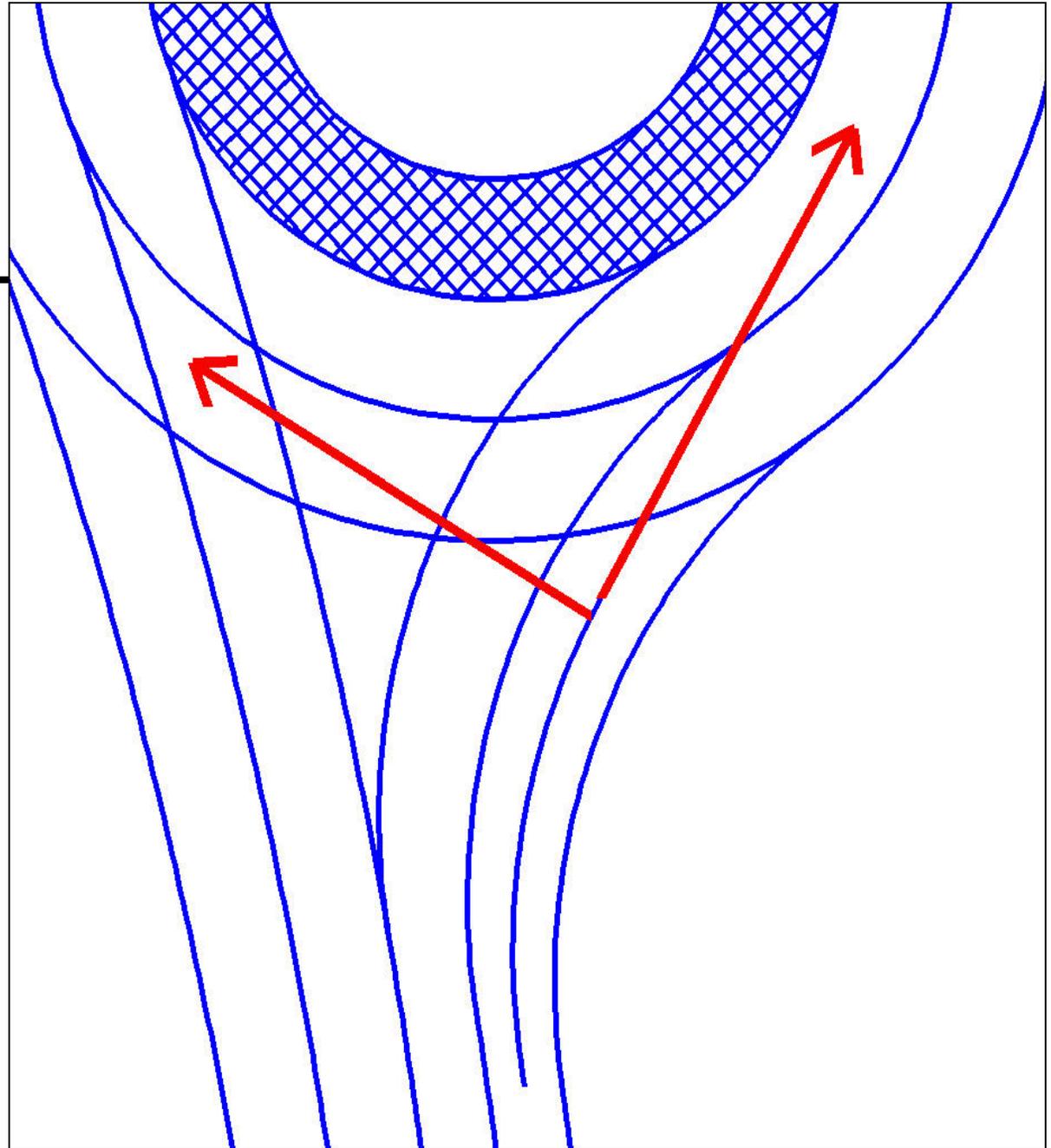
There is one critical
new step that needs
to be added...



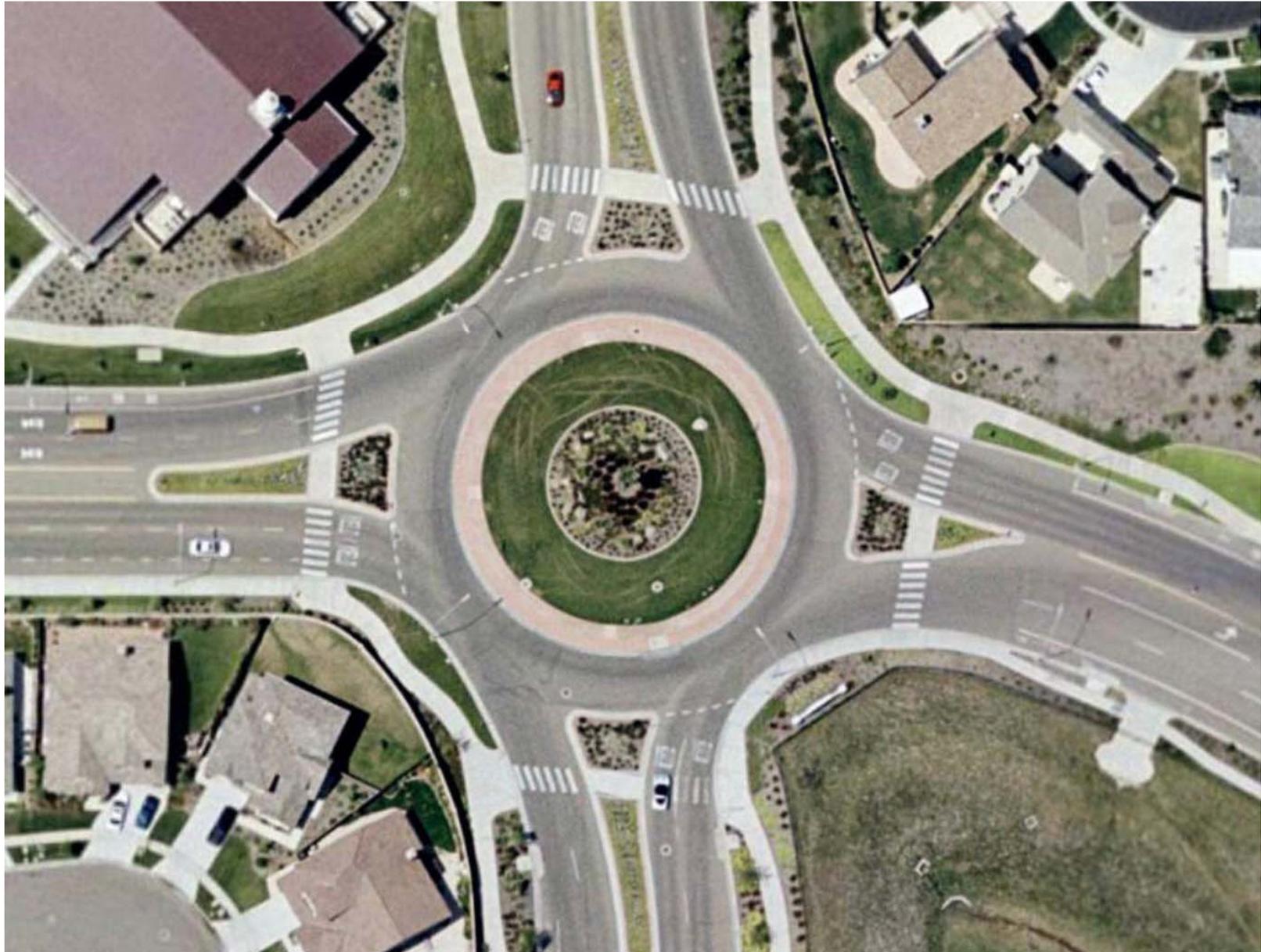
ENTRY PATH OVERLAP

Think about the driver....

They get to the yield line – look left – then look straight ahead – they forget about the 100' radius that they have just been following



Entry Path Overlap Example



Which lane do I want to enter???



Which lane would you likely enter???



Offset Left Design and Entry Path Overlap Eliminated per NCHRP 672

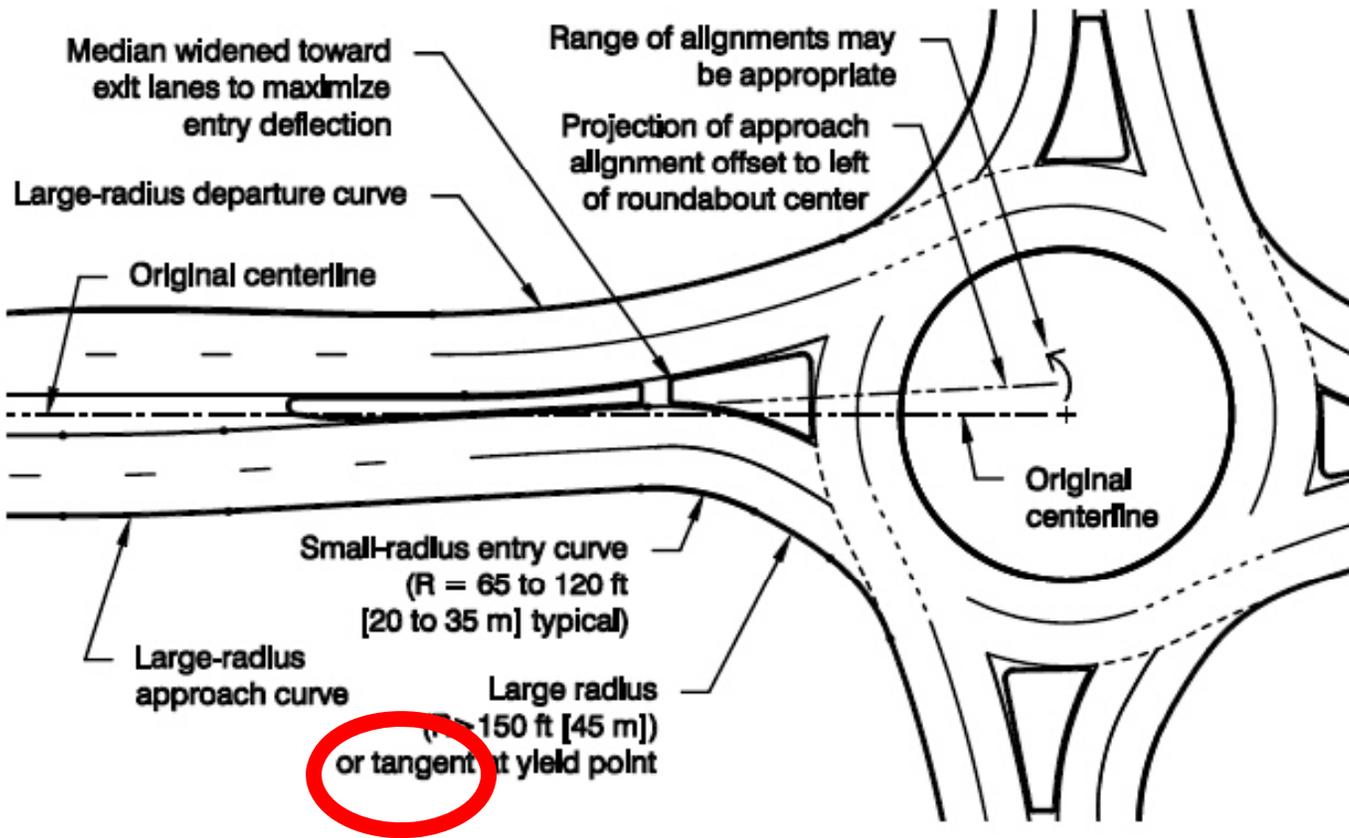


Exhibit 6-30
Example Minor Approach
Offset to Increase Entry
Deflection

What Can You Do If Already Built?



Entry Path Overlap “Fixed” With Striping



Entry Path Overlap **FIXED!**

<http://teachamerica.com/RAB11/RAB1109Vorisek/player.html>

Modification #2; Summer 2010

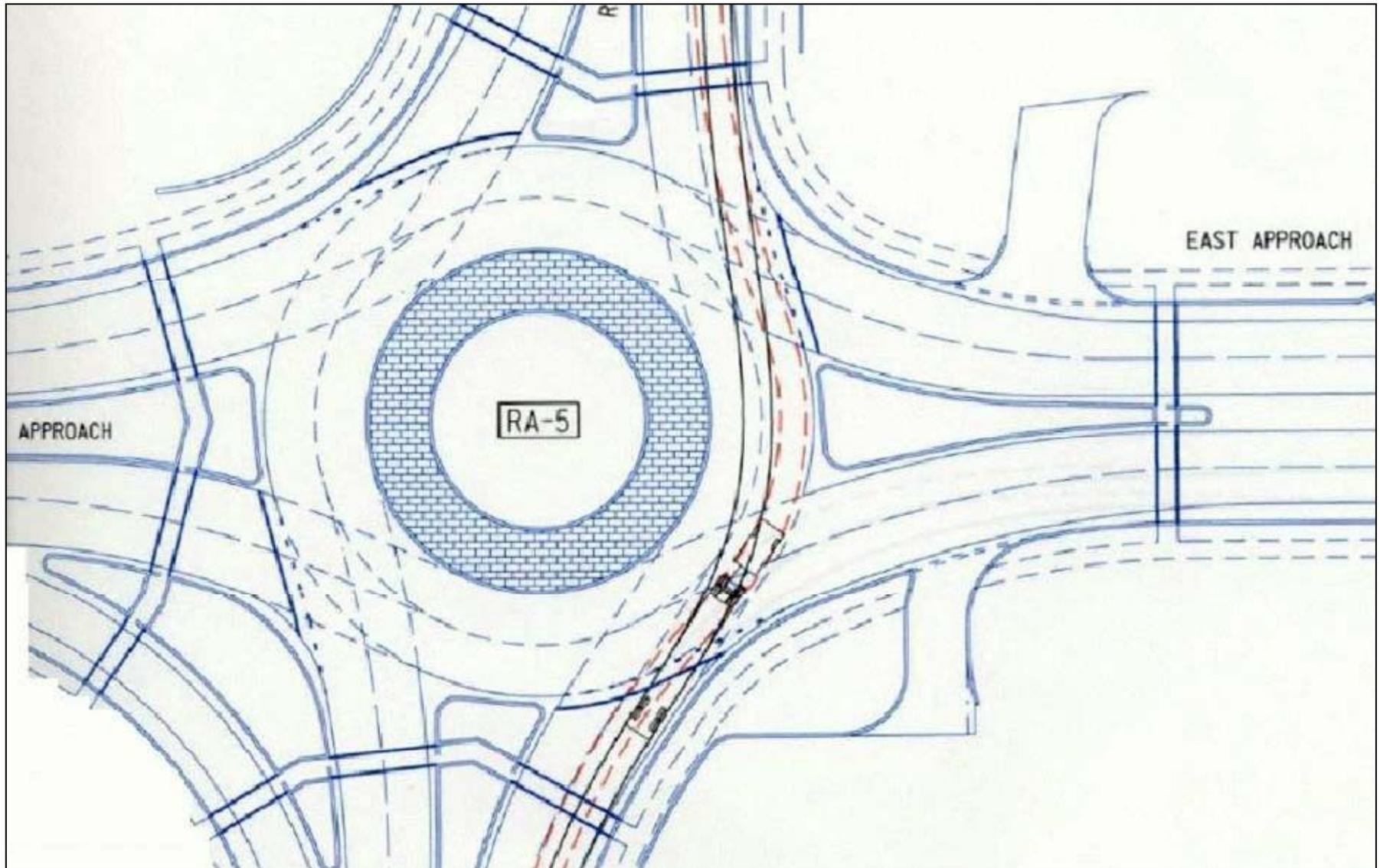


Entrance Modifications at Existing Roundabout



Circulatory Roadway Tracking

Malta, NY



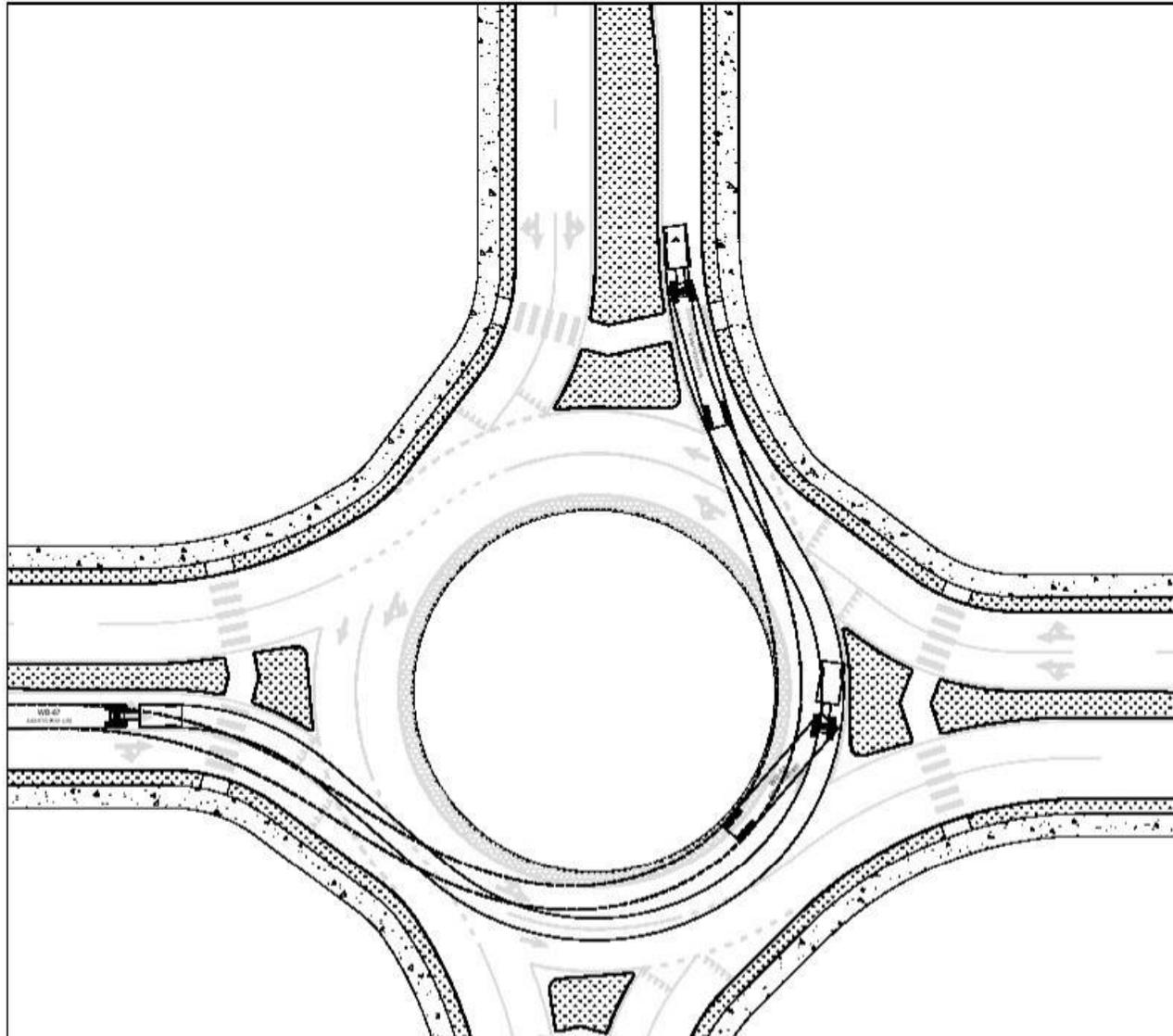
Circulatory Roadway Tracking

Allwood, NJ

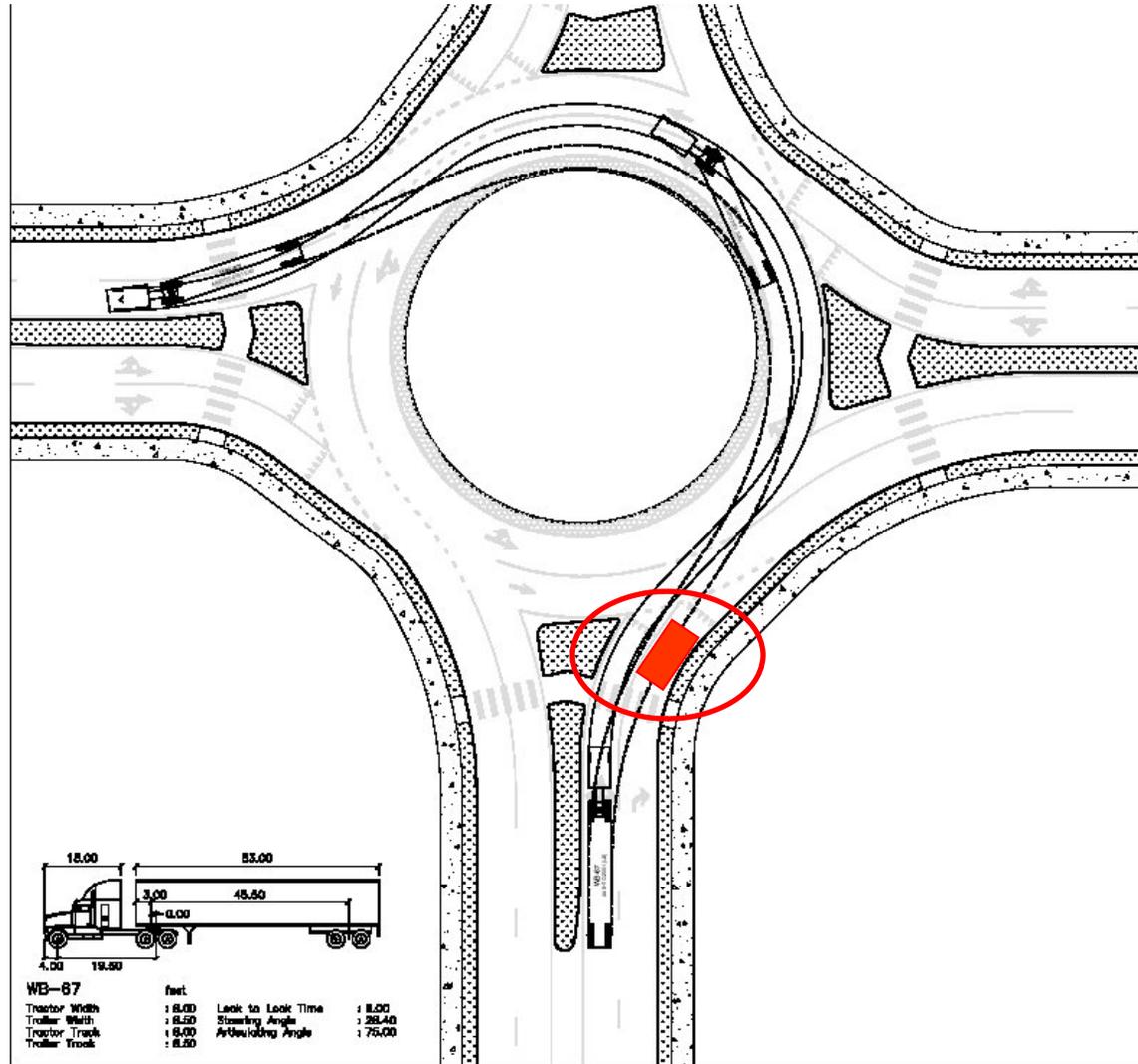


MUTCD Path Overlap

*Exhibit 3H-09B
with WB-67 (WB-20m) path*



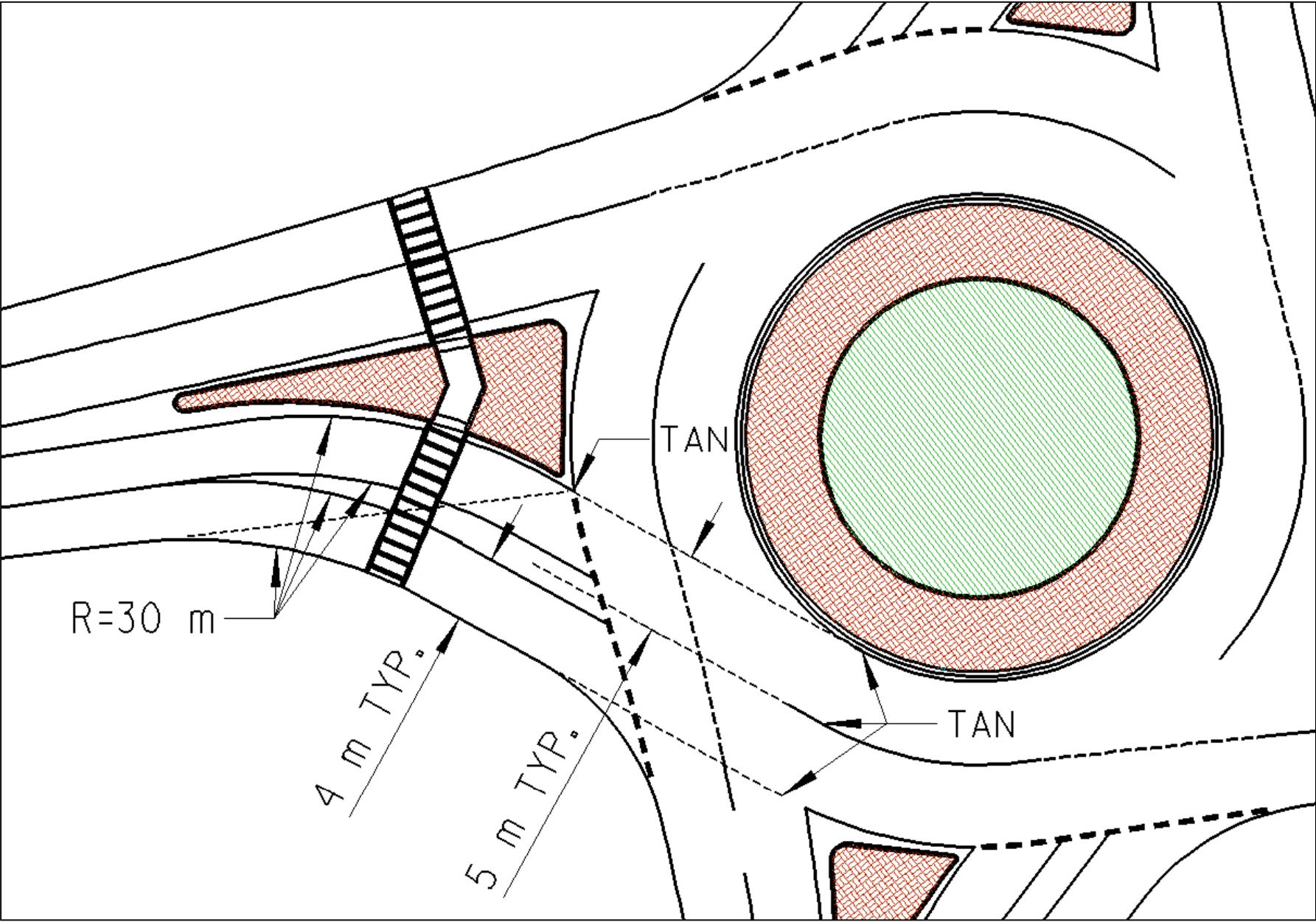
MUTCD Path Overlap – What Happens to Red Car?



Scale 1" = 60'

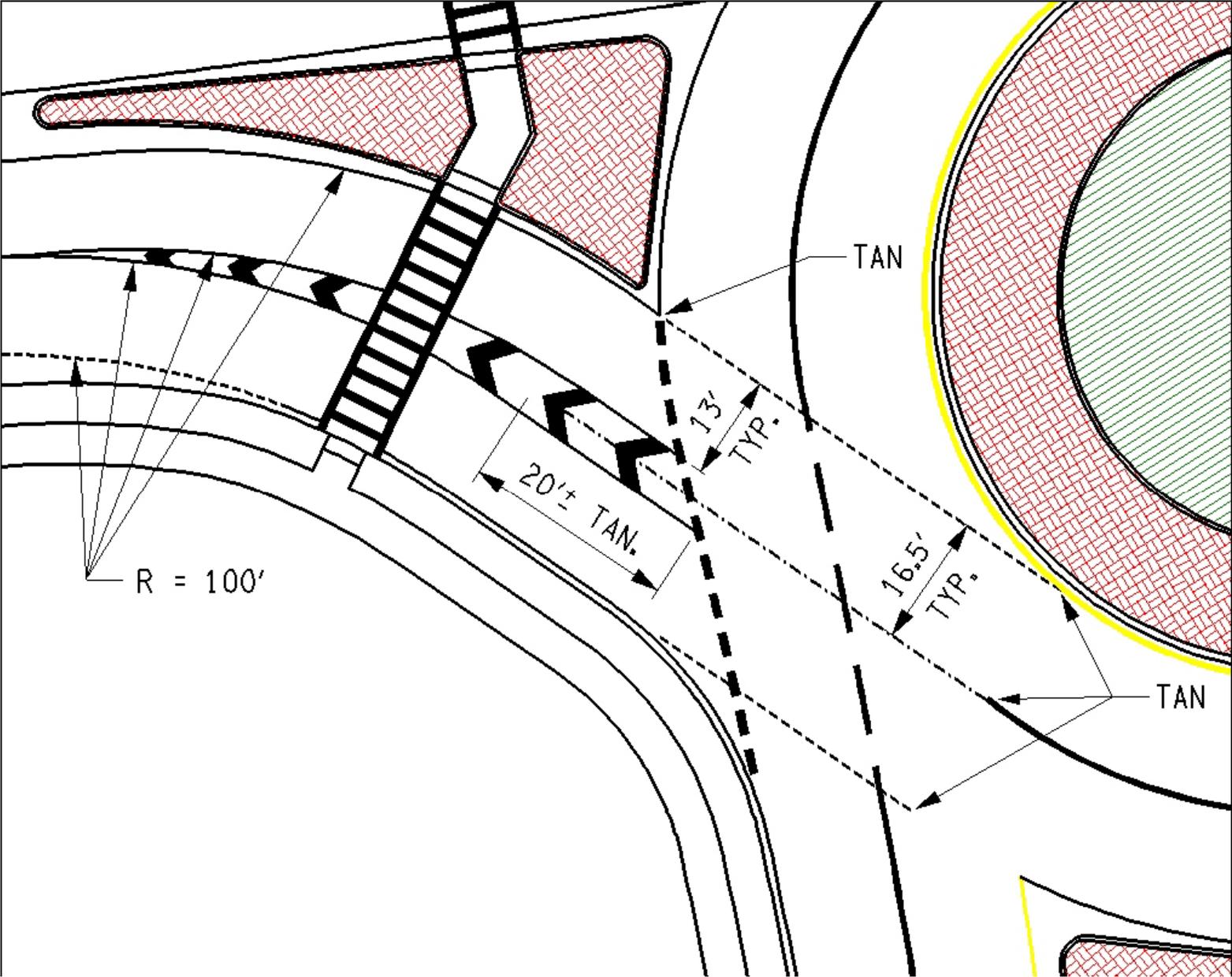
2 lane Approach Layout

with Left Offset & Truck Gore Striping



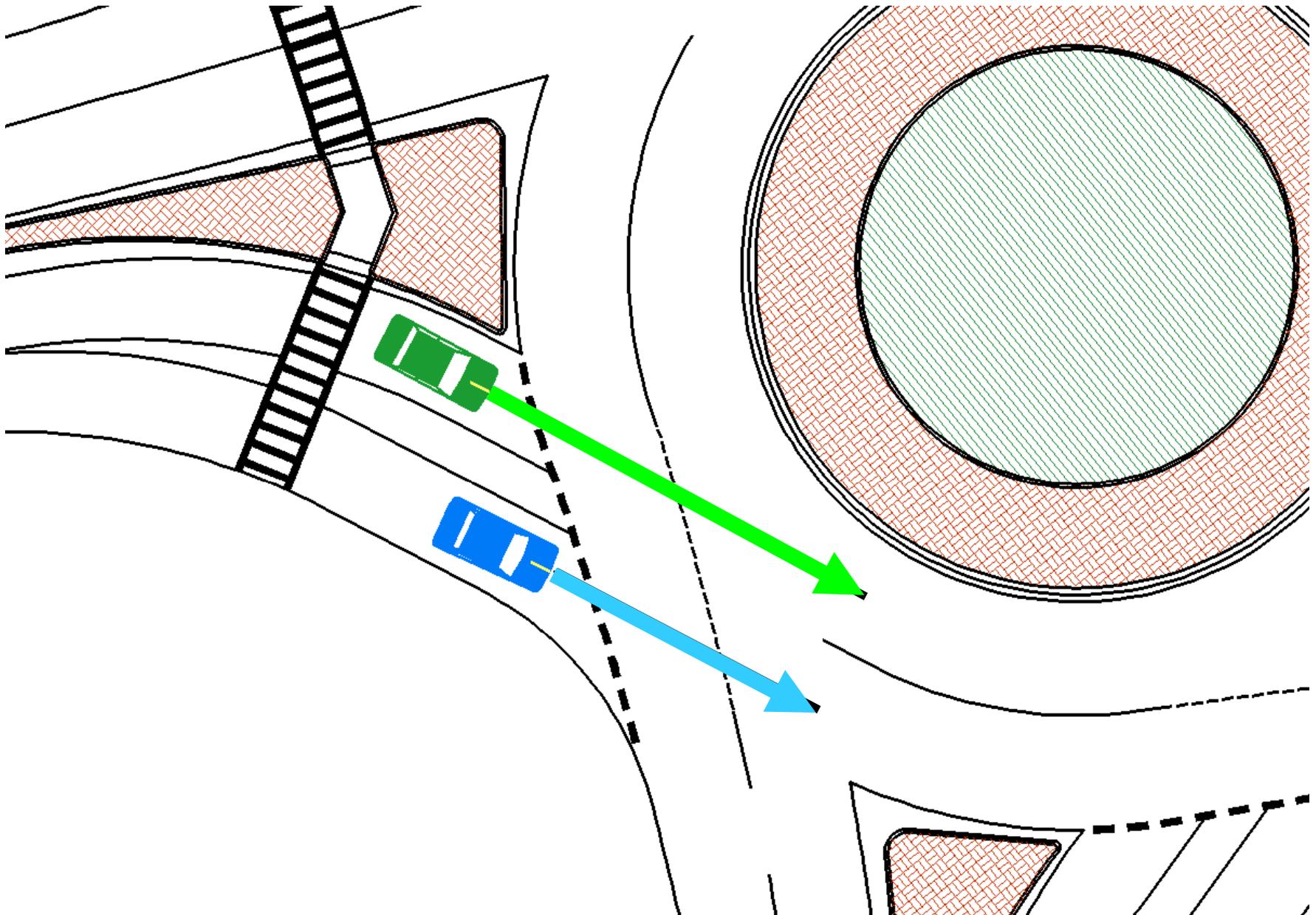
2 lane Approach Layout

we are now using 14 or 15' wide lanes and a 4 or 6' gore

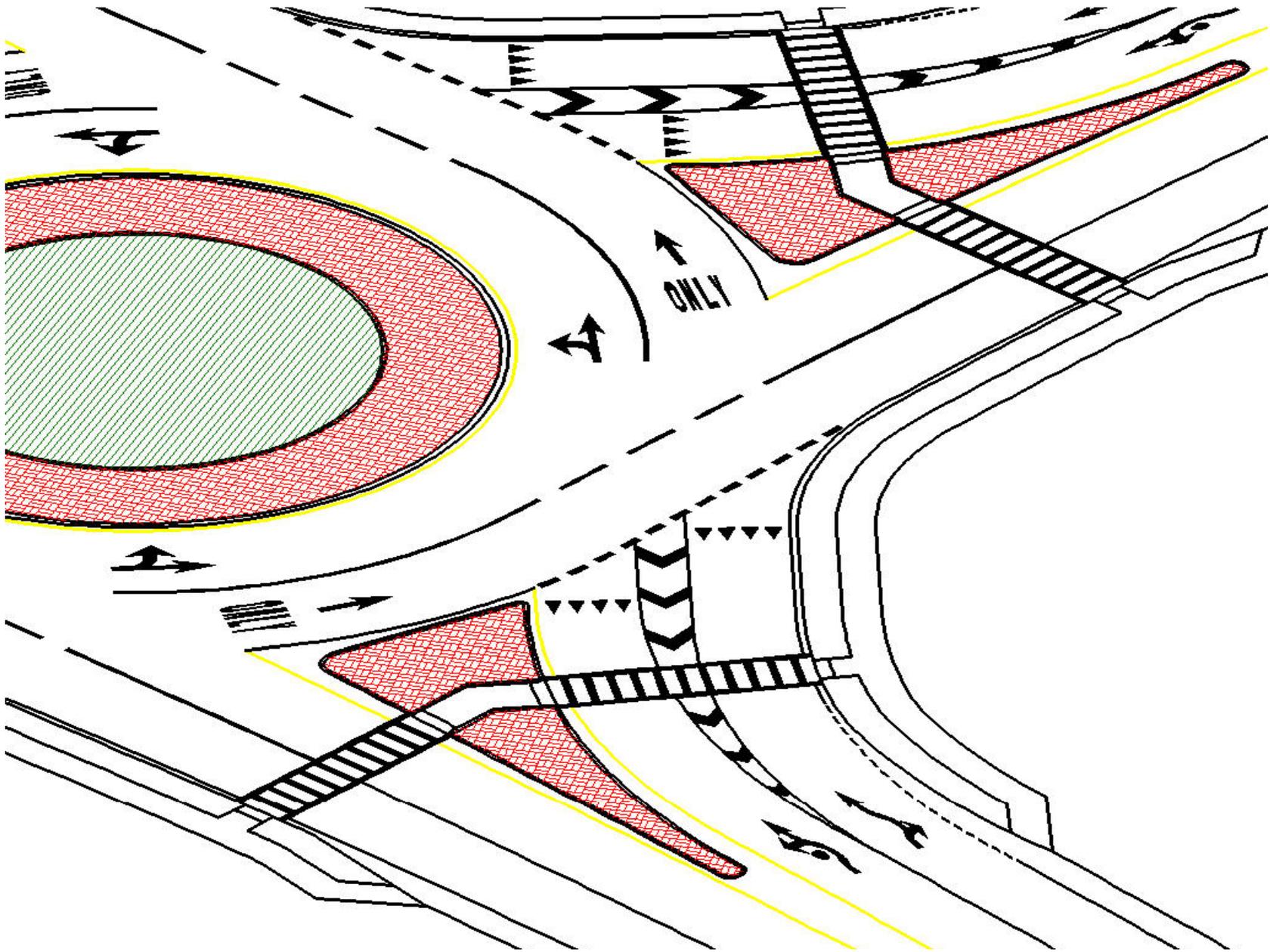


2 lane Approach Layout

Entry Path Overlap Check



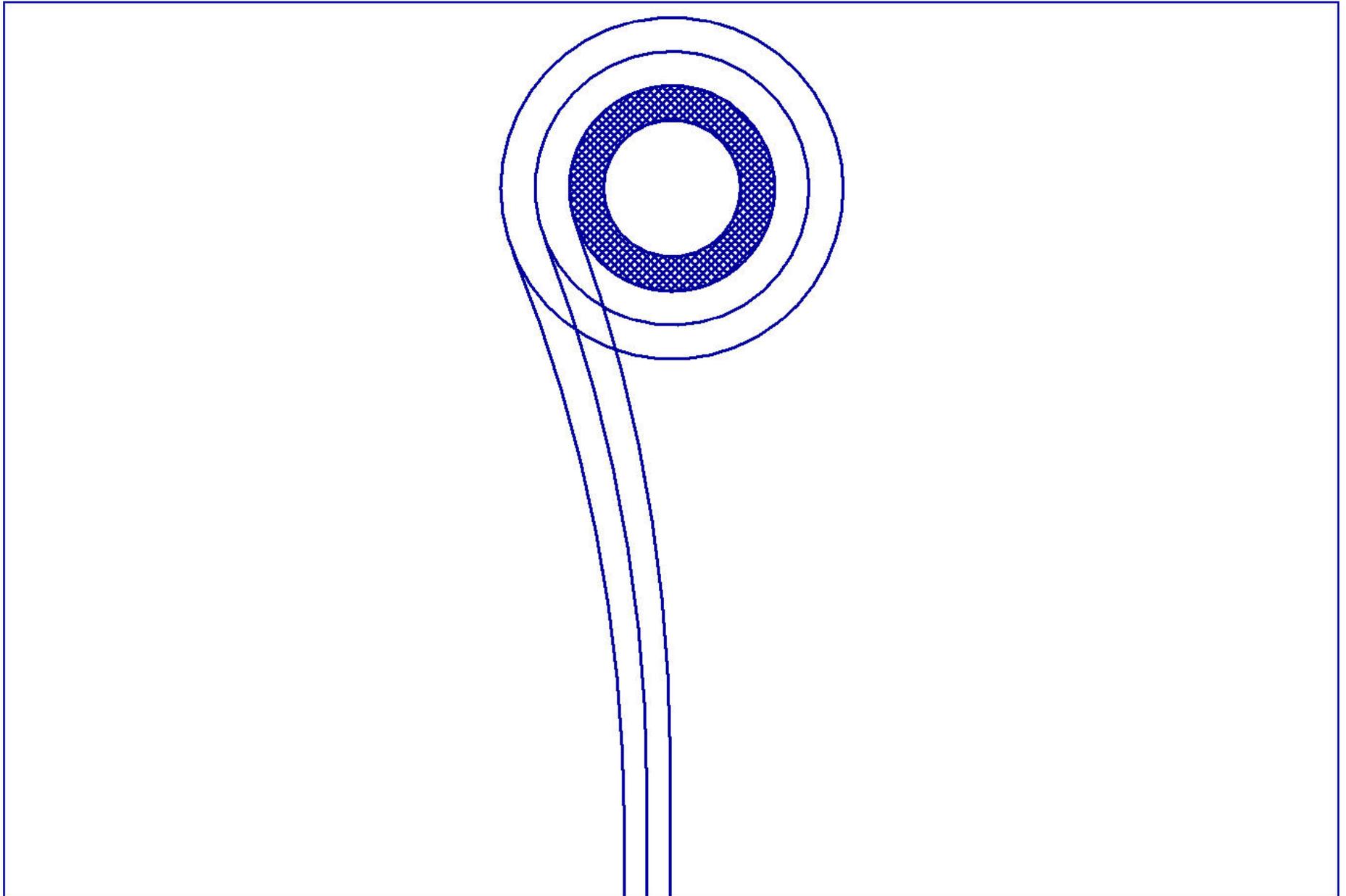
Improved Driver View From Yield Line



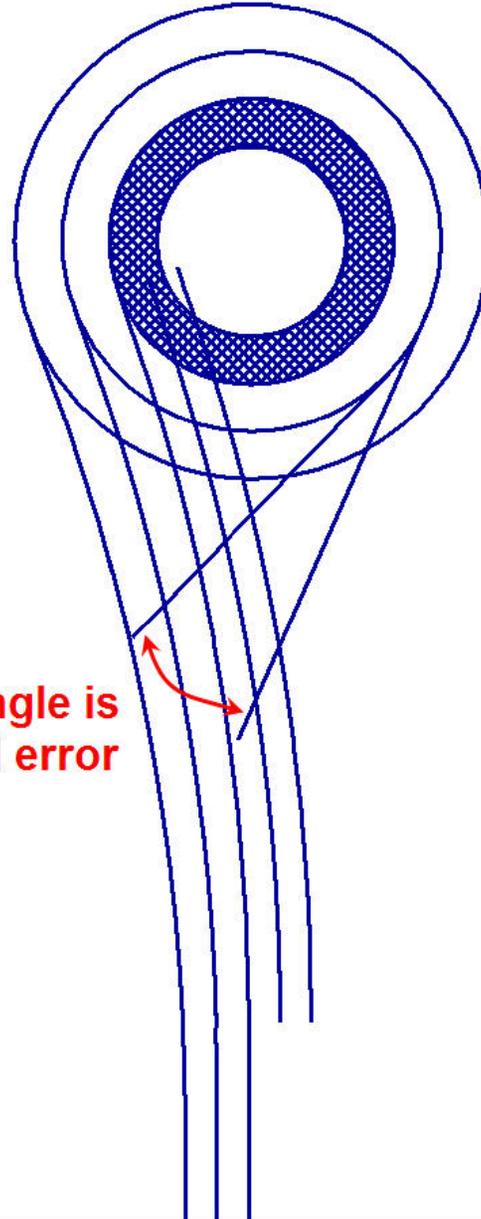
Desired View From Yield Line



CAD Steps for 2 Laners

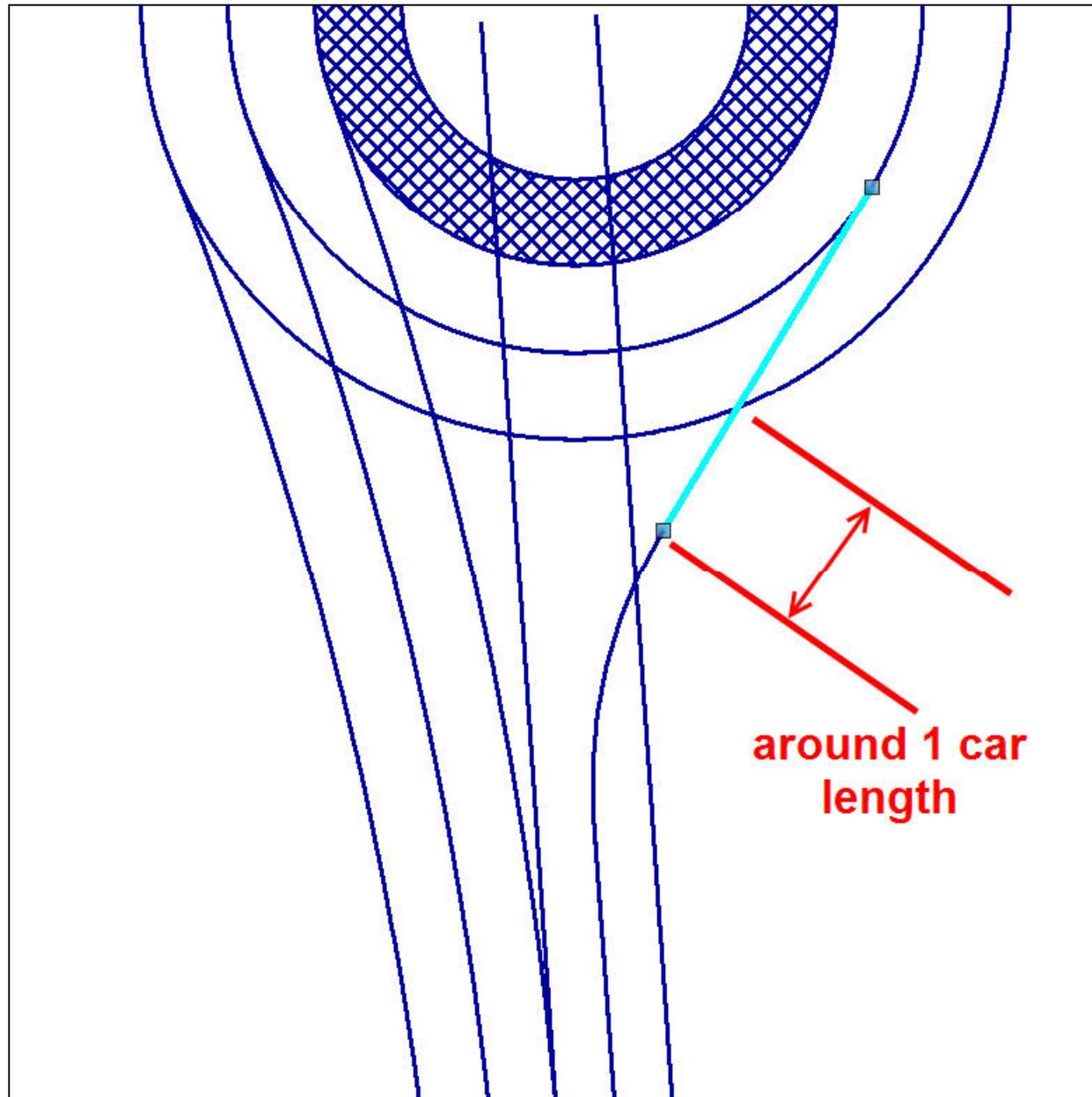


CAD Steps for 2 Laners – Guestimating?

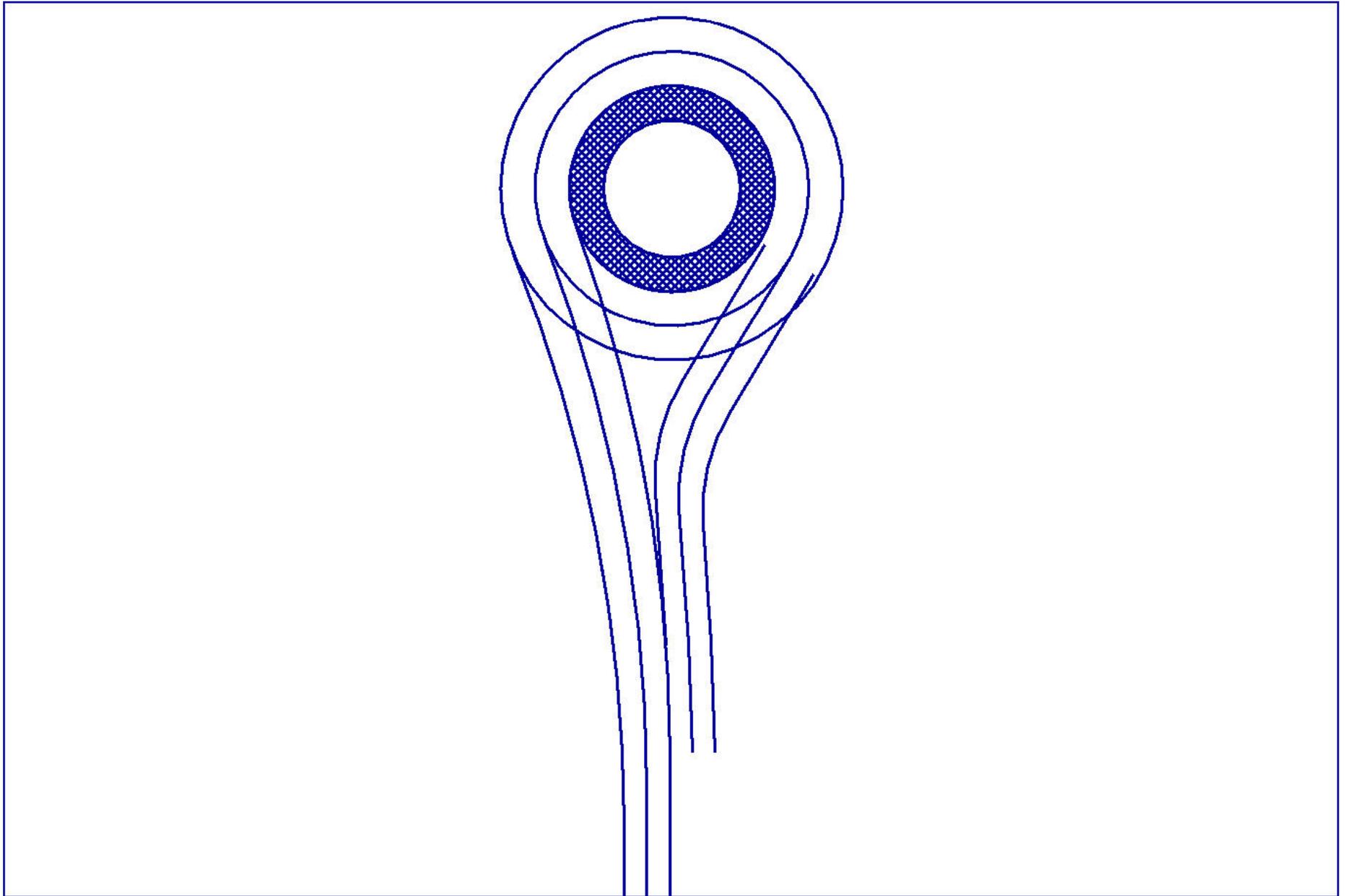


**figuring this angle is
a little trial and error**

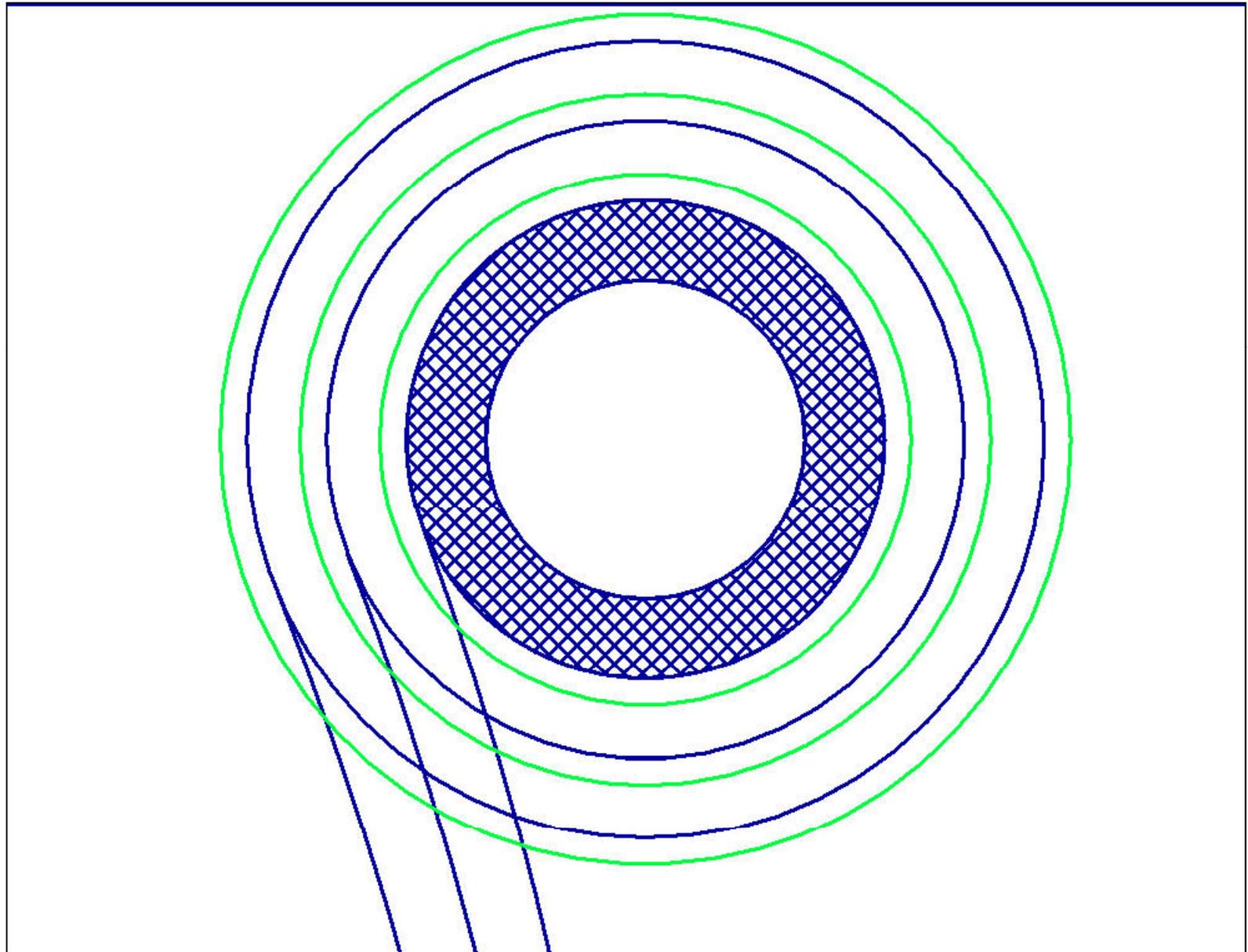
CAD Steps for 2 Laners – 1 car length



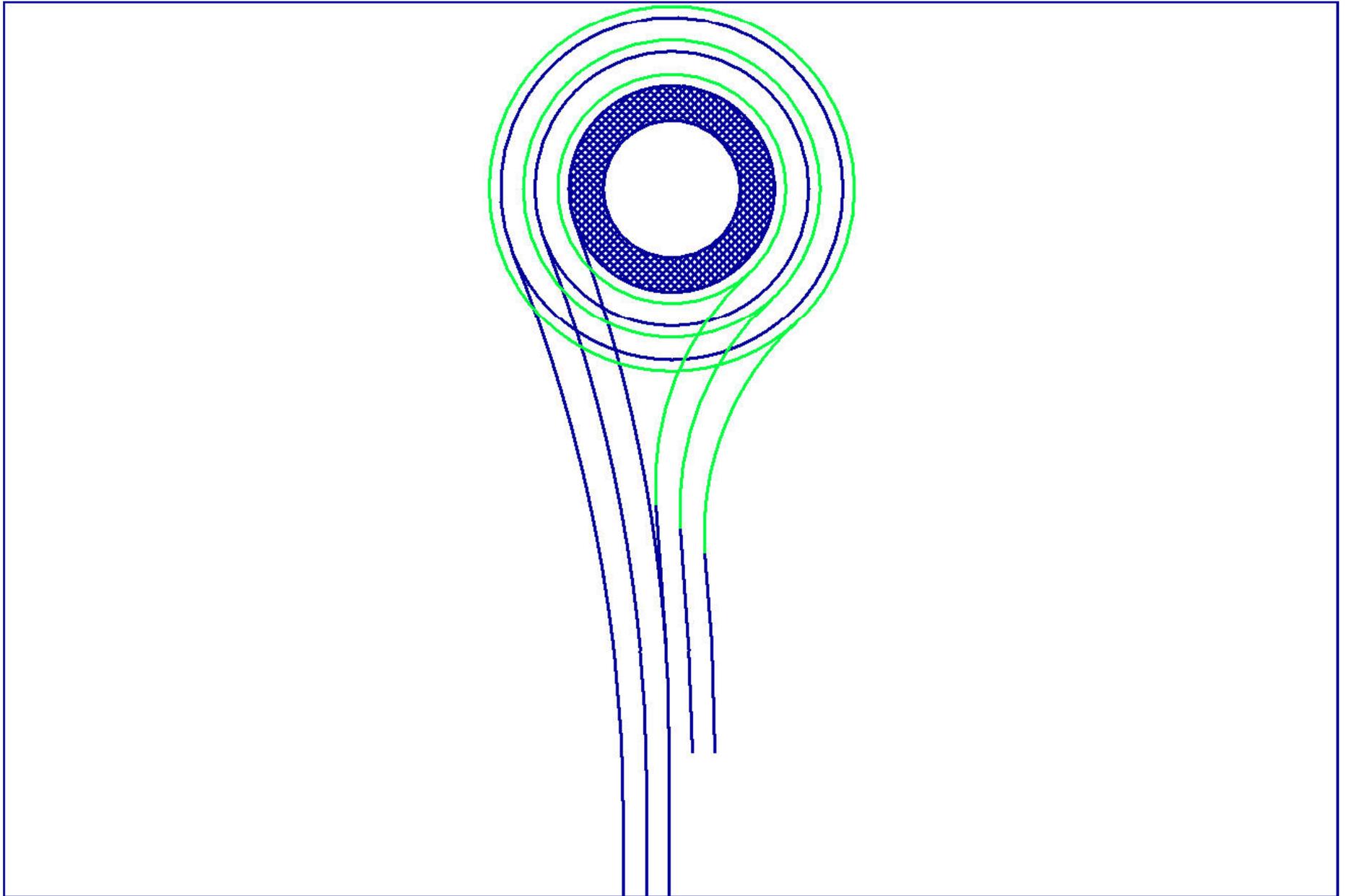
CAD Steps for 2 Laners – Tangents Done



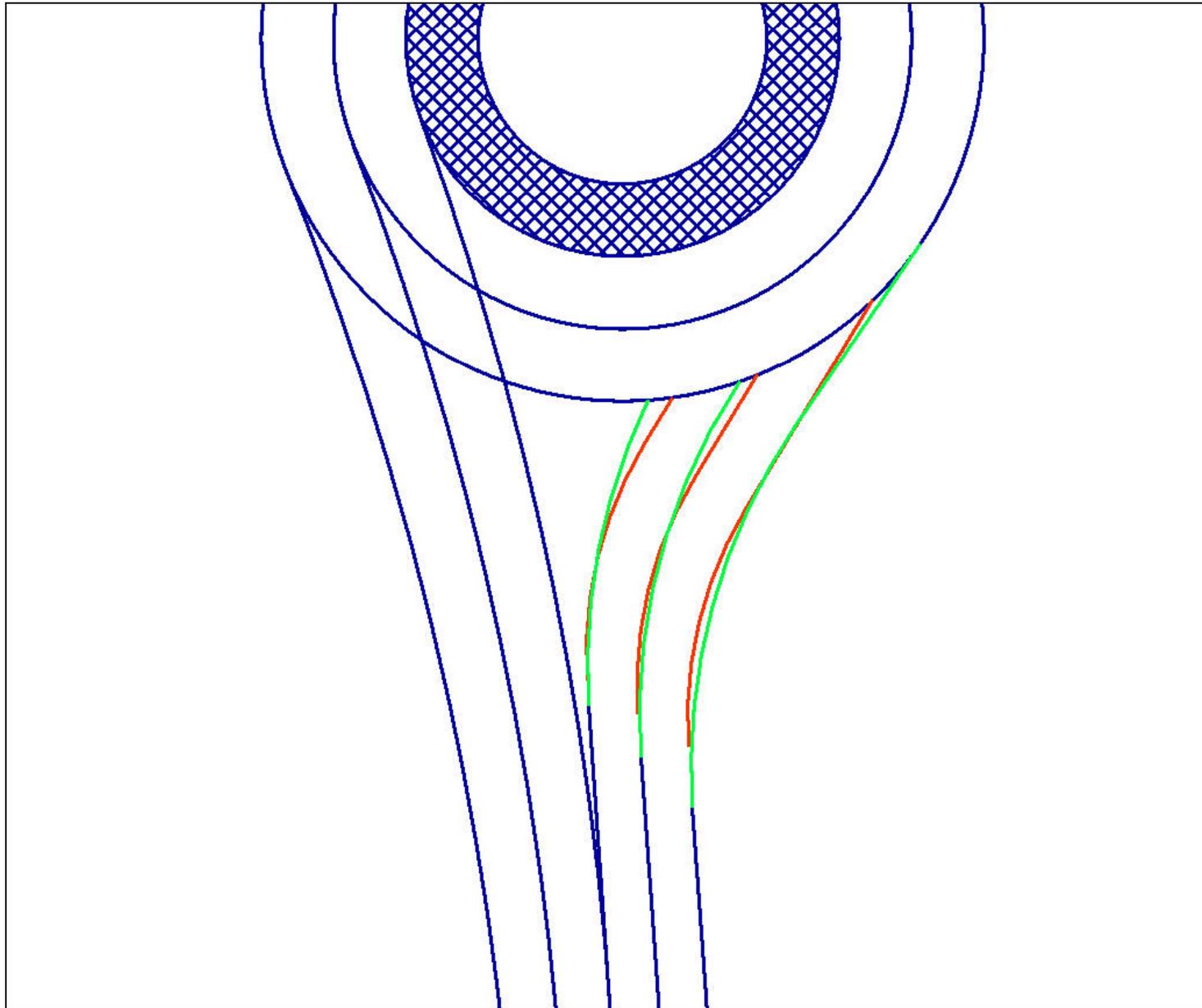
CAD Steps for 2 Laners – 6' Offset Method



CAD Steps for 2 Laners – Now 130 - 140' Fillets

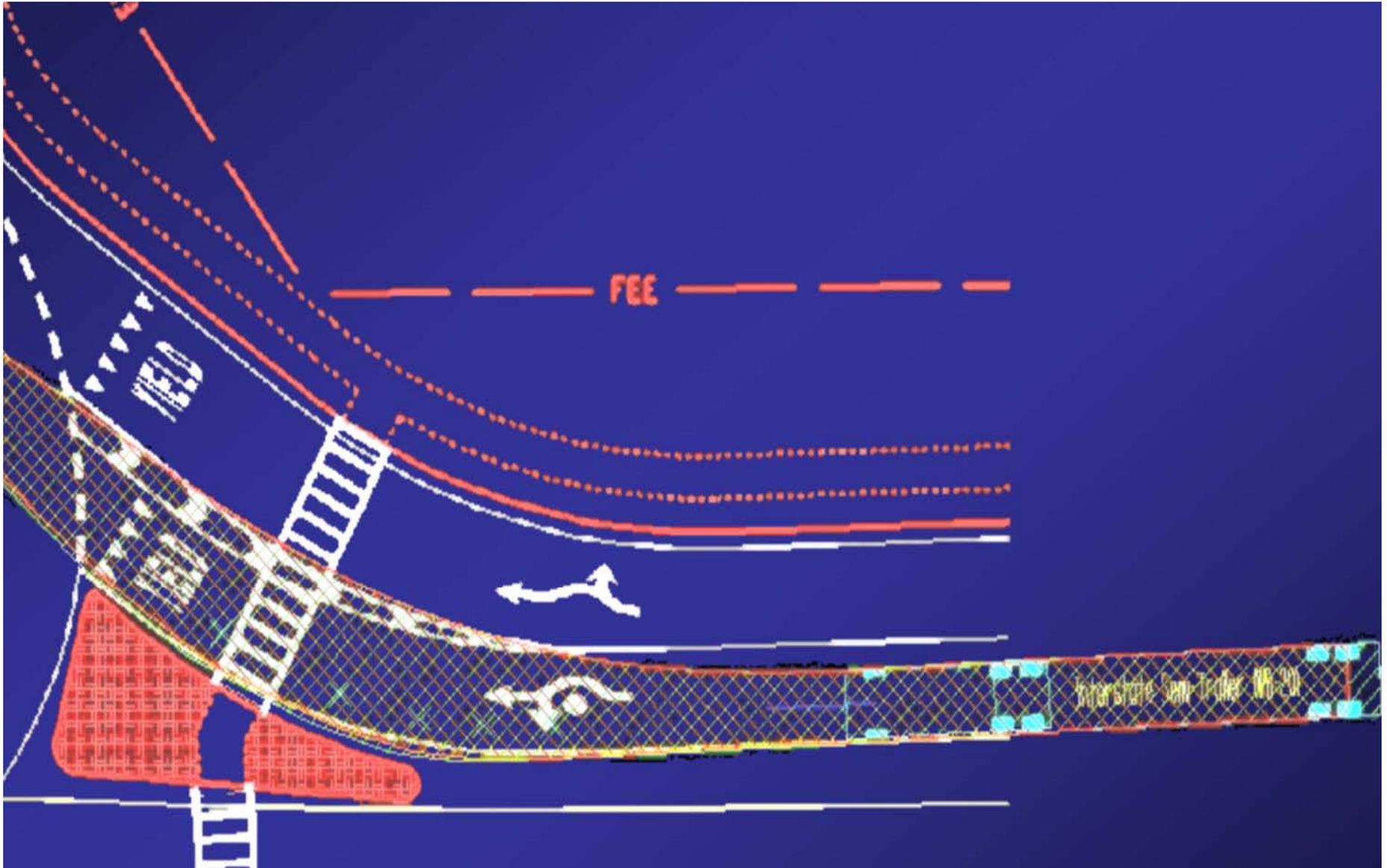


CAD Steps for 2 Laners – Almost Identical



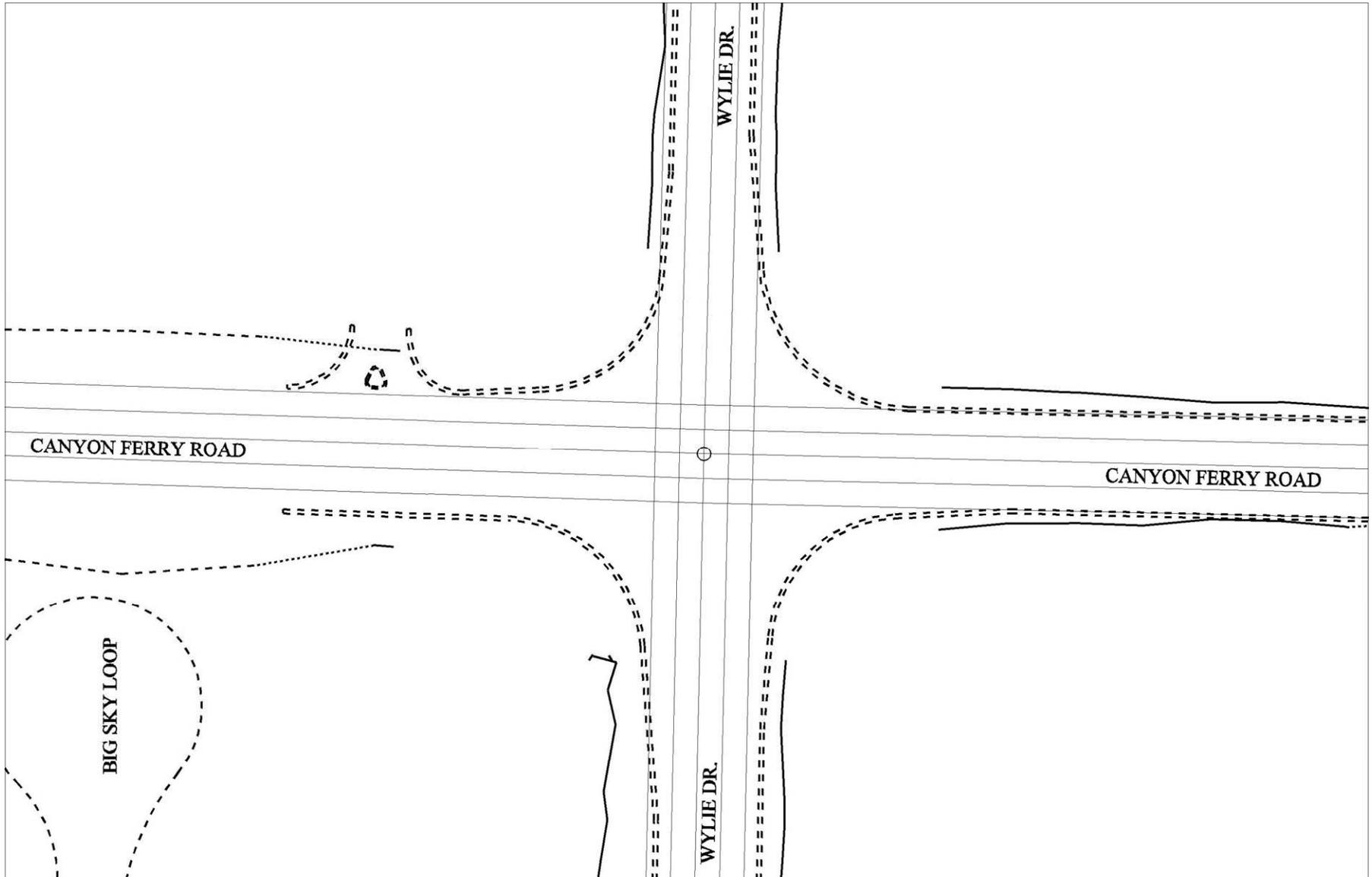
Left Approach Lane Tracking

With Truck Gore Striping



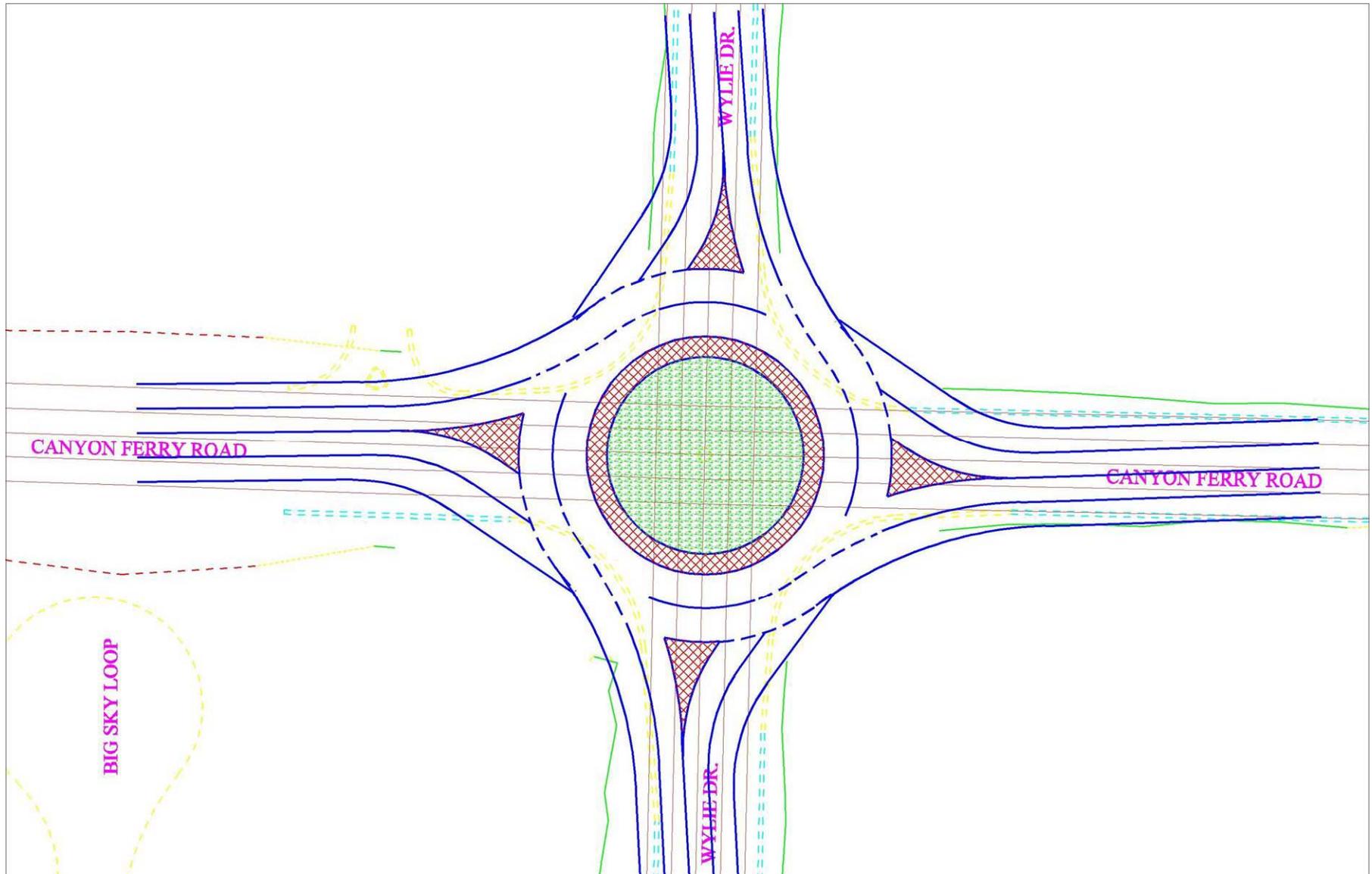
Canyon Ferry 2 Laner

Base mapping

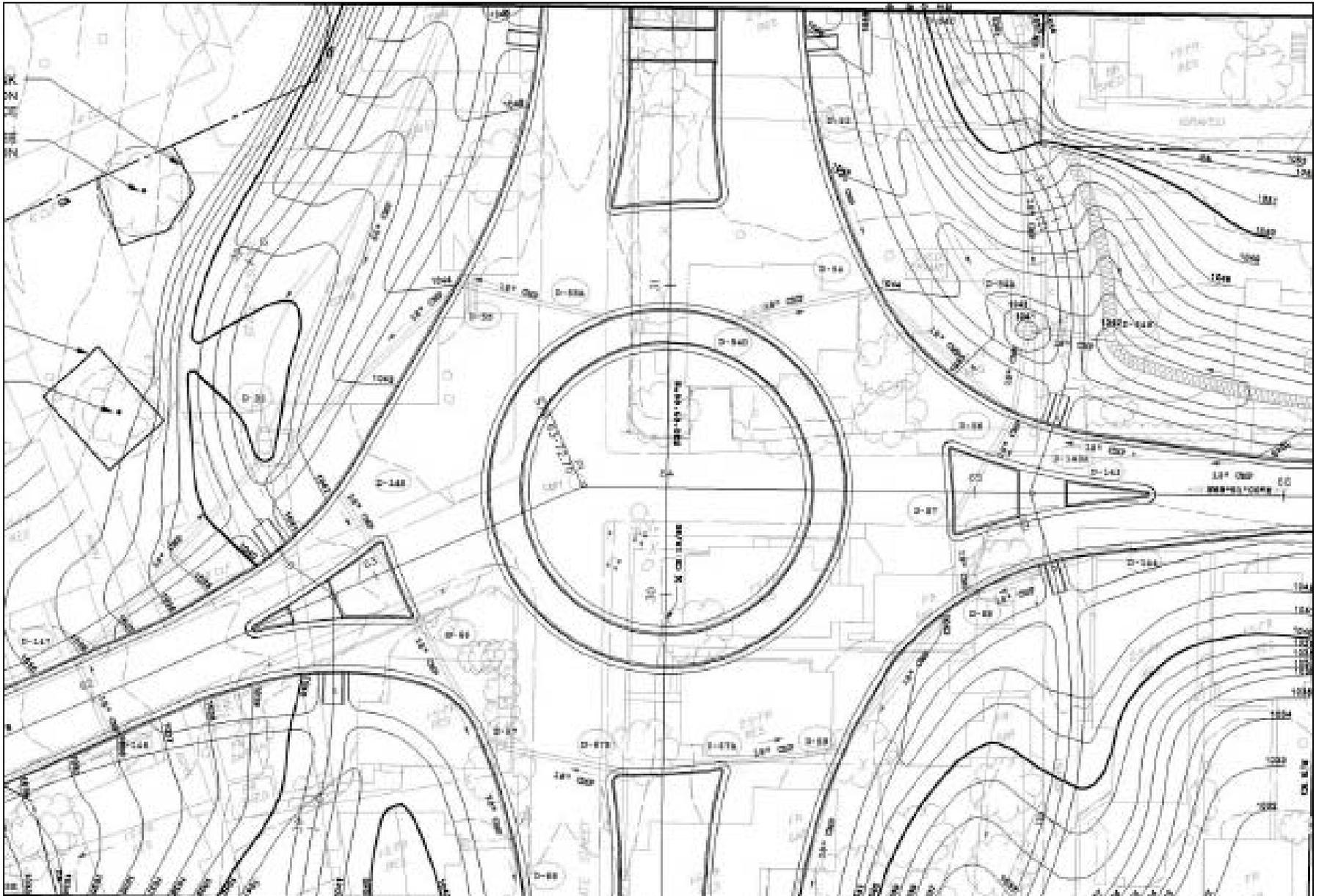


Canyon Ferry 2 Laner

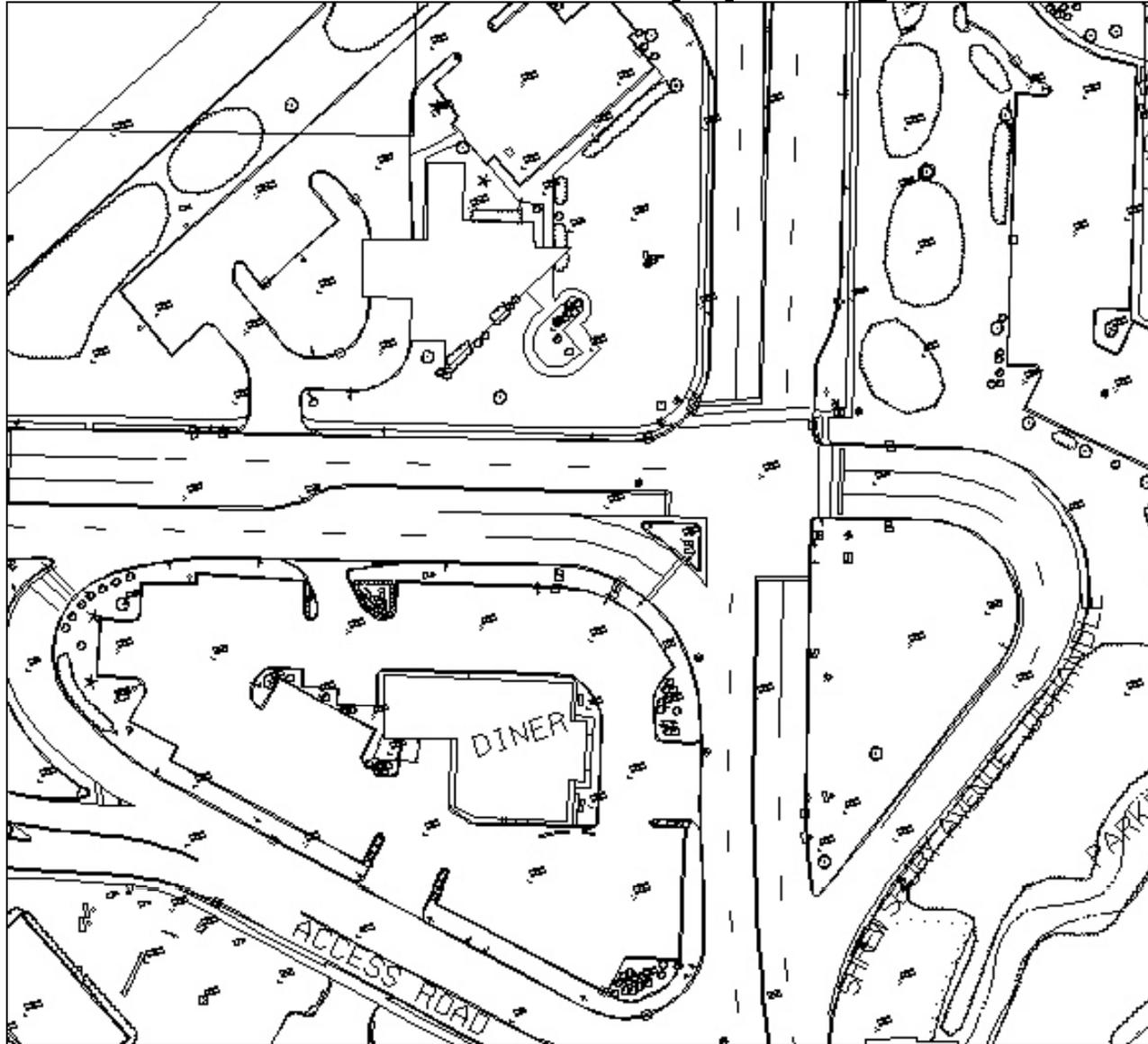
Striping Solution



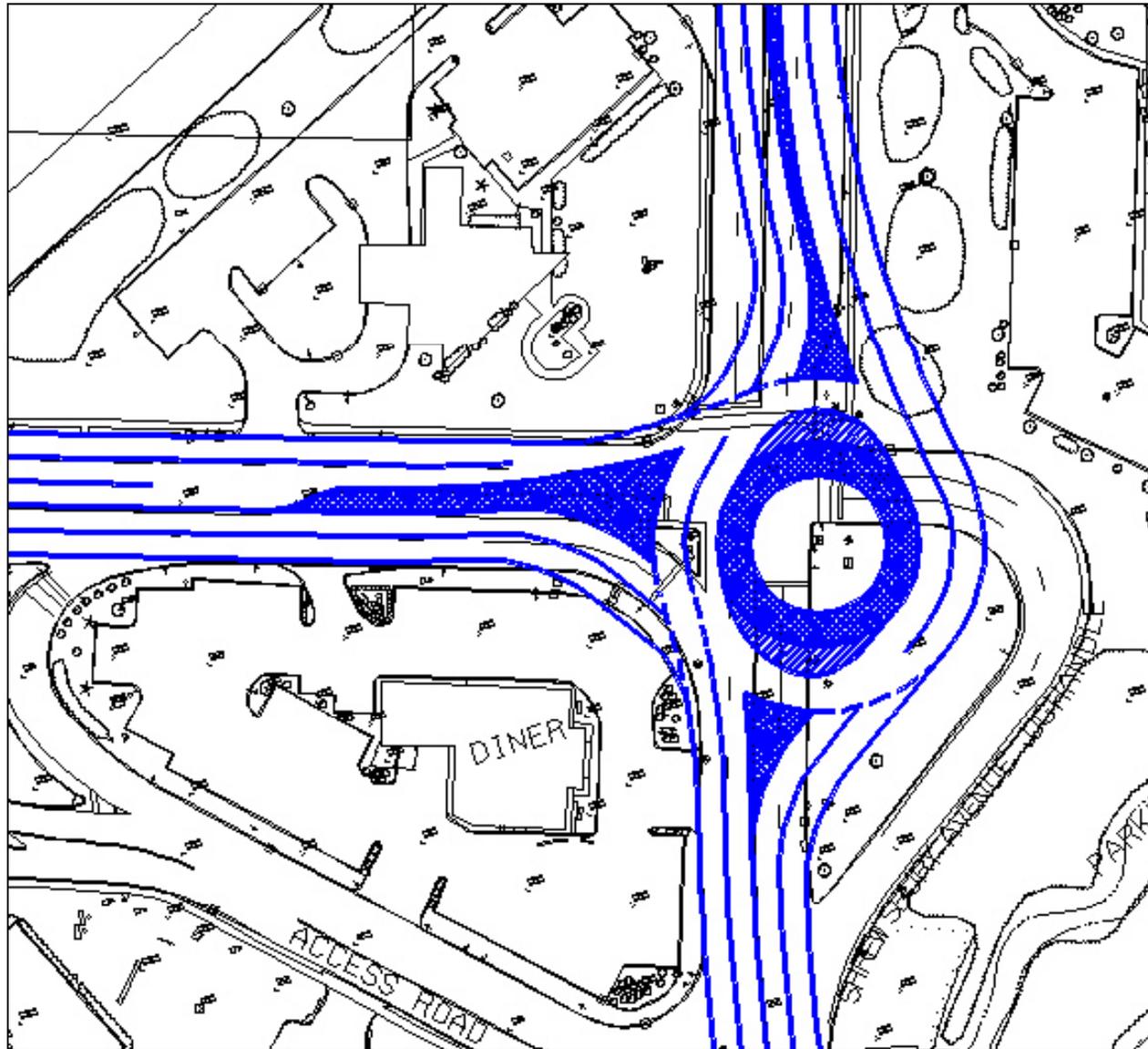
Design Comments?



Route 35 Base Mapping



Route 35 Final Product



**The NYSDOT
Roundabout Design Unit
would like to thank
everyone for their interest
and attendance
at today's session.**



NYSDOT Roundabout Design Unit

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