



Transportation Engineering Services



City of Flagstaff Roundabout Design



1

Kevin Farrell
Amal Abdelaziz
T.J. Sullivan
Ryon Ubert

Date: January 26th, 2016

Intro

- Redesign the intersection of Old Walnut Canyon Road/Oakmont Drive and Country Club Drive.
- Improve the sight distance, and intersection safety.
- The sight distance in the intersection is poor due to the presence of large grades on the southern end of Country Club Drive.
- Left turns off of Old Walnut Canyon, minor road, are dangerous due to the limited sight distance.

Project Status

Task
Data Collection
Site Evaluation
Topographic Survey
Client Meeting
Roadway Design Guidelines
Research Guidelines
Data Analysis
Survey Data
Traffic Statistics
Level of Service
Site Design
Roundabout
Geometry
Grading
Striping
Signage
Site Development
Drainage
Landscaping
Pedestrian Consideration

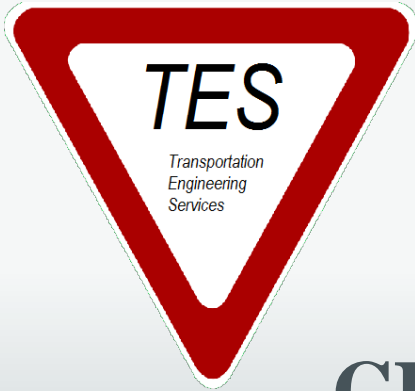
Task
Economics
Construction Costs
Benefits
Impacts
Project Management
Project Schedule
50% Design Report
Final Design Report
Final Presentation
Website

Work Completed

- Emailed Stephanie Sarty, City of Flagstaff Project Manager
- Planned time to survey
- Scheduled meeting with Dr. Russo, Technical Advisor

Future Work

- ▶ Perform Data Analysis: Survey
- ▶ Perform Data Analysis: Level of Service
- ▶ Begin Site Design: Geometry
- ▶ Begin Site Design: Grading



**Transportation
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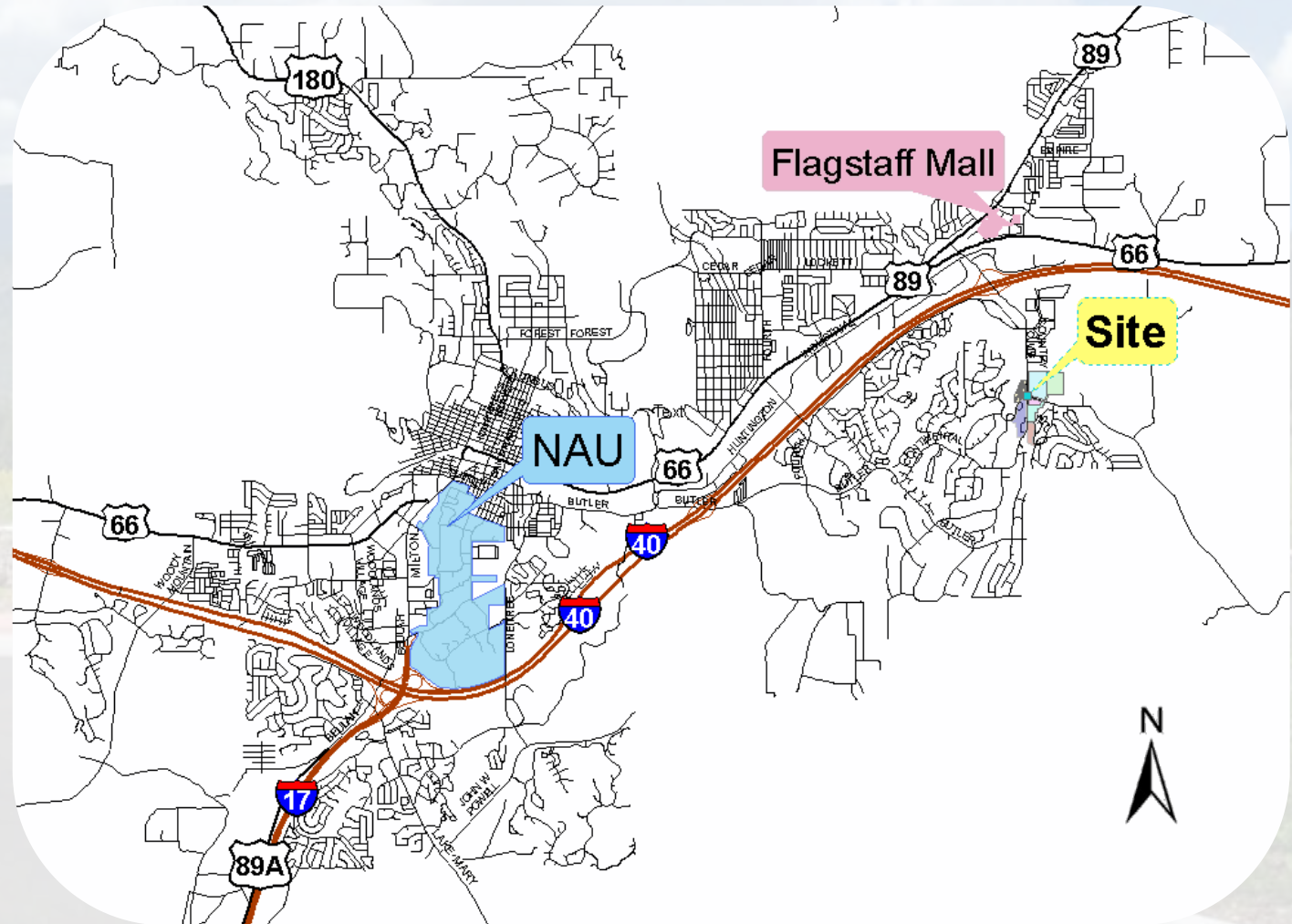
CITY OF FLAGSTAFF ROUNDABOUT DESIGN

T.J. Sullivan
Amal Abdelaziz
Kevin Farrell
Ryon Ubert

Date: February 9th, 2016

BACKGROUND

- **Site Location**
- Old Walnut Canyon Rd. and Country Club Dr.



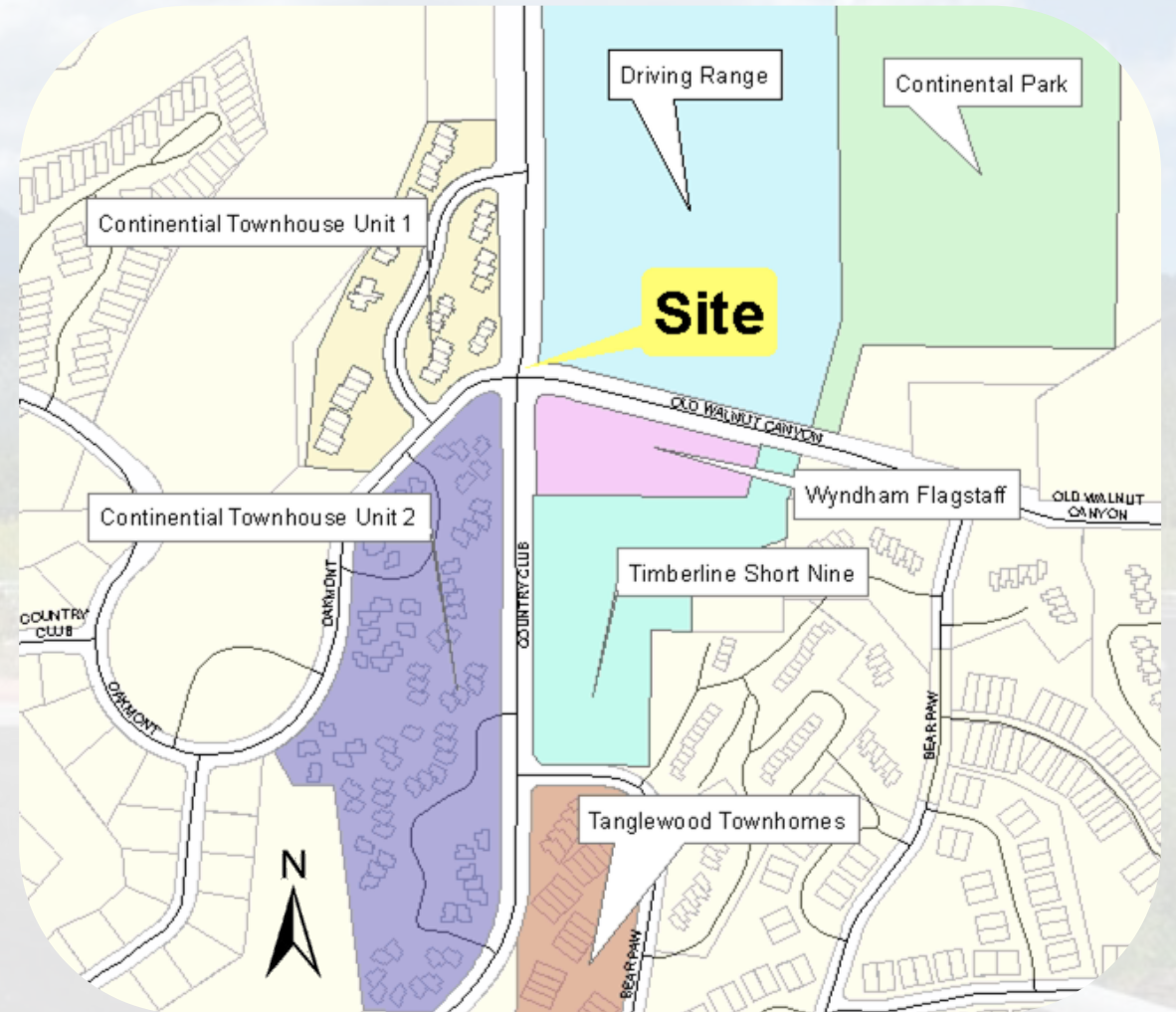
BACKGROUND

■ Site Location

- Old Walnut Canyon Rd. and Country Club Dr.

■ Purpose

- Redesign intersection of Old Walnut Canyon Rd. and Country Club Dr. to improve Sight distance, and safety of the intersection.



SCHEDULE

In progress, behind schedule

In progress, on time

Future 2 weeks

Task Name	Finish Date	Task Name	Finish Date
Data Collection	Tue 11/3/15	Site Development	Fri 2/26/16
Site Evaluation	Thu 9/10/15	Drainage	Fri 2/12/16
Topographic Survey	Mon 9/14/15	Landscaping	Wed 2/17/16
Client Meeting	Tue 11/3/15	Pedestrian Consideration	Thu 2/25/16
Roadway Design Guidelines	Fri 12/11/15	Economics	Mon 3/7/16
Research guidelines	Fri 11/6/15	Construction Costs	Tue 3/1/16
Data Analysis	Fri 12/11/15	Benefits	Mon 2/29/16
Survey Data	Tue 11/3/15	Impacts	Tue 3/1/16
Traffic Statistics	Tue 11/10/15	Project Management	Fri 4/29/16
Level of Service	Wed 11/18/15	Project Schedule	Fri 11/20/15
Site Design	Fri 3/4/16	50% Design Report	Fri 3/11/16
Roundabout	Mon 2/29/16	Final Design Report	Fri 4/29/16
Geometry	Mon 2/8/16	Final Presentation	Fri 4/29/16
Grading	Fri 2/19/16	Website	Fri 12/4/15
Striping	Thu 2/25/16		
Signage	Mon 2/29/16		

COMPLETED WORK

- **Topographic Surveying**
 - Finished Surveying the intersection
 - Received the survey data from the City of Flagstaff.
- **Traffic Statistics**
 - Received the collected traffic data.
- **Research Guidelines**
 - Completed research on roundabout design guidelines in the city of Flagstaff.



WORK IN PROGRESS

- **Geometry of the Roundabout**
- **Striping**
- **Signage**



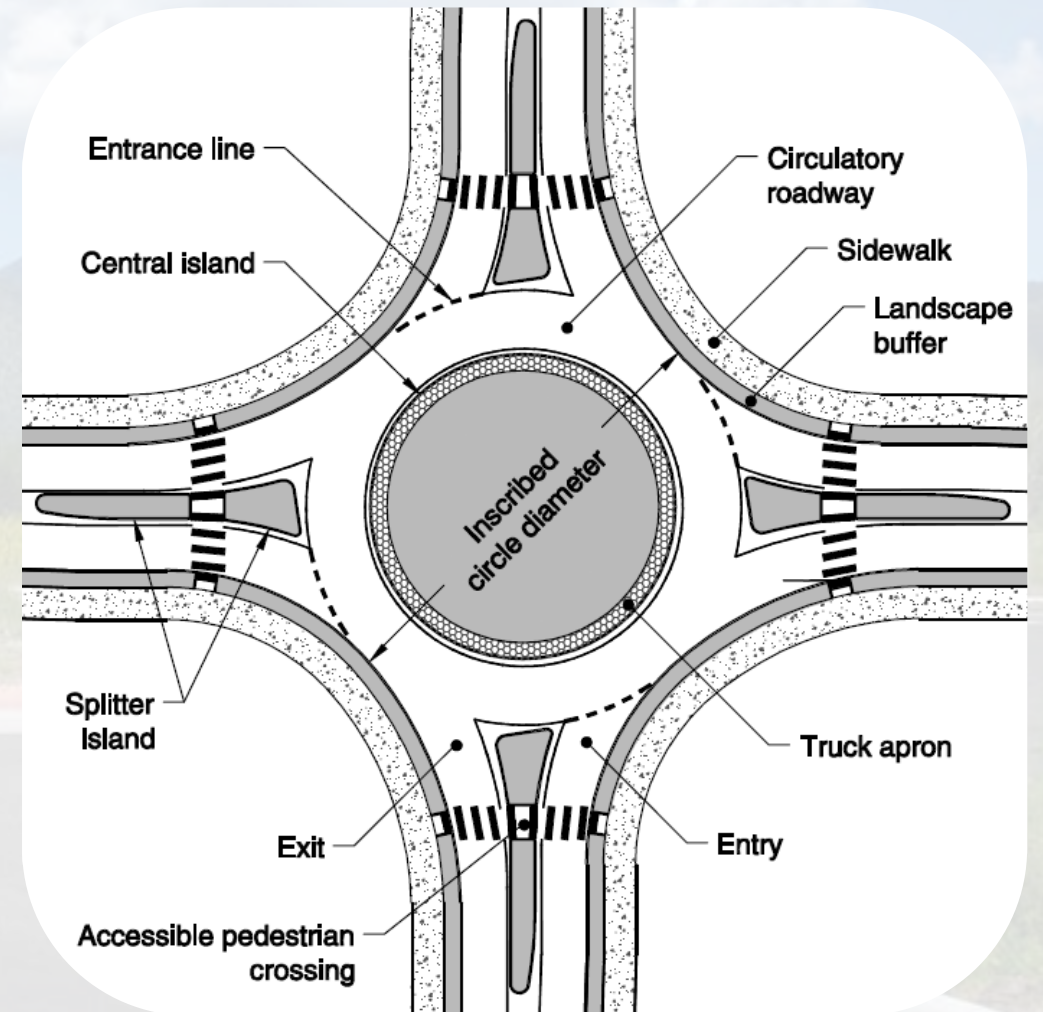
WORK IN PROGRESS

■ Geometry of the Roundabout

● Inscribed Circle Diameter

- Determine the Number of Design Objects
- Accommodation of Design Vehicles
- Determine the Speed

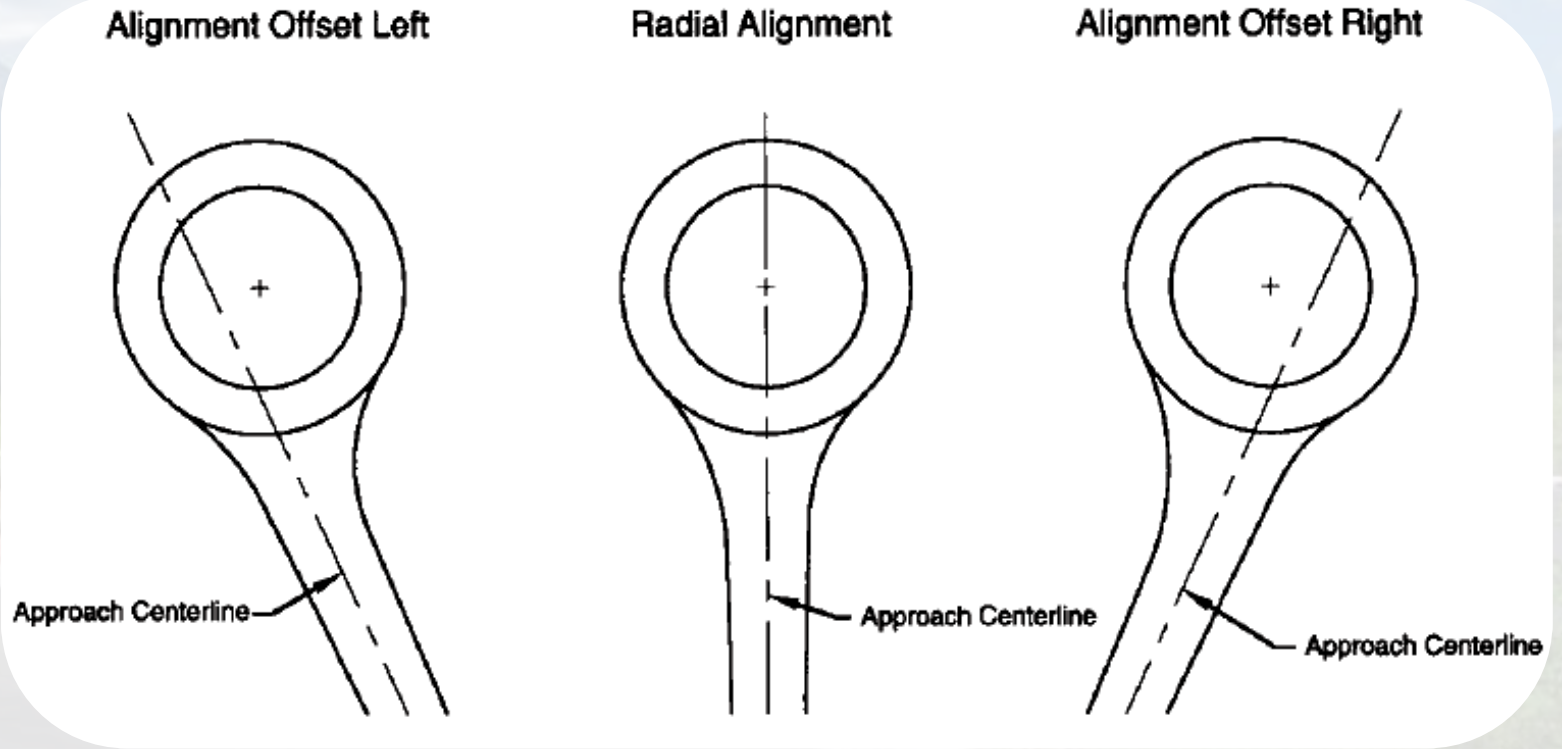
Roundabout Configuration	Common Inscribed Circle Diameter
Mini-Roundabout	45 to 90 ft
Single-Lane Roundabout	90 to 150 ft



WORK IN PROGRESS

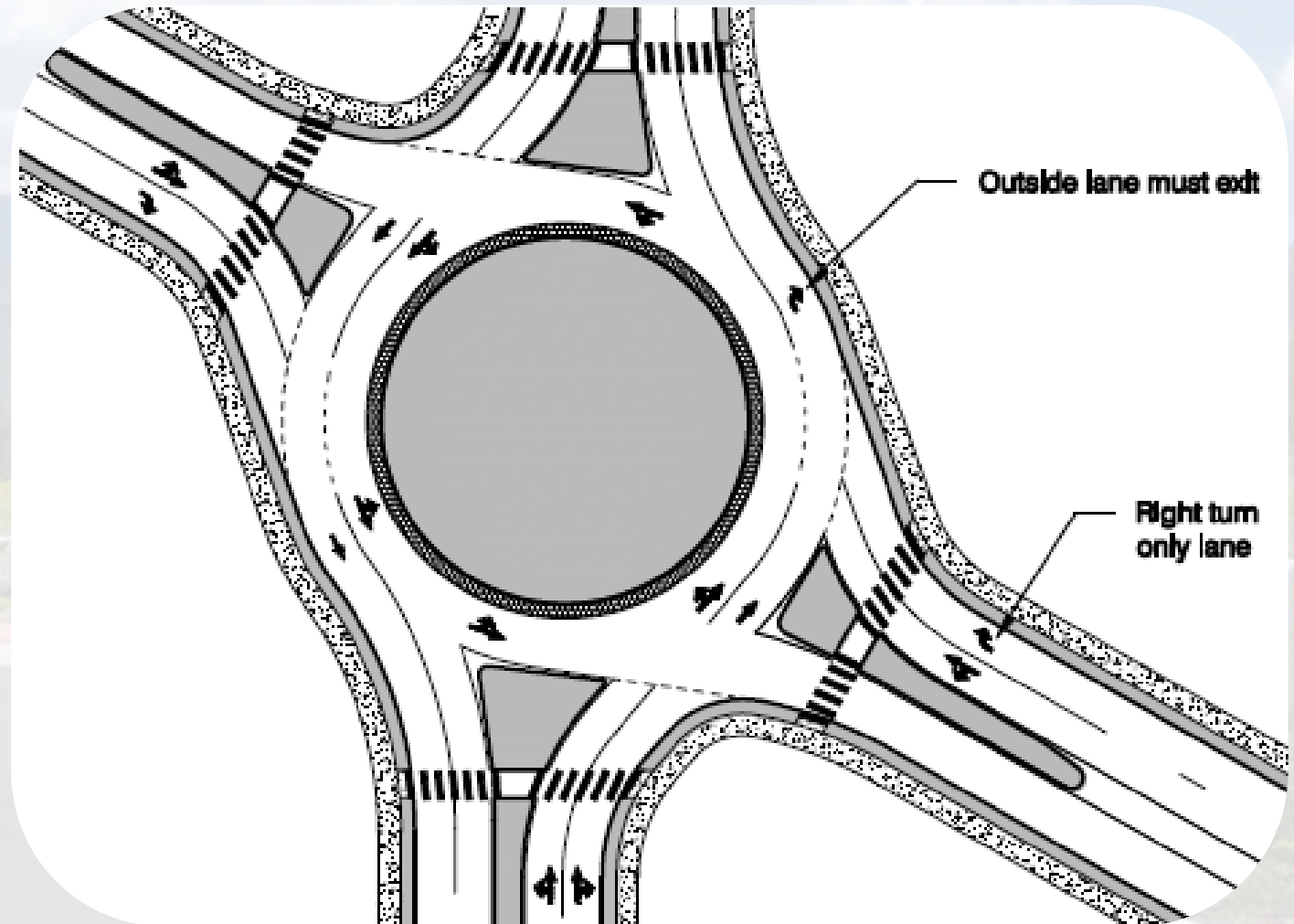
■ Geometry of the Roundabout

- Alignment of Approaches
 - Offset Alignment to the Left
 - Alignment through Center (Ideal)
 - Offset Alignment to Right



WORK IN PROGRESS

- **Geometry of the Roundabout**
- Angle Between Approach Legs
 - Faster Paths



WORK IN PROGRESS

- **Specific Parameters and Guidelines for the Design of a Roundabout**

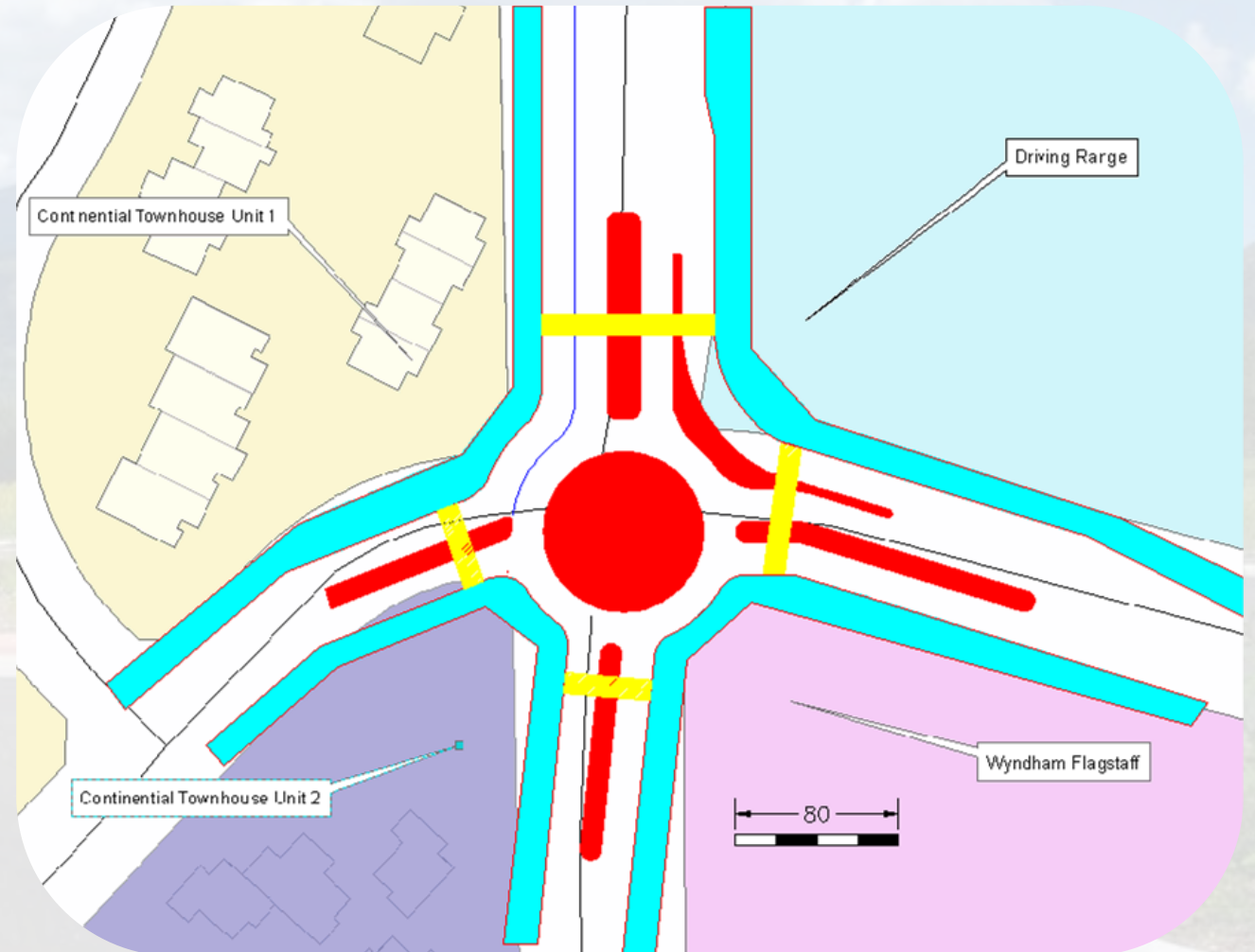
	Single-Lane	Mini
Diameter	90 to 150 ft	45 to 90 ft
Speeds	20 – 25 mph	15 mph
Splitter Island		
Entry Width	14 to 18 ft	14 to 18 ft
Circulatory Roadway Width	100% to 120% of Entry Width	100% of Entry Width
Central Island	Circular, Oval, and Raindrop	Circular
Entry Design		
Exit Design		
Design Vehicle		
Pedestrians		
Bicycles		

Table 1: Basic design characteristics of roundabouts (FHWA)

WORK IN PROGRESS

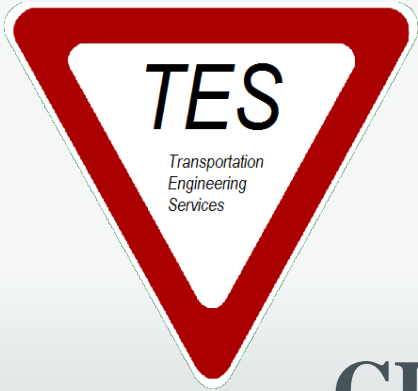
- Rough Draft of Site Roundabout

	Single-Lane
Diameter	110 ft Left Align
Speeds	20 mph
Splitter Island	
Entry Width	16 ft
Circulatory Roadway Width	16 ft
Central Island	Circular
Entry Design	
Exit Design	
Design Vehicle	
Pedestrians	
Bicycles	



FUTURE 2 WEEKS OF WORK

- **Site Design**
- Grading
- **Site Development**
- Drainage
- Landscaping
- Pedestrian Considerations



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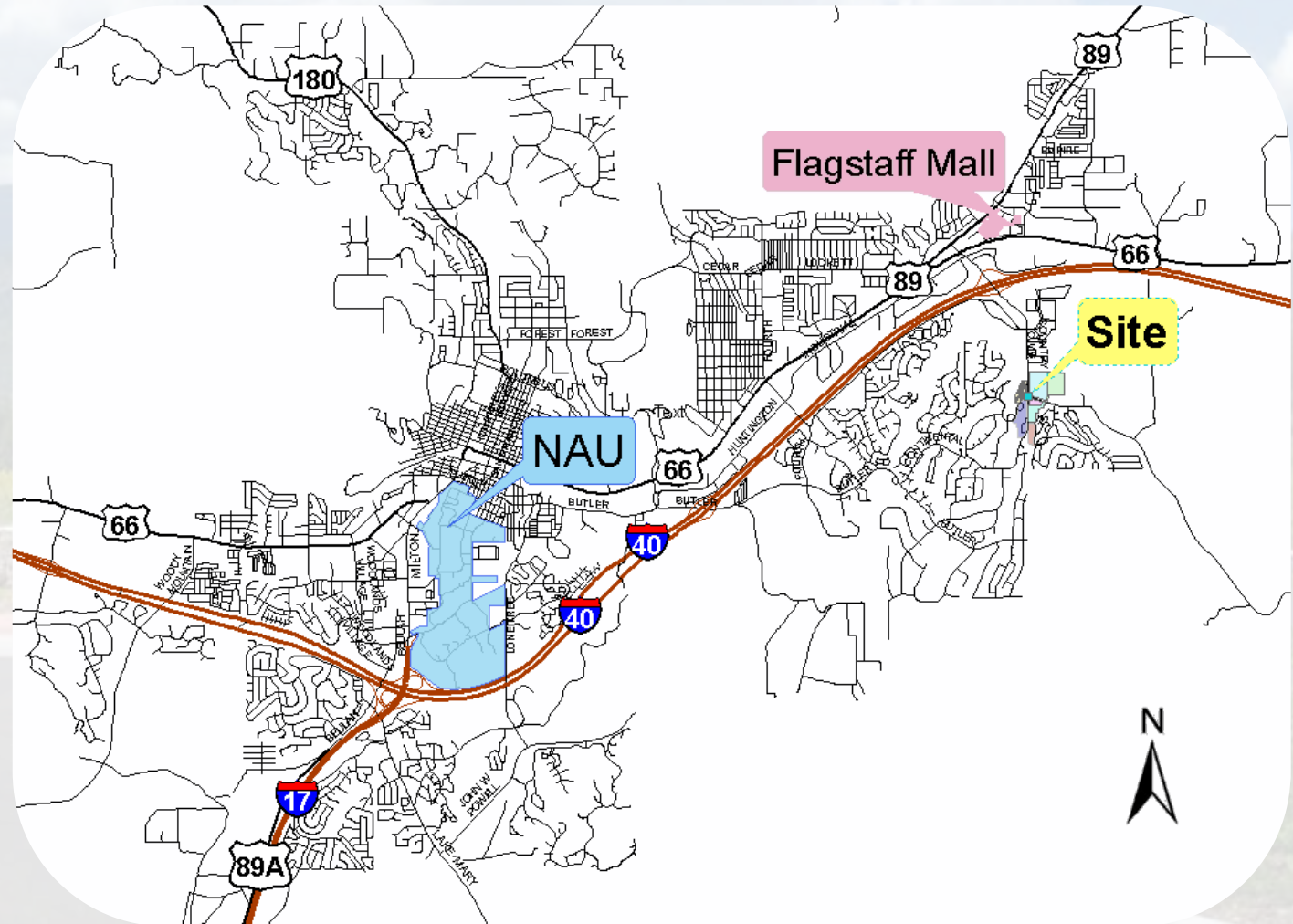
CITY OF FLAGSTAFF ROUNDABOUT DESIGN

T.J. Sullivan
Amal Abdelaziz
Kevin Farrell
Ryon Ubert

Date: February 9th, 2016

BACKGROUND

- **Site Location**
- Old Walnut Canyon Rd. and Country Club Dr.



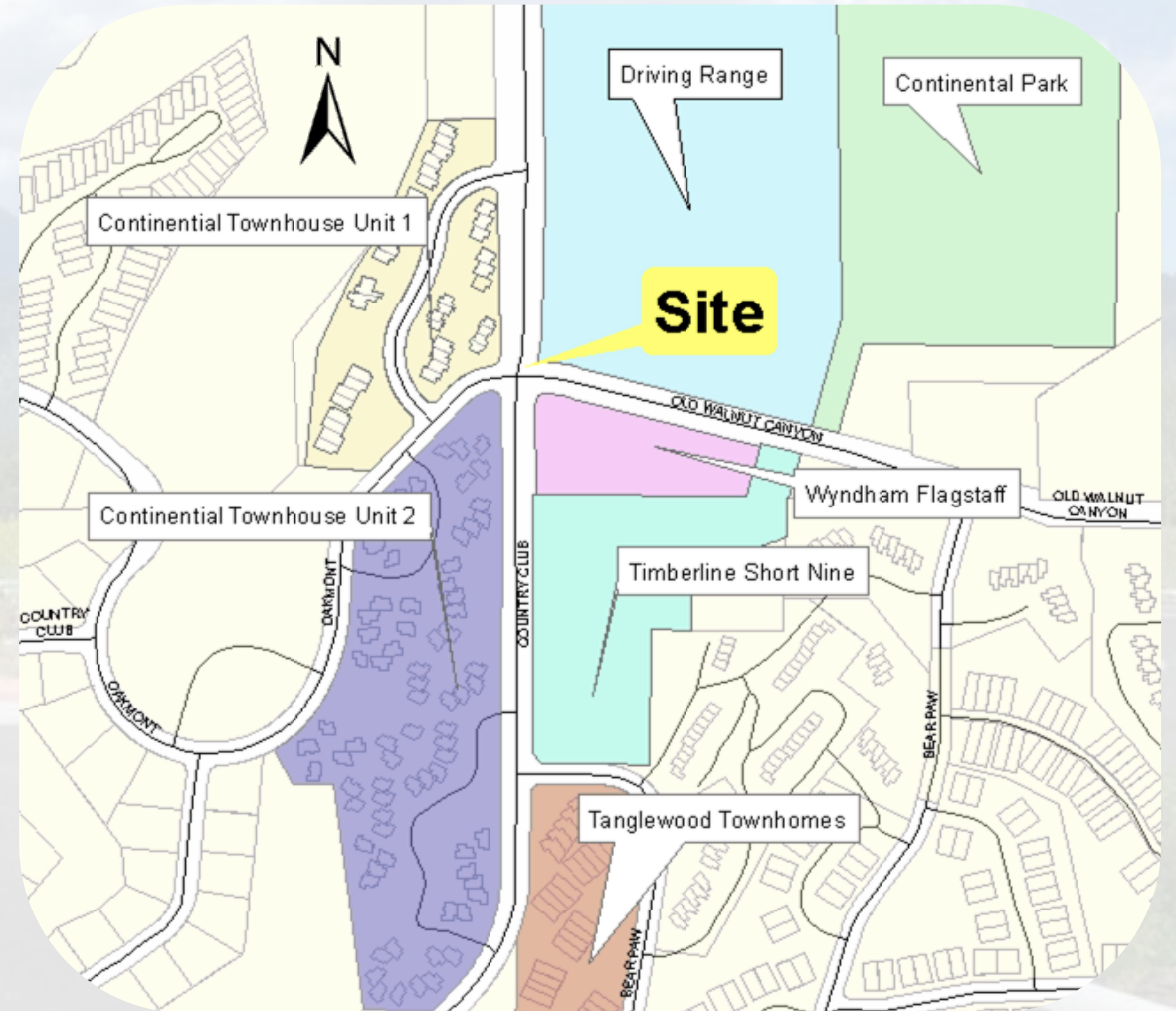
BACKGROUND

■ Site Location

- Old Walnut Canyon Rd. and Country Club Dr.

■ Purpose

- Redesign intersection of Old Walnut Canyon Rd. and Country Club Dr. to improve Sight distance, and safety of the intersection.



SCHEDULE

In progress, behind schedule

In progress, on time

Future 2 weeks

1	Data Collection	Fri 9/4/15	Tue 11/3/15	4.2	Site Development	Mon 1/25/16	Fri 2/26/16
1.1	Site Evaluation	Fri 9/4/15	Thu 9/10/15	4.2.1	Drainage	Mon 2/29/16	Fri 3/25/16
1.2	Topographic Survey	Fri 9/11/15	Mon 9/14/15	4.2.2	Landscaping	Sat 2/29/16	Wed 3/25/16
1.3	Client Meeting	Tue 11/3/15	Tue 11/3/15	4.2.3	Pedestrian Consideration	Thu 3/10/16	Thu 3/25/16
2	Roadway Design Guidelines	Mon 11/2/15	Fri 12/11/15	5	Economics	Mon 2/29/16	Fri 4/1/16
2.1	Research guidelines	Mon 11/2/15	Fri 11/6/15	5.1	Construction Costs	Mon 3/5/16	Wed 4/1/16
3	Data Analysis	Mon 11/2/15	Fri 3/4/16	5.2	Benefits	Mon 3/7/16	Fri 4/1/16
3.1	Survey Data	Tue 11/3/15	Tue 11/3/15	5.3	Impacts	Mon 3/21/16	Fri 4/1/16
3.2	Traffic Statistics	Wed 11/4/15	Tue 11/10/15	6	Project Management	Tue 10/27/15	Thu 5/12/16
3.3	Level of Service: TWSC	Thu 11/12/15	Wed 11/18/15	6.1	Project Schedule	Mon 11/16/15	Fri 11/20/15
3.4	Level of Service: Roundabout	Mon 2/22/16	Fri 3/4/16	6.2	50% Design Report	Fri 3/11/16	Fri 3/11/16
4	Site Design	Tue 1/19/16	Fri 3/4/16	6.3	Final Design Report	Fri 4/29/16	Thu 5/12/16
4.1	Roundabout	Tue 1/19/16	Mon 2/29/16	6.4	Final Presentation	Fri 4/29/16	Fri 4/29/16
4.1.1	Geometry	Tue 1/19/16	Sun 2/21/16	6.5	Website	Mon 11/23/15	Fri 12/4/15
4.1.2	Grading	Tue 2/9/16	Sun 2/21/16				
4.1.3	Striping	Mon 2/22/16	Thu 3/11/16				
4.1.4	Signage	Fri 2/26/16	Mon 3/11/16				

COMPLETED WORK

- **Topographic Surveying**
 - Finished Surveying the intersection
 - Received the survey data from the City of Flagstaff.
- **Traffic Statistics**
 - Received the collected traffic data.
- **Research Guidelines**
- **Current Level of Service (LOS)**



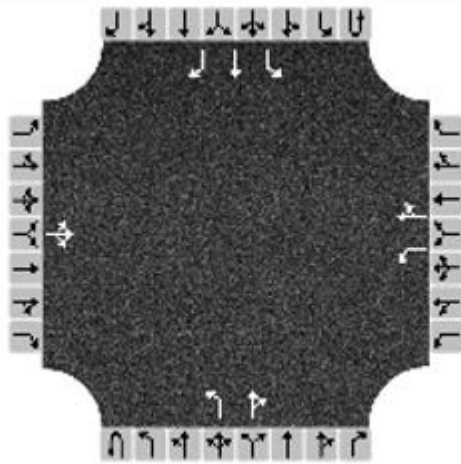
COMPLETED WORK: LEVEL OF SERVICE (LOS)

Vehicle Volumes and Adjustments

Approach	Eastbound				Westbound				Northbound				Southbound				
	U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R	
Movement																	
Priority		10	11	12		7	8	9	1U	1	2	3	4U	4	5	6	
Number of Lanes		0	1	0		1	1	0	0	1	1	0	0	1	1	1	
Configuration			LTR			L		TR		L		TR		L	T	R	
Volume (veh/h)		04	12	53		0118	13	11		17	89	7		57	75	113	
Percent Heavy Vehicles		3	3	3		3	3	3		3				3			
Proportion Time Blocked																	
Right Turn Channelized		No				No				No				No			
Median Type	Left Only																
Median Storage	1																

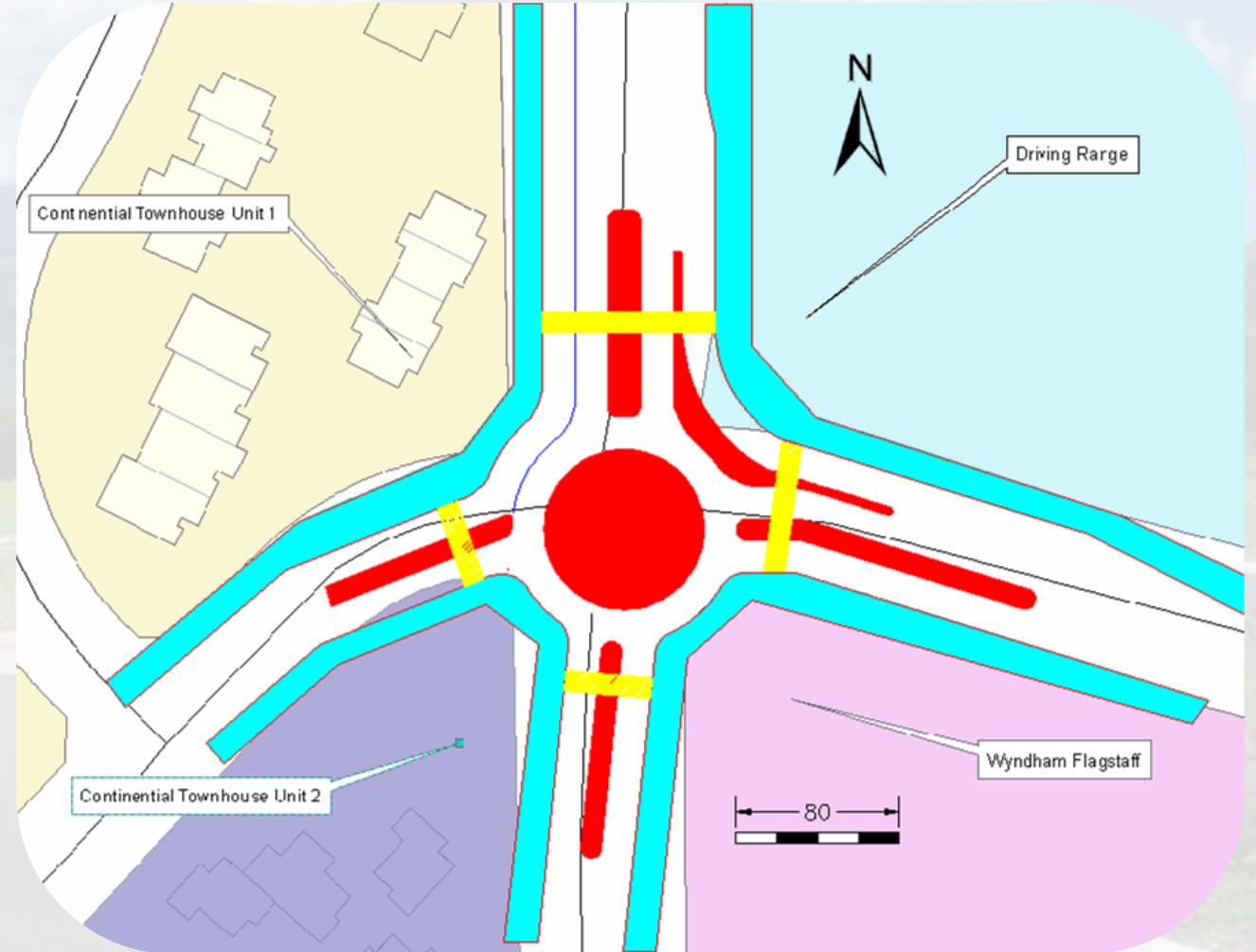
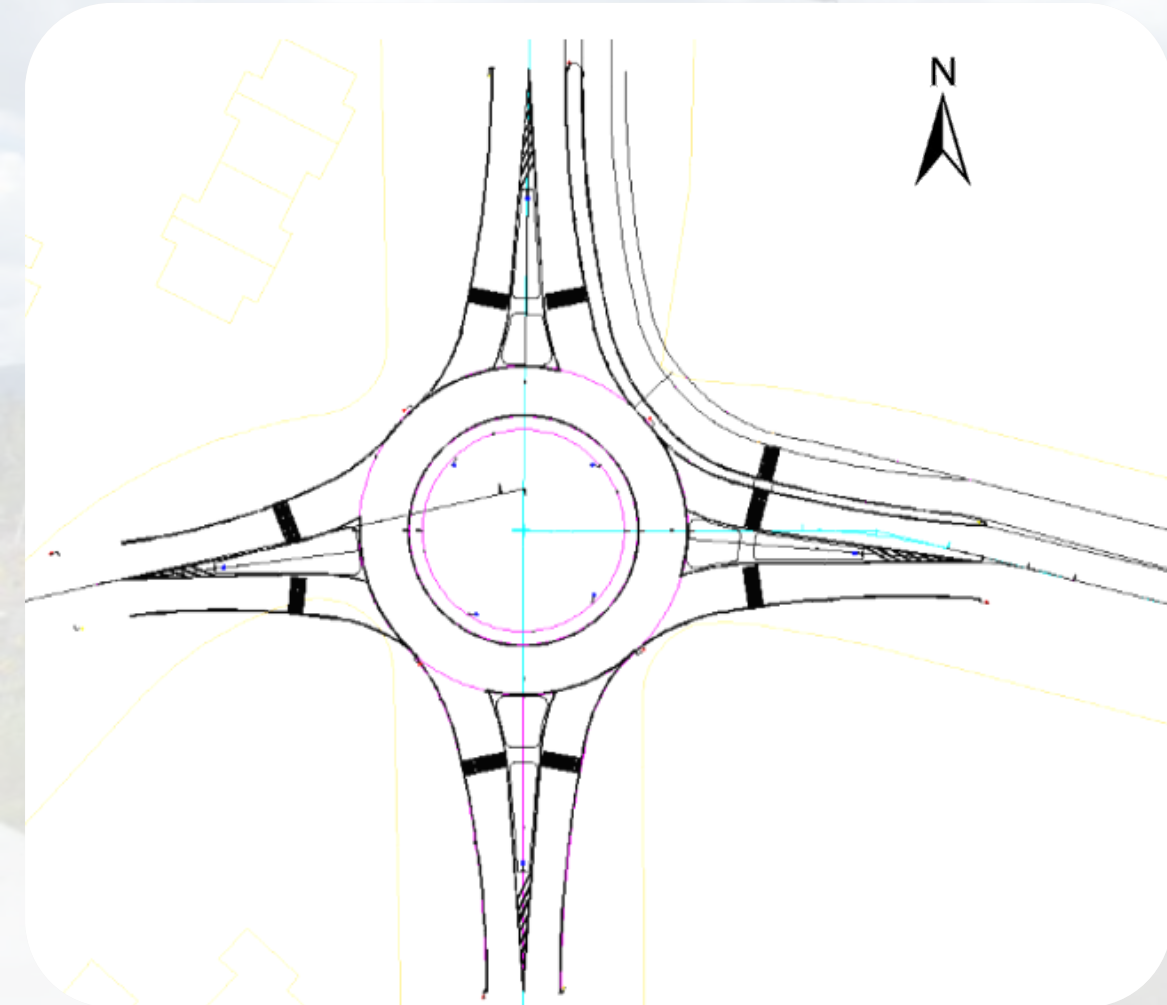
Delay, Queue Length, and Level of Service

Flow Rate (veh/h)			75			128		26		18					62		
Capacity			1132			560		2053		1359					1478		
v/c Ratio			0.07			0.23		0.01		0.01					0.04		
95% Queue Length			0.2			0.9		0.0		0.0					0.1		
Control Delay (s/veh)			8.4			13.3		6.8		7.7					7.5		
Level of Service (LOS)			A			B		A		A					A		
Approach Delay (s/veh)		8.4				12.2				1.1				1.8			
Approach LOS		A				B				A				A			

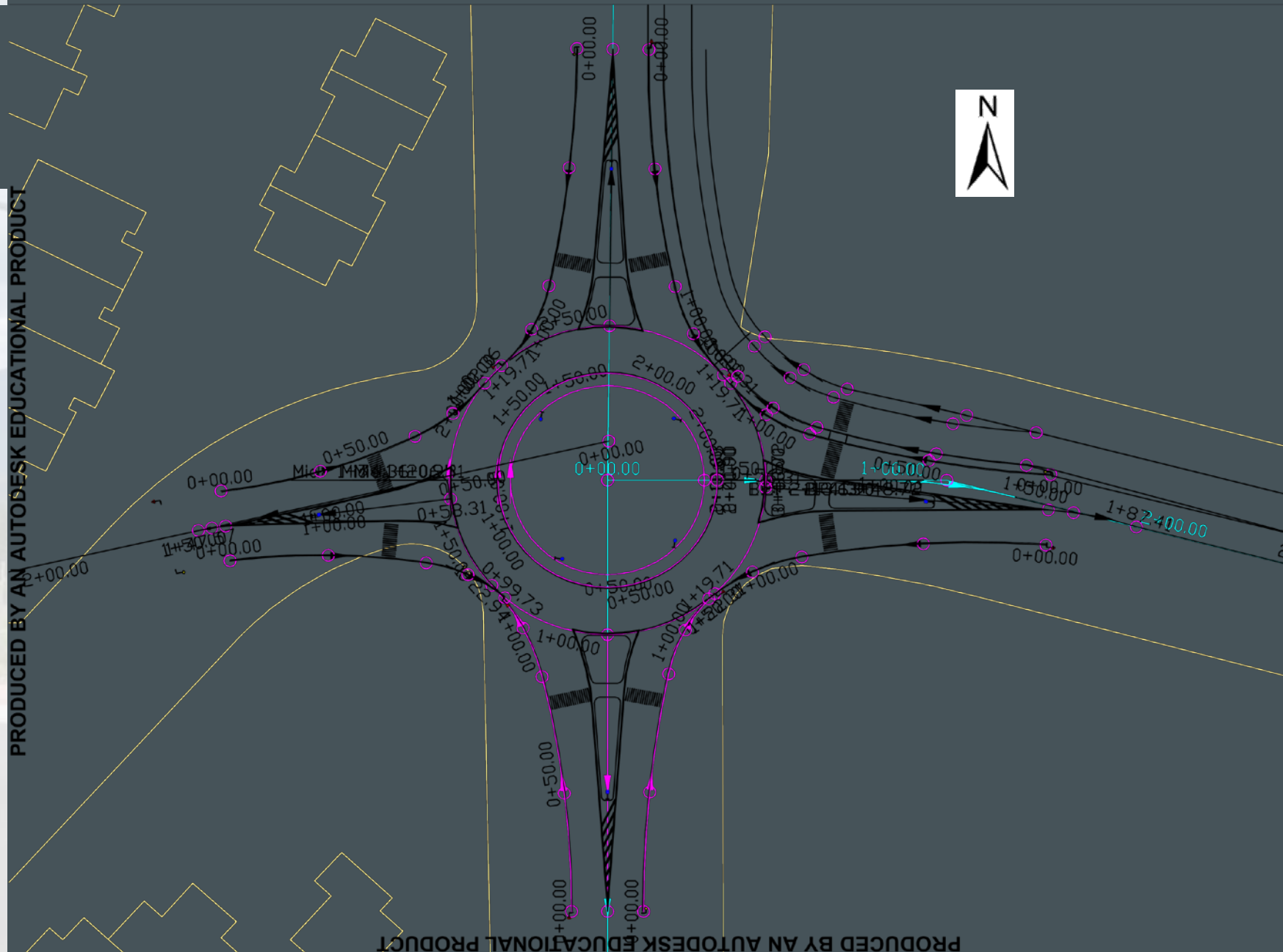


Major Street: North-South

WORK IN PROGRESS: GEOMETRY



- 110 Diameter w/ a left align
- Speed limit 20 mph
- Entry width 16 feet



WORK IN PROGRESS: LEVEL OF SERVICE (LOS)

- **LOS: Roundabout**
- **Rodel Analysis**
- **Designed for Roundabouts**

Entry Geometry					Circ Geom		
E	n	L'	R	Φ	D	C	n
24.00	2	164.00	66.00	30.00	164.00	33.00	2
24.00	2	164.00	66.00	30.00	164.00	33.00	2
24.00	2	164.00	66.00	30.00	164.00	33.00	2
24.00	2	164.00	66.00	30.00	164.00	33.00	2

Exit Geometry			
Ex	n	Vx	n
24.00	2	12.00	1
24.00	2	12.00	1
24.00	2	12.00	1
24.00	2	12.00	1

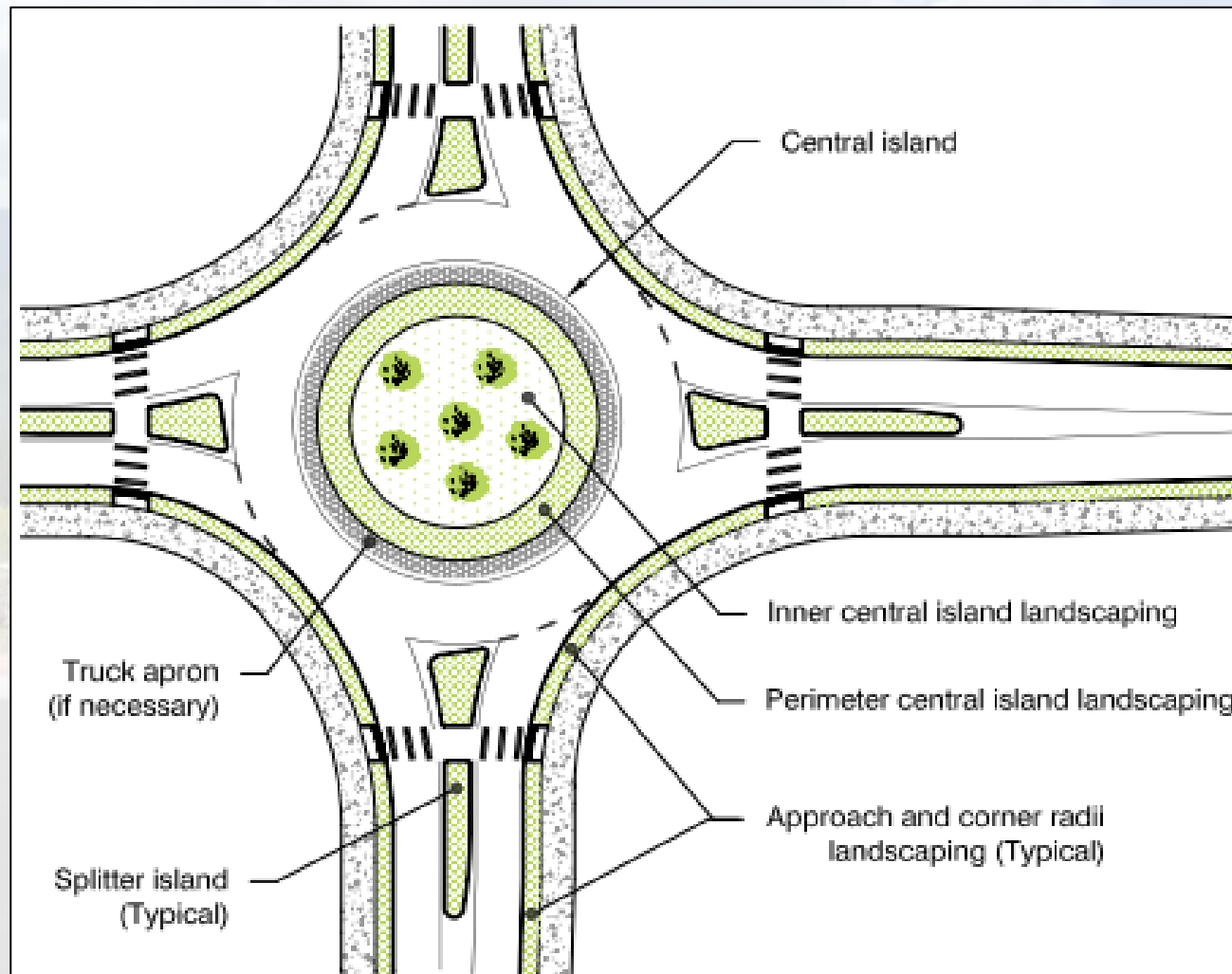
Entry Capacity Mods	
-+ Cap (v/h)	Xwalk Fact
0	1.000
0	1.000
0	1.000
0	1.000

Turning Volumes (veh/hr)						
		U-Turn	Exit-3	Exit-2	Exit-1	Bypass
		0	100	100	100	0
		0	100	100	100	0
		0	100	100	100	0
		0	100	100	100	0

Arrival Volume Ratios			Arrival Volume Times (min)			PHF
Ratio1	Ratio2	Ratio3	Time1	Time2	Time3	
0.750	1.125	0.750	0	30	60	
0.750	1.125	0.750	0	30	60	
0.750	1.125	0.750	0	30	60	
0.750	1.125	0.750	0	30	60	

WORK IN PROGRESS: DRAINAGE AND LANDSCAPING

- Makes Central Island more visible
- Aesthetically pleasing
- No Landscaping
 - No maintenance cost
 - Save \$\$
- Drainage
 - Contacting ADOT



FUTURE 2 WEEKS OF WORK

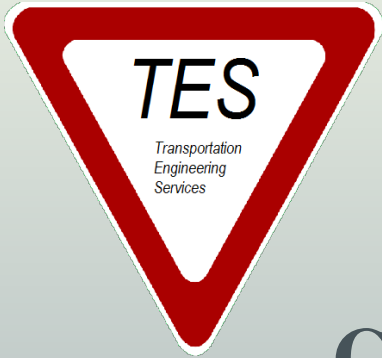
■ Site Design

- Striping
- Signage

■ Site Development

- Pedestrian Considerations
- **50% Design Report**





**Transportation
Engineering
Services**

CITY OF FLAGSTAFF ROUNDABOUT DESIGN

Amal Abdelaziz

T.J. Sullivan

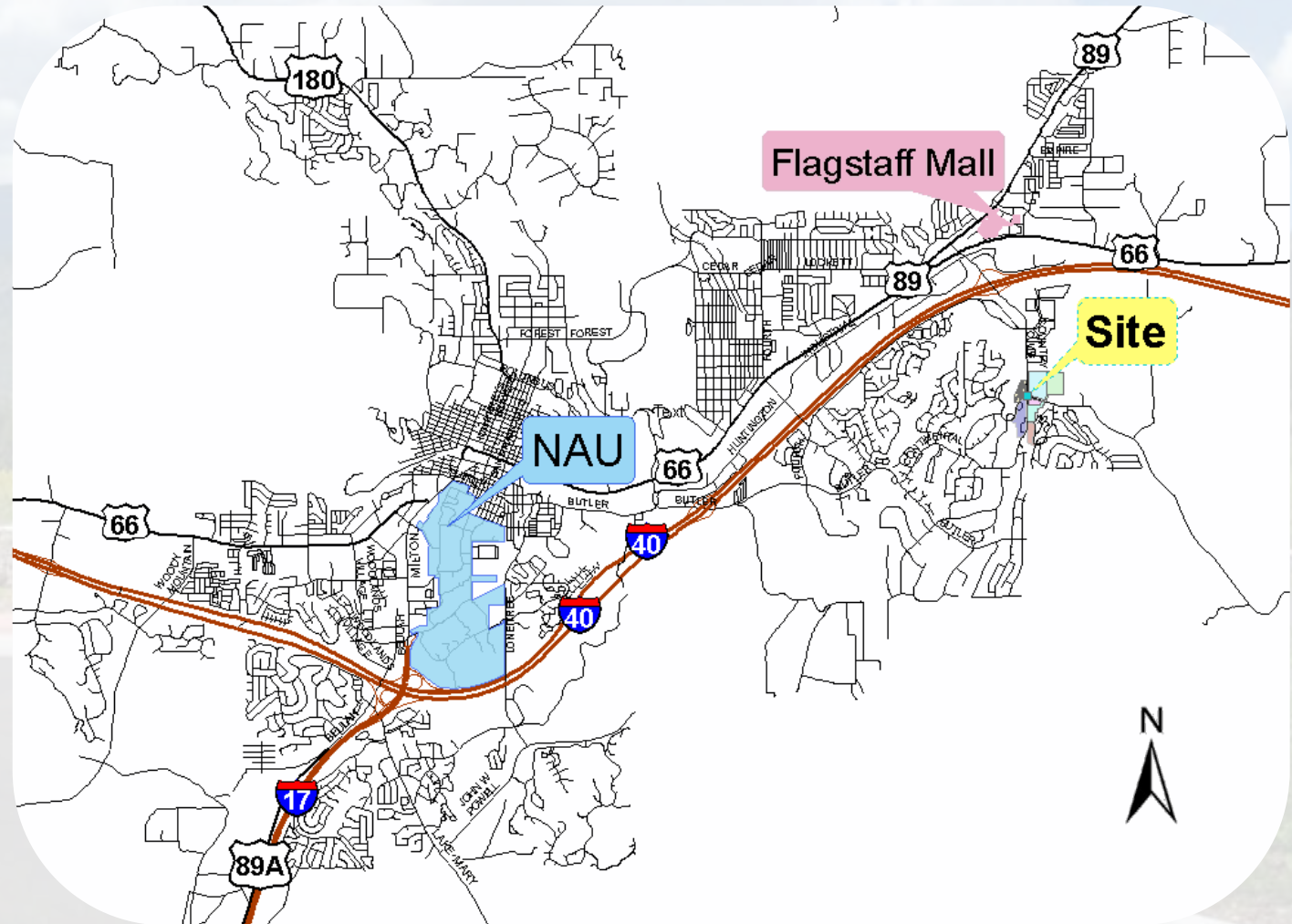
Kevin Farrell

Ryon Ubert

Date: March 22nd , 2016

BACKGROUND

- **Site Location**
- Old Walnut Canyon Rd. and Country Club Dr.



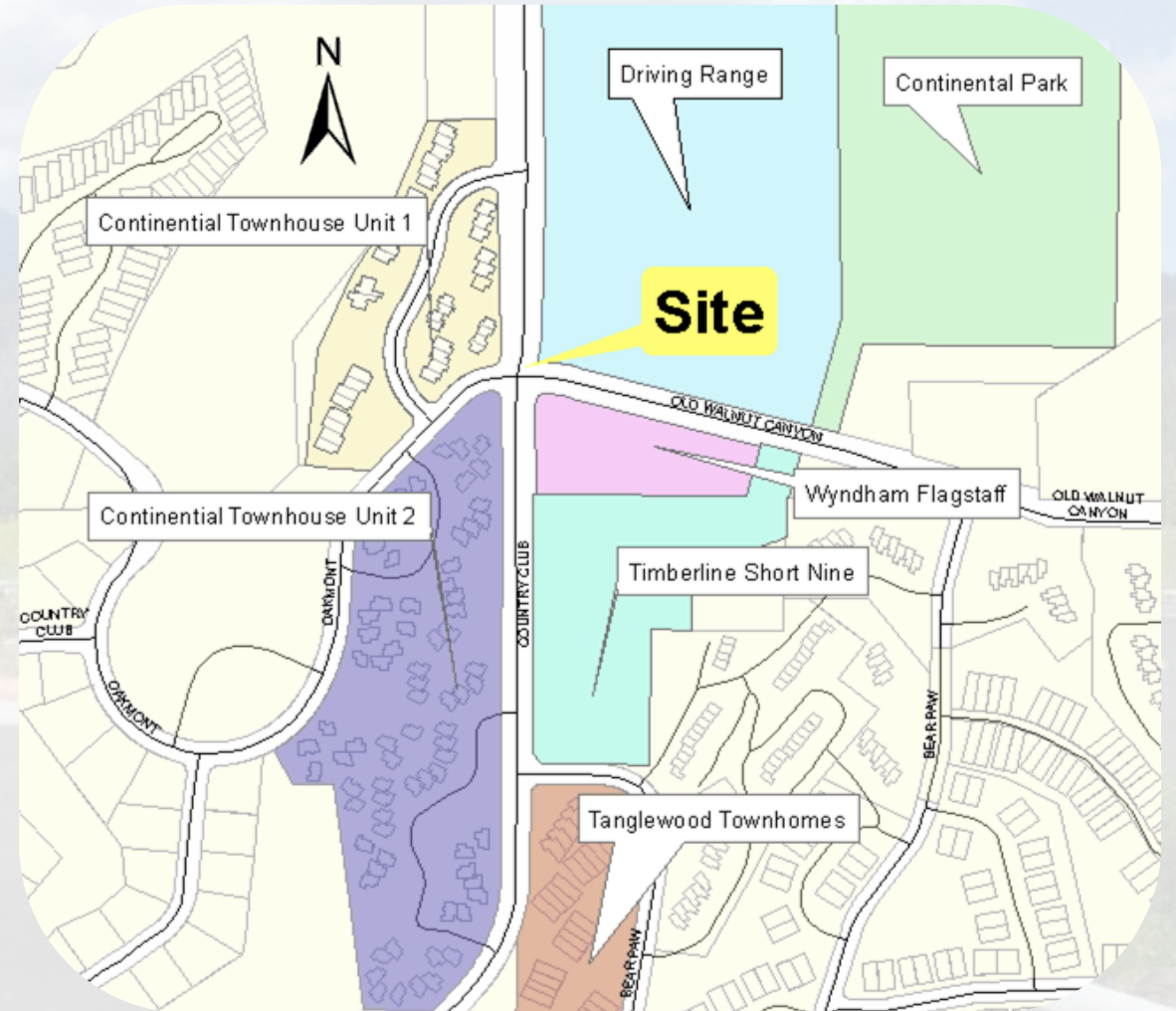
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3.4	LOS: Roundabout	Mon 2/22/16	Fri 3/4/16	Projected date: 4/1/16	6.2	50% Design Report	Fri 3/11/16	Fri 3/11/16
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4.1.4	Signage	Fri 2/26/16	Mon 3/11/16					

COMPLETED WORK

- **Topographic Surveying**
 - Finished Surveying the intersection
 - Received the survey data from the City of Flagstaff.
- **Traffic Statistics**
 - Received the collected traffic data.
- **Research Guidelines.**
- **Current and future Level of Service (LOS) for current state of the intersection.**
- **Signage and Striping at the intersection**
- **Landscaping of the roundabout.**



COMPLETED WORK: LEVEL OF SERVICE (LOS)- CURRENT SITUATION

- **The LOS for the two way stop sign controlled (TWSC) intersection .**

- Current level of service at the two way stop sign controlled intersection with no growth factor.

- LOS for year 2035 for the current intersection situation.

- Growth rate equals 1.4% between 2015 and 2035 (*Based on 2013 edition of the City of Flagstaff Parks and Recreation Organizational Master Plan*)

Equation: 1	$Future = Existing * (1 + i)^n$	Where i – Annual Growth Rate n – Design Life
Equation: 2	$PHF = \frac{V}{4 * V_{15}}$	Where V – Peak Hour Volume V ₁₅ – Peak 15 Minute Volume

Year		Eastbound	Westbound	Northbound	Southbound
2015	Approach Delay (s/veh)	8.9	17.1	1.8	1.3
	Approach LOS	A	C	A	A
2035	Approach Delay (s/veh)	9.3	29.3	1.9	1.3
	Approach LOS	A	D	A	A

COMPLETED WORK: SITE DESIGN- SIGNAGE AND STRIPING

- **Circulation plaque:** South and west bounds.
- **Keep right plaque:** installed at the splitter island.
- **One way sign:** middle of the roundabout.
- **Yield plaque:** installed at each approach leg.
- **Yield ahead:** Placed on the northbound.
- **Dotted lines:** Installed at entrances of roundabout.
- **Ground lane arrows:** Normal arrows based on MUTCD.

Roundabout Circulation Plaque



One Way Plaque



Keep Right Plaque



Yield Plaque



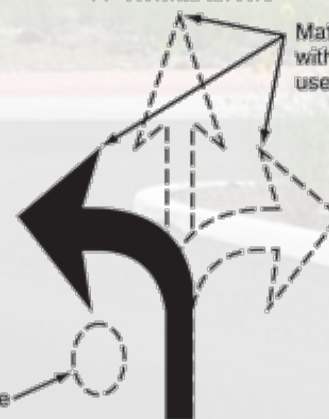
Right Turn Only Plaque



Yield Ahead



A - Normal arrows



Match arrow(s) with desired lane use configuration

Optional for left-most lane

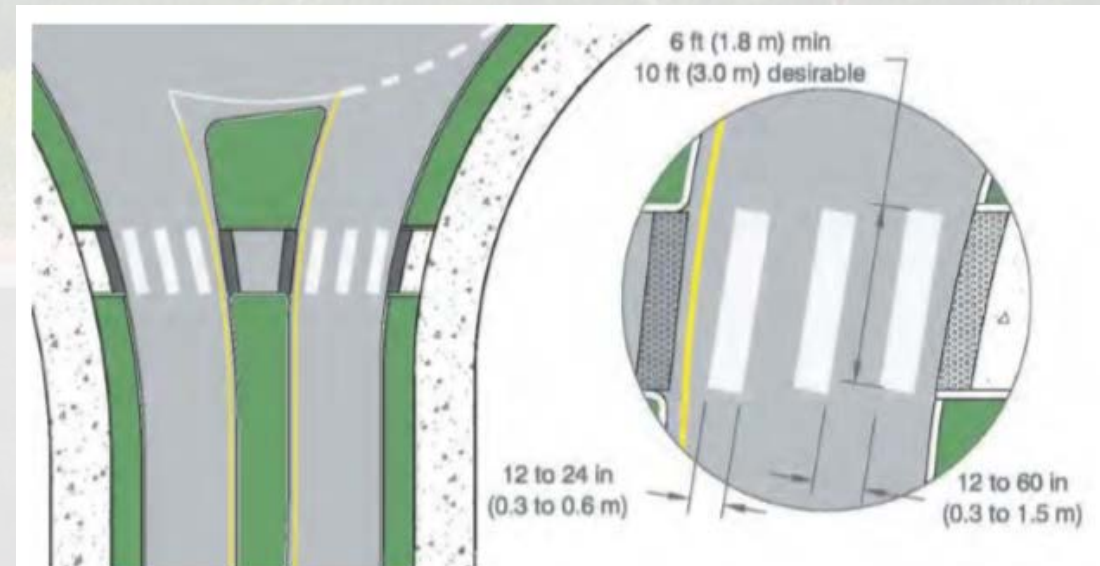
COMPLETED WORK: PEDESTRIAN AND BIKE CONSIDERATION

■ Pedestrian considerations

- Very low number of pedestrians.
- Sidewalk will be put through the splitter island
- Crosswalk markings are “zebra”
- Crosswalk markings will be 6-10 ft. long, 12-24 inches wide, spaced at 12-60 inches.

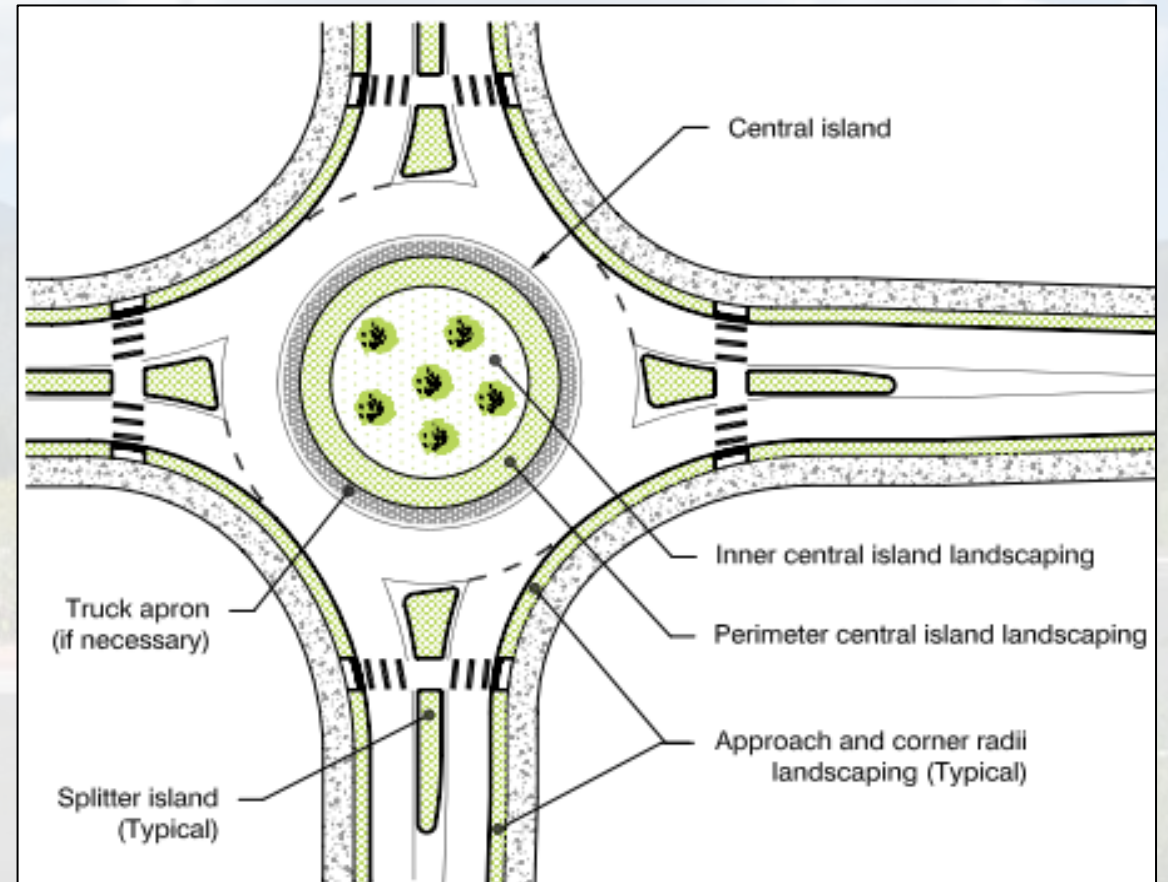
■ Bike Considerations

- MUTCD Manual prohibits the use of marked bicycle lanes within the roundabout.
- Bike traffic emerge onto sidewalk or enter roundabout



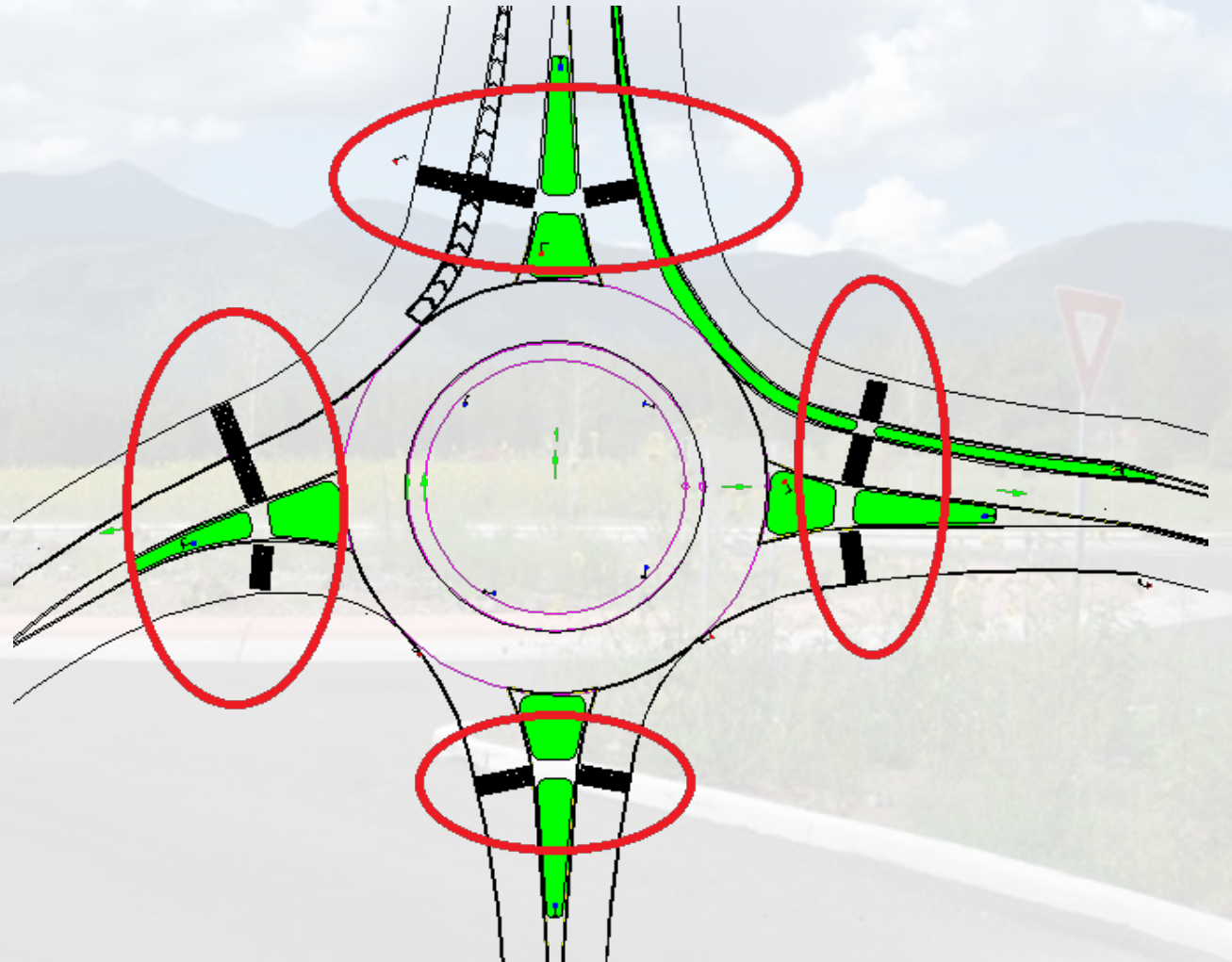
COMPLETED WORK: LANDSCAPING

- Landscaping at the central island and the splitter island will be made of low level plants (3ft- 6ft).
- Landscaping encourage pedestrians to use intersection properly.
- A landscaped intersection would be aesthetically pleasing.
- Enhances the safety at the intersection.
- Makes central island more visible.



WORK IN PROGRESS: GEOMETRIC DESIGN

- Completed work:
 - Inscribed diameter of 110 ft.
 - Speed limit is 20 mph
 - Entry width is 16 ft.
 - Design of a right turn by-pass lane.
 - Accommodate large semi-trailer.
- Work on Progress:
 - Determine the vertical Alignment.



WORK IN PROGRESS

LOS: Roundabout

- Rodel Analysis
- Designed for Roundabouts

Drainage

- Drainage inlets will be placed along the outer curb line of the roundabout or along the central island.

Entry Geometry					Circ Geom		
E	n	L'	R	Φ	D	C	n
24.00	2	164.00	66.00	30.00	164.00	33.00	2
24.00	2	164.00	66.00	30.00	164.00	33.00	2
24.00	2	164.00	66.00	30.00	164.00	33.00	2
24.00	2	164.00	66.00	30.00	164.00	33.00	2

Exit Geometry			
Ex	n	Vx	n
24.00	2	12.00	1
24.00	2	12.00	1
24.00	2	12.00	1
24.00	2	12.00	1

Entry Capacity Mods	
-+ Cap (v/h)	Xwalk Fact
0	1.000
0	1.000
0	1.000
0	1.000

Turning Volumes (veh/hr)						
		U-Turn	Exit-3	Exit-2	Exit-1	Bypass
		0	100	100	100	0
		0	100	100	100	0
		0	100	100	100	0
		0	100	100	100	0

Arrival Volume Ratios			Arrival Volume Times (min)			PHF
Ratio1	Ratio2	Ratio3	Time1	Time2	Time3	
0.750	1.125	0.750	0	30	60	
0.750	1.125	0.750	0	30	60	
0.750	1.125	0.750	0	30	60	
0.750	1.125	0.750	0	30	60	

FUTURE 2 WEEKS OF WORK

- Benefits of installing the roundabout.
- Impacts of the roundabout.
- Construction costs and Economics.
- Roundabout grading.
- Drainage at the intersection.
- Finding the vertical alignment.
- Calculating the level of service after installing the roundabout.

REFERENCE

- [1] City of Flagstaff Parks and Recreation Organizational Master Plan, Flagstaff:Web, 2013.
- [2] Support Article." Support Article. Jamar Technologies, n.d.Web. 07 Mar. 2016.
- [3] HCS 2010. Computer software. HCS 2010 Overview.Vers. 6.80. McTrans Center, n.d.Web.
- [4] Rodel Interactive. Computer software. Roundabout Analysis Software.Vers.VI. Rodel Interactive, n.d.Web
- [5] N. C. H. R. Program, Ed., Landscaping, US. Department of Transportation.
- [6] N. C. H. R. Program, Ed., Geometric Design, US. Department of Transportation.
- [7] N. C. H. R. Program, Ed.,Application of Traffic Control Devices, US. Department of Transportation.