US-89 Page Roundabout

ARNA Engineering
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CENE 486C
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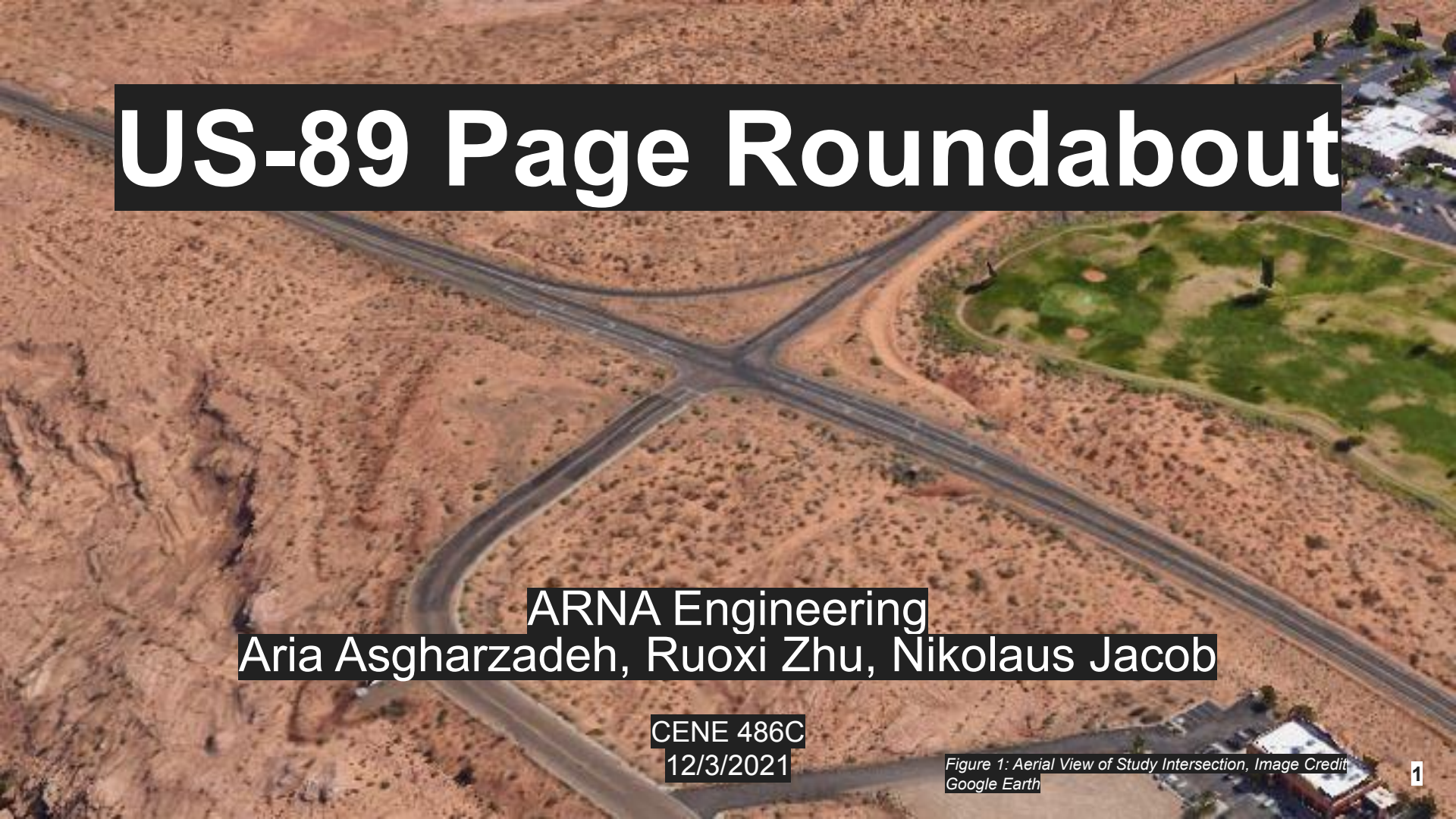


Figure 1: Aerial View of Study Intersection, Image Credit Google Earth

Project Information

Client: Nate Riesner, ADOT
Technical Advisor: Brendan Russo
Grading Instructor: Bridget Bero

Figure 2: Location of Page within Arizona

Figure 3: Location of Project within Page

Tasks

- Obtain Existing Data
- Hydrology Assessment
- Roundabout Selection & Design
- Project Impacts

Image Credit Google

Existing Traffic Data Along US 89

Figure 3: Location of US 89

Table 1: Traffic Counts Along US 89

Location ID	102080
Located	US 89r
Direction	2-Way
AADT	6,860
NB Count	3,384
SB Count	3,476

Existing Traffic Data Along N Lake Powell Blvd

Figure 4: location of N Lake Powell Blvd and Scenic View Rd

Table 2: Traffic Counts Along N Lake Powell Blvd

Location ID	3101
Located	SR-89L
Direction	2-Way
AADT	2,389
EB Count	625
WB Count	1764

Existing and Future Turning Movements

Table 3: Estimated Turning Movement Volumes

Approach	Movement	Turning %	Volume
NB US 89	Left	15	508
	Thru	60	2030
	Right	25	846
SB US 89	Left	30	1043
	Thru	50	1738
	Right	20	695
WB N Lake Powell Blvd	Left	35	617
	Thru	20	353
	Right	45	794
EB Scenic View Rd	Left	40	250
	Thru	15	94
	Right	45	281

Existing (2020)

Table 4: 2040 Estimated Turning Movement Volumes

Approach	Movement	Turning %	Volume
NB US 89	Left	15	948
	Thru	60	3791
	Right	25	1580
SB US 89	Left	30	1973
	Thru	50	3288
	Right	20	1315
WB N Lake Powell Blvd	Left	35	1210
	Thru	20	691
	Right	45	1555
EB Scenic View Rd	Left	40	1395
	Thru	15	523
	Right	45	1570

Future (2040)

City Codes & Standards

Arizona Department of Transportation Roadway Design Guidelines

ADOT Traffic Engineering

Coconino County Engineering Design and Construction Manual

Image Credit Google

Topographic Map of Site

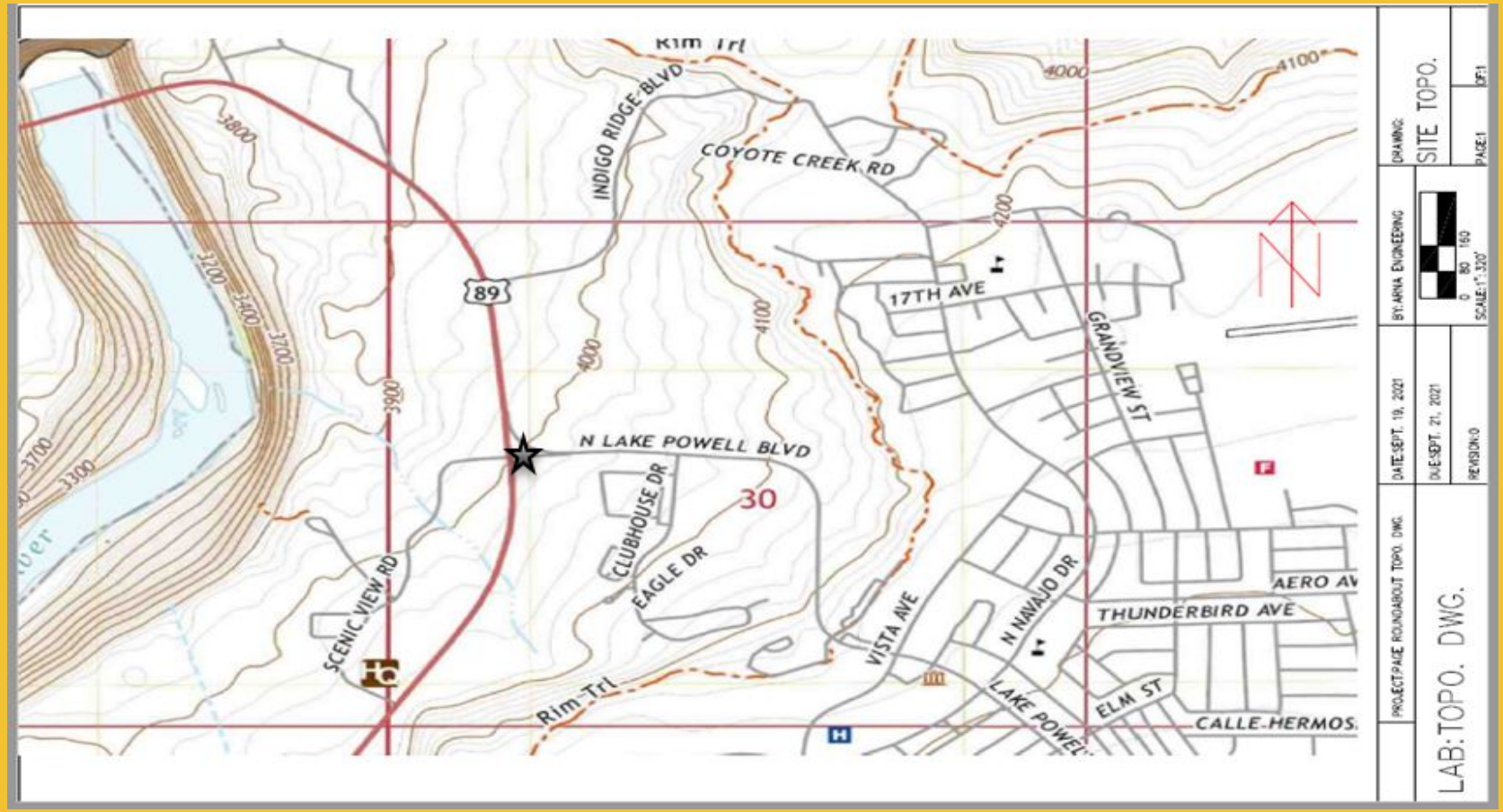


Figure 5: Topographic Map of Surrounding Area [1]

Hydrology Assessment

Figure 6: SB US 89 Culvert

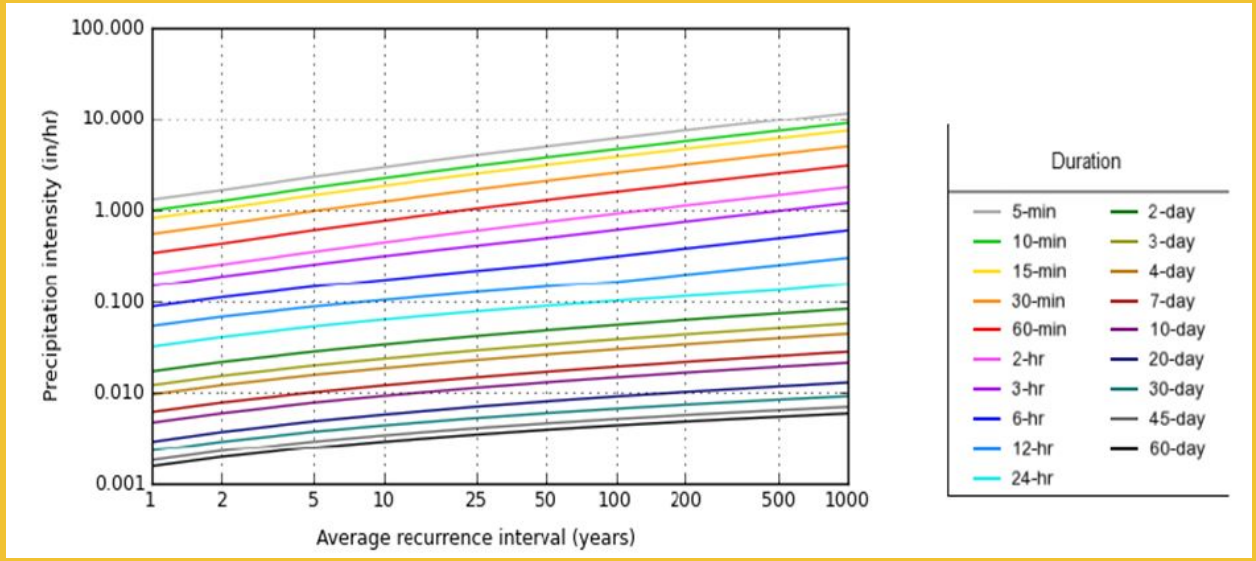


Figure 7: Precipitation Frequency on Site [2]

Time of Concentration

Table 5: Time of Concentration

Storm Event	Length (mi)	Kb	Slope (ft/mi)	Intensity(in/hr)	Tc (min)
10-year	1.353	0.2	327.42	0.063	**33.22**
100-year	1.353	0.2	327.42	0.101	**27.77**

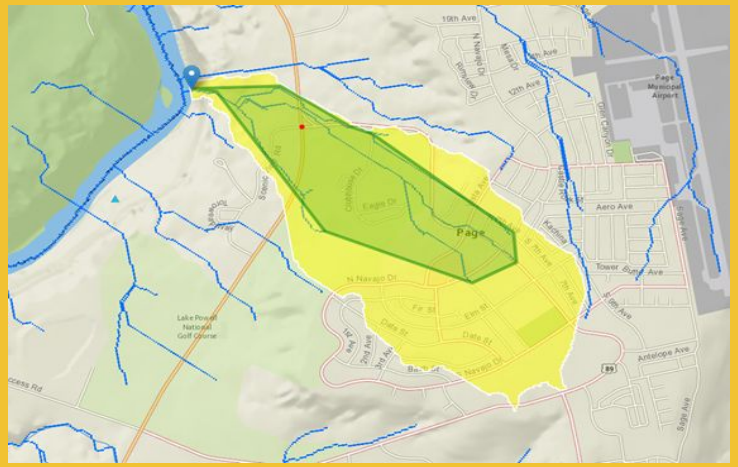


Figure 8: Modified Watershed from USGS StreamStats [2]

Equation 1: Time of Concentration

$$T_c = 11.4(L^{0.5})(K_b{}^{0.52})(S^{-0.31})(i^{-0.38})$$

Tc=Time of Concentration (min)
L=Length of Longest Flow Path (miles)
Kb=Watershed Resistance Coefficient
S=Slope of Longest Flow Path (ft/mile)
i=Average Rainfall Intensity (in/hr)

Weighted Runoff Coefficient

Table 6: Weighted Runoff Coefficient

Weighted Runoff Coefficient				
Surface Type	**Streets/Concrete**	**Clay Soils**	**Sandy Soil Lawn**	**Total**
Area (acres)	8.469	79.894	33.106	121.469
Weight (%)	6.97	65.77	27.25	100
Runoff Coefficient (C)	0.95	0.31	0.2	**Cw = 0.32**

Equation 2: Weighted Runoff Coefficient

$$Cw=(\sum CiAi)/Atot$$

Cw=Area Weighted Runoff Coefficient
Ci=Runoff Coefficient for Specific Surface Type
Ai=Area of Specific Surface Type (acres)
Atot=Total Area (acres)

Runoff

Table 7: Peak Discharge

Discharge				
Storm Event	**Weighted Runoff Coefficient (Cw)**	**Rainfall Intensity (in/hr)**	**Area (Acres)**	**Discharge (cfs)**
10-year	0.32	0.063	121.469	2.439
100-year	0.32	0.101	121.469	3.911

- Since the roundabout is designed to extend just outside of the original boundaries of the existing intersection, the runoff coefficient will not significantly change for pre and post development. Therefore, peak discharges derived from the rational method will be similar for pre and post development as well.

Equation 3: Rational Equation

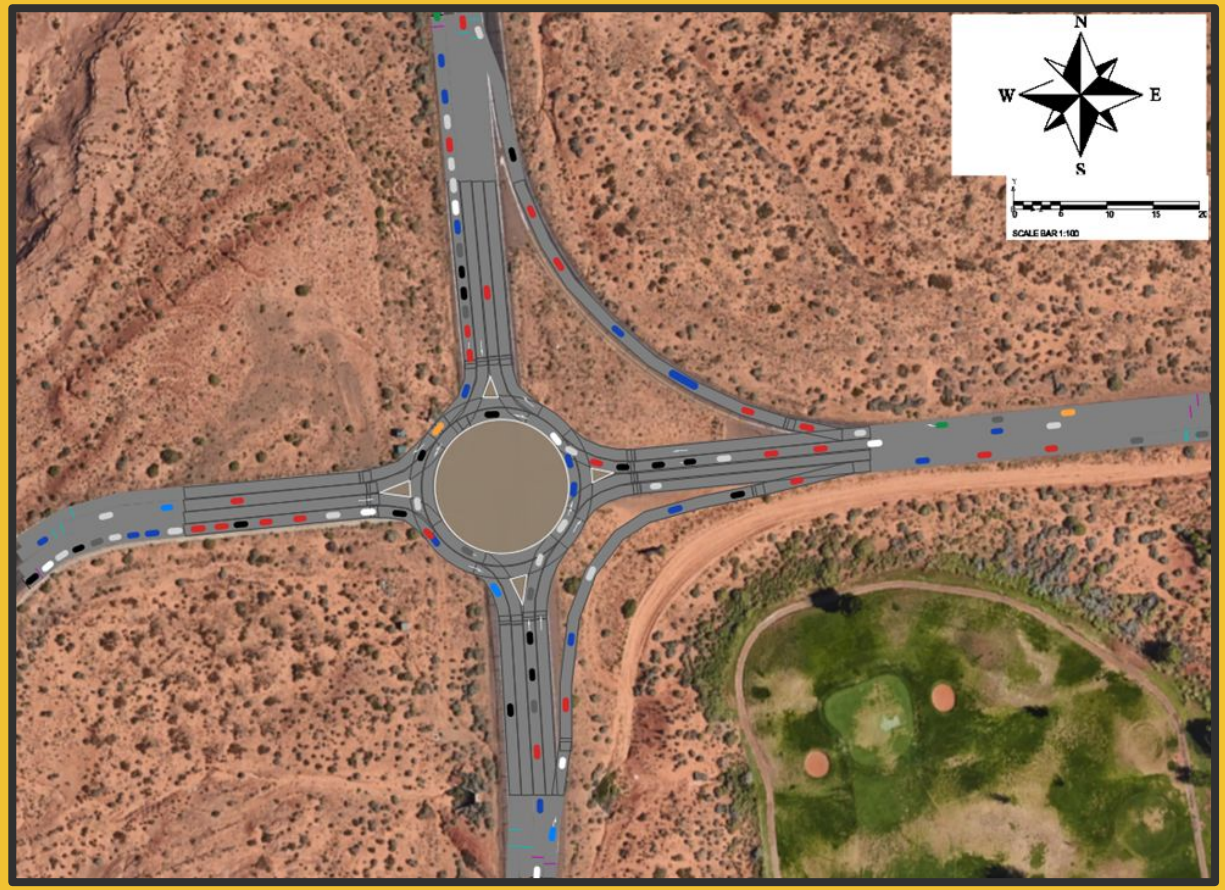
$$Q = C_w i A$$

$$Q = Peak\ Discharge\ of\ Selected\ Return\ Period\ (cfs)$$
$$C_w = Area\ Weighted\ Runoff\ Coefficient$$
$$i = Average\ Rainfall\ Intensity\ (in/hr)$$
$$A = Contributing\ Drainage\ Area\ (acres)$$

Roundabout Selection & Design

- VISSIM Models were created to analyze three alternative roundabout designs
- The LOS was then determined for each alternative by utilizing the projected 20-year traffic volumes and evaluating results based on how each alternative performed in the VISSIM Model
- Parameters that affected LOS for each alternative include number of lanes, oncoming vehicle speeds, roundabout speeds, vehicle composition, and the relative flow of vehicles for each approach.

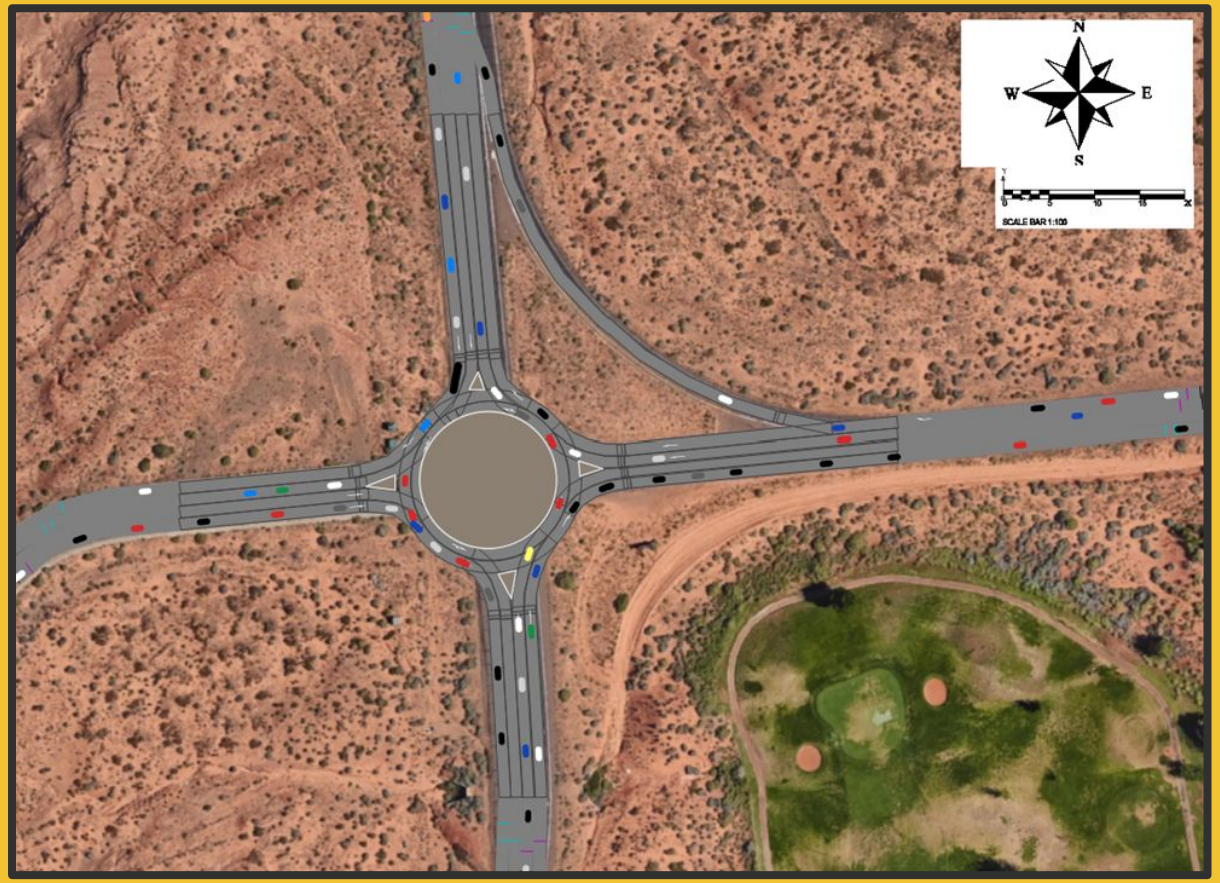
2-Lane 2-Slip Alternative



- 2 Lane with 2 Slip Lane Alternative
- Slip Lane 1 is from WB to NB traffic
- Slip Lane 2 is from NB to EB traffic

Figure 9: 2-Lane 2-Slip Alternative

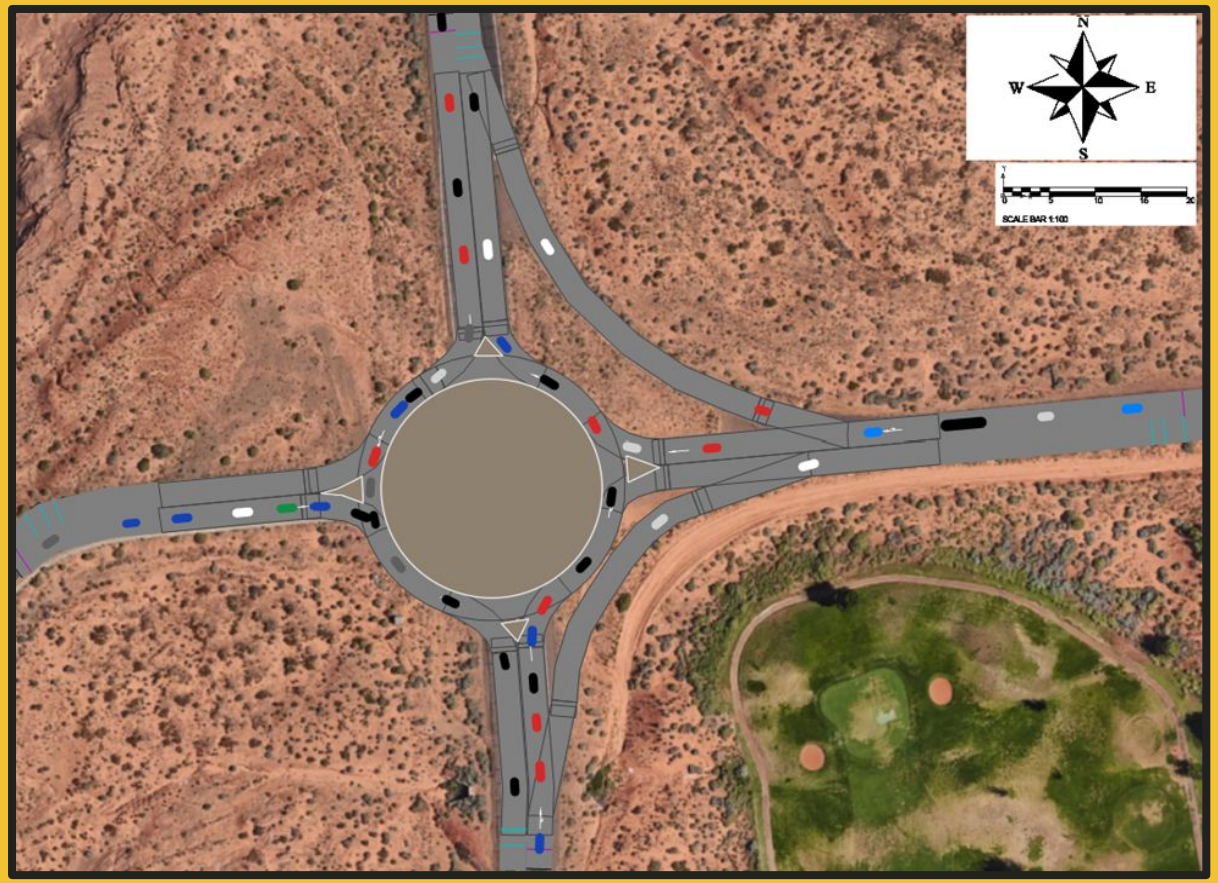
2-Lane 1-Slip Alternative



- 2 Lane with 1 Slip Lane Alternative
- Slip Lane would be from WB traffic to NB traffic

Figure 10: 2-Lane 1-Slip Alternative

1-Lane-2-Slip Alternative



- 1 Lane with 2 Slip Lanes Alternative
- Slip Lane 1 is from WB to NB traffic
- Slip Lane 2 is from NB to EB traffic

Figure 11: 1-Lane 2-Slip Alternative

LOS Comparison of Each Alternative

Table 8: LOS Comparison

Legend		LOS A / LOS B	LOS C / LOS D	LOS E / LOS F
Approach	Movement	2-lane 2-slip	2-lane 1-slip	1-lane 2-slip
NB US 89	Left			
	Thru			
	U			
	Right			
SB US 89	Left			
	Thru			
	U			
	Right			
WB N Lake Powell Blvd	Left			
	Thru			
	U			
	Right			
EB Scenic View Rd	Left			
	Thru			
	U			
	Right			
Average score		**1.55**	**1.68**	**3.59**

- Each Approach is reviewed & color coded based on its LOS determination
- LOS A is ranked at a value of 1 and LOS F is ranked at a value of 6. The lower the final value, the better the LOS and quality of transportation services

Decision Matrix

Table 9: Decision Matrix

Weighting Factor	Category & Criteria	Raw Alternatives			Weighted Alternatives		
		2-lane 2-slip raw score	2-lane 1-slip raw score	1-lane 2-slip raw score	2-lane 2-slip weighted score	2-lane 1-slip weighted score	1-lane 2-slip weighted score
0.6	Level of Service (LOS)	3	3	1	1.8	1.8	0.6
0.2	Construction Costs	1	2	2	0.2	0.4	0.4
0.2	Maintenance Costs	2	3	3	0.4	0.6	0.6
	Total				2.4	2.8	1.6

Table 10: Modeling Values

Modeling Values	Level of Service (LOS)	Construction Costs	Maintenance Costs
1	E-F	$1,500,000-$2,000,000	≥ 5 Lanes
2	C-D	$1,000,000-$1,500,000	4 Lanes
3	A-B	$500,000-$1,000,000	3 Lanes

- A score of 3 is considered the best and a score of 1 is the worst
- Based on the Scoring Matrix created it was determined that Alternative 2 is the best feasible option

Selected Roundabout Design

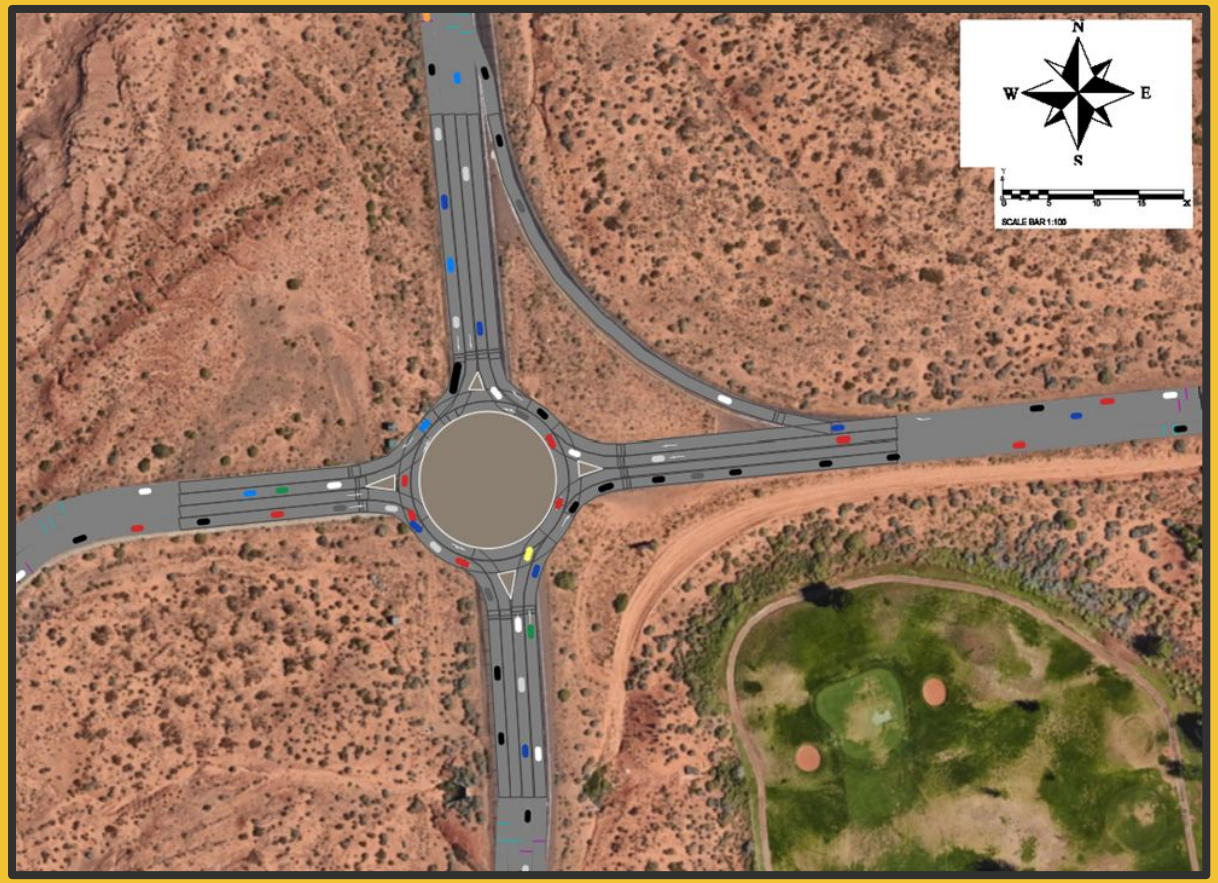


Figure 12: 2-Lane 1-Slip Alternative

- Best overall working design 2-Lane 1-Slip Roundabout

Existing Intersection

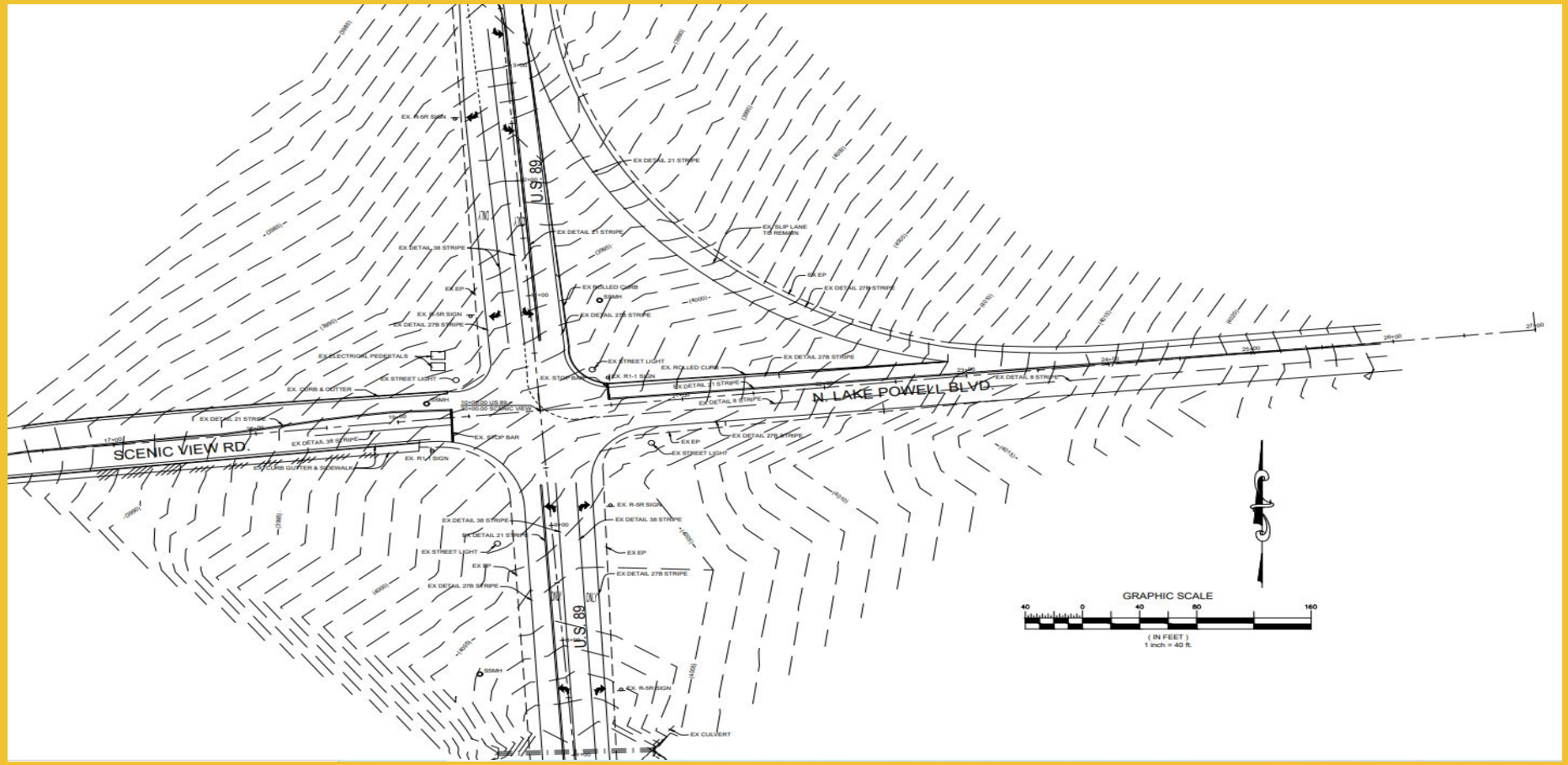


Figure 13: Existing Intersection Layout

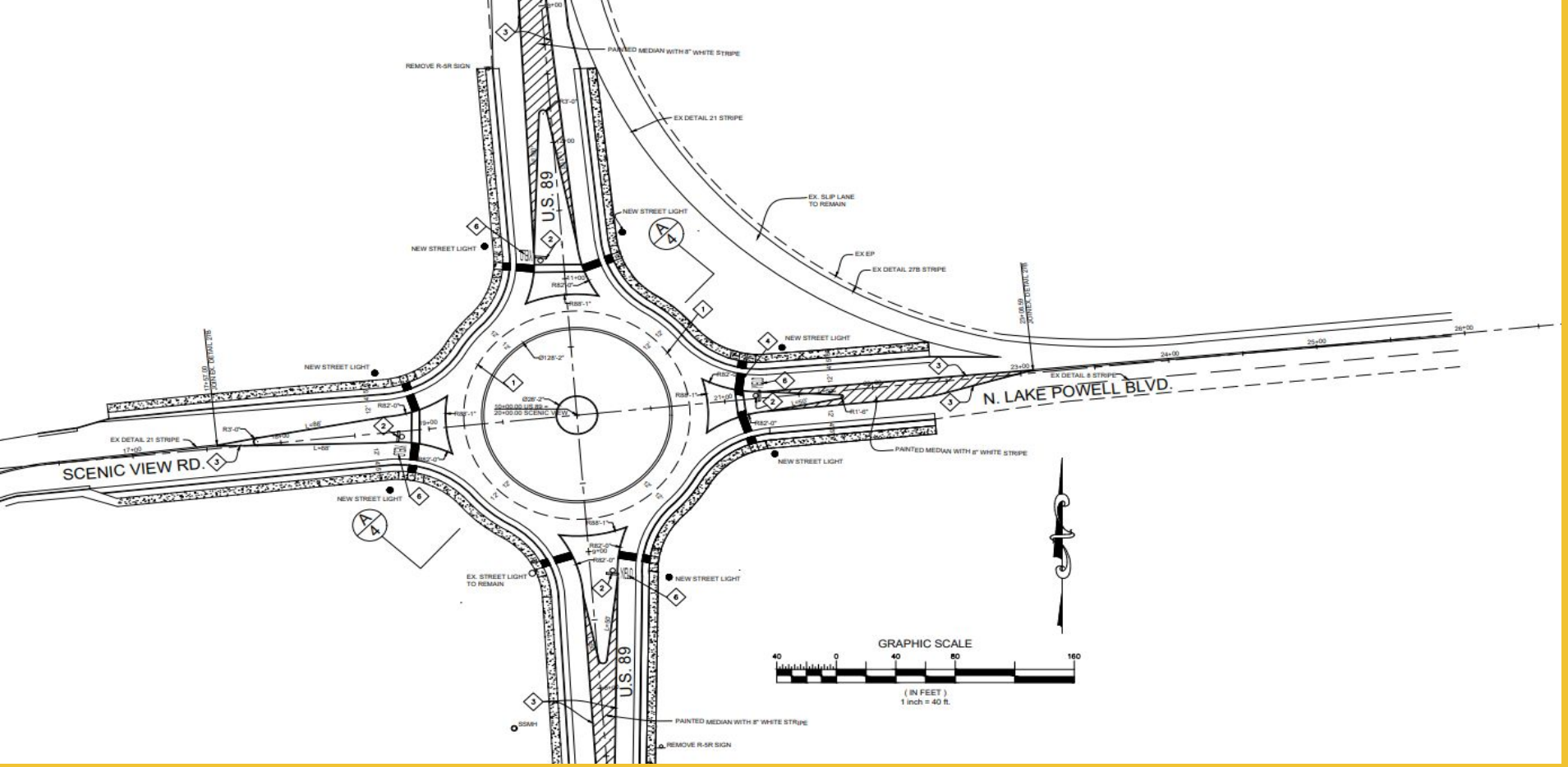


Figure 14: Roundabout Layout

Roundabout Configuration

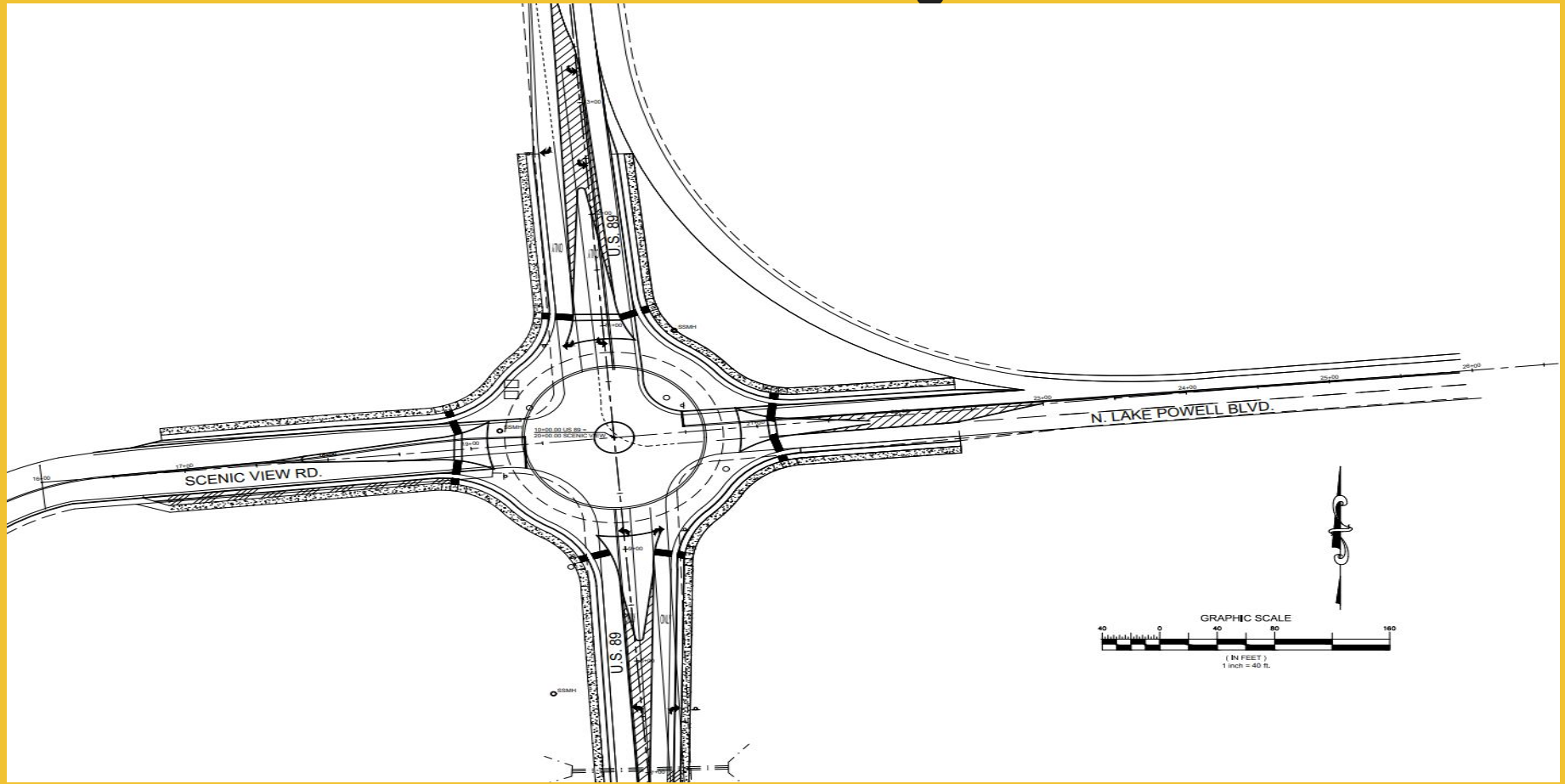


Figure 15: Roundabout Overlay of Existing Intersection

Typical Section of Roundabout Legs

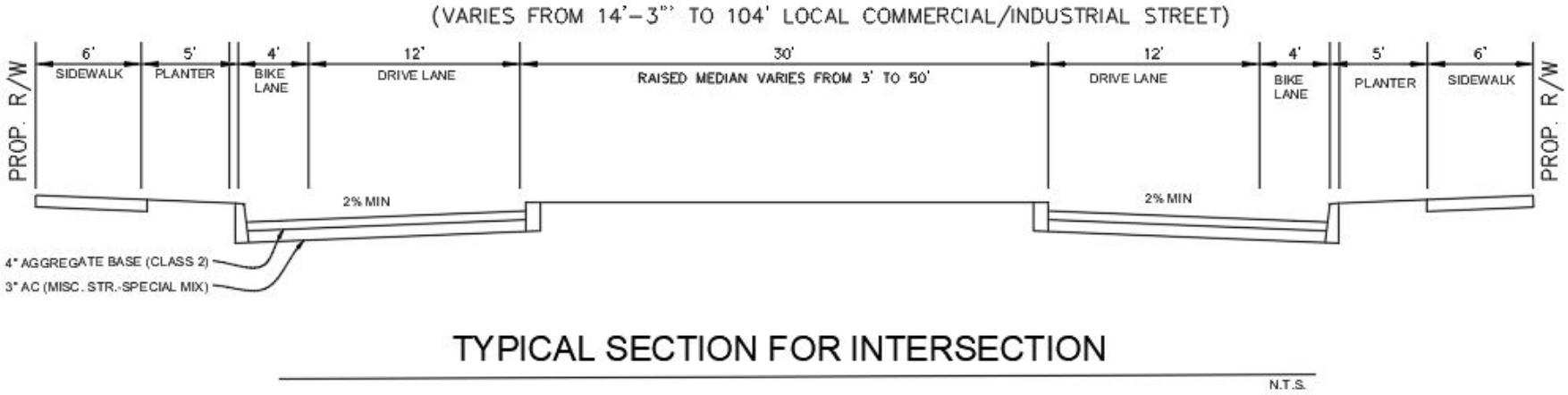


Figure 16: Roundabout Leg Section

Center Section Cut

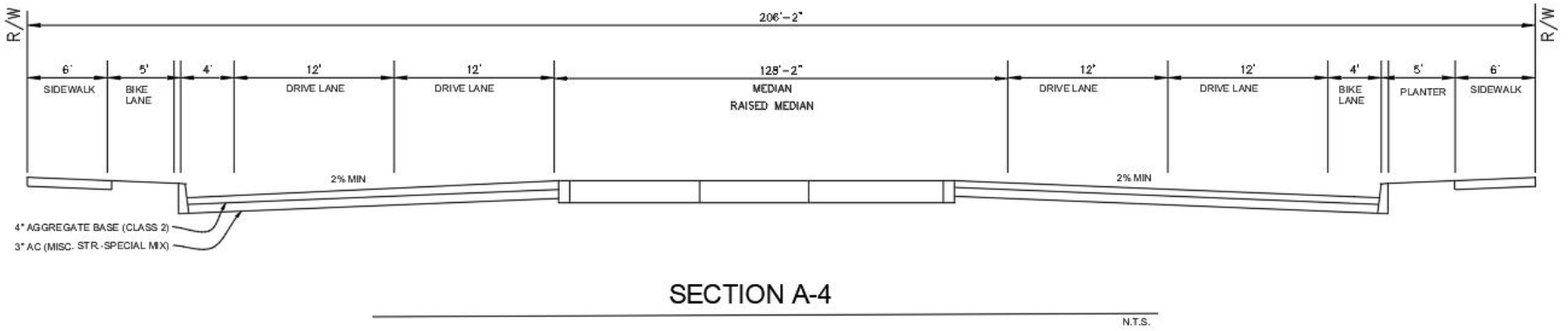


Figure 17: Roundabout Section

Project Impacts

Table 13: Impacts

Impacts	Social	Environmental	Economic
Short Term	Noise During Construction	Dust Pollution During Construction	The Initial Construction Cost is Expensive
	Traffic Congestion During Construction	Noise Made During construction	Sales of Surrounding Commercial Buildings are Affected
Long Term	Improved User Safety	Reduced Hydrocarbon Emissions	Reduce Economic Losses Caused by Collisions
	Improve the Travel Experience of Tourists	Reduced Vehicle Noise Pollution	Drive Local Economic Development

Construction Costs

Table 12: Construction Costs

Items	Quantity	Unit	Unit Cost	Total Cost
Construction Staking	0.67	KM	$778	$521.26
Clearing and Grubbing	0.09	HA	$3,700	$333.00
Earthwork				
Roadway Excavation	418	CY	$3.32	$1,387.76
Drainage Excavation	766	CY	$3.33	$2,550.78
Embankent	5953	CY	$0.50	$2,976.50
Borrow Material	4769	CY	$1.38	$6,581.22
Base and Surface Treatment				
Concrete Pavement	1382	SY	$38.40	$53,068.80
Asphalt Pavement	1025	SY	$23.80	$24,395.00
Structure (2)	900	SF EACH	$49.58	$89,244.00
Traffic Engineering				
Signing	10	UNIT	$25.00	$250.00
Lighting	20	UNIT	$200.00	$4,000.00
Subtotal				$185,308.32
Overhead (10%)				$18,530.83
Total				**$203,839.15**

References

[1] "Soil Consistency," [Online]. Available: http://www.fao.org/fishery/docs/CDrom/FAO_Training/FAO_Training/General/x6706e/x6706e08.htm. [Accessed 19 September 2021].

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