ARNA Engineering

December 7, 2021

Nate Reisner, PE, ADOT
Development Engineer
Flagstaff, AZ

Dear Mr. Reisner,

This report and plan set follows the process necessary for ARNA Engineering to create and implement a roundabout at the intersection of Highway US 89 and N Lake Powell Boulevard in Page, Arizona. The proposed design incorporates a 2-lane, 1-slip lane roundabout that meets the goal of reducing crashes, improving safety, and providing a Level of Service of A with the use of projected 20-year traffic counts. If you have any questions, please email Aria Asgharzadeh @aa3723@nau.edu.

Sincerely, ARNA Engineering

Aria Asgharzadeh
Nikolaus Jacob
Ruoxi Zhu

Final Design Report

US-89 and North Lake Powell Blvd. Roundabout

CENE 486C

December 7, 2021

ARNA Engineering

Aria Asgharzadeh

Ruoxi Zhu

Nikolaus Jacob

Northern Arizona University

College of Engineering, Informatics, and Applied Sciences

Table of Contents

List of Figures

List of Tables

List of Equations

List of Abbreviations

AADT	Average Annual Daily Traffic
ADOT	Arizona Department of Transportation
AOI	Area of Interest
BCR	Beginning of Curb Returns
EB	East Bound
ECR	End of Curb Returns
EP	Edge of Pavement
GNIS	Geographic Names Information System
HCM	Highway Capacity Manual
LOS	Level of Service
NB	North Bound
PHF	Peak Hour Factor
PF	Precipitation Frequency
SB	South Bound
SSD	Stopping Sight Distance
TCD	Transport Control Department
TCDS	Traffic Count Database System
USGS	United States Geological Survey
WB	West Bound

Acknowledgements

Thank you to Bridget Bero for serving as our grading instructor and guiding us through the construction of this design report with your insightful comments.

Thank you to Brendan Russo for serving as our technical advisor and support with your brilliant knowledge of traffic engineering.

Thank you to Adam Bringhurst for your knowledge of municipal engineering and help with the hydrology aspect of the project.

Thank you to Nate Reisner for being patient with our team and providing us with preliminary data needed to begin the project.

1.0 Project Introduction

1.1 Project Purpose

Page is the gateway to the Glen Canyon National Recreation Area and Lake Powell and attracts more than three million tourists every year [1]. Traffic on Highway 89, the main road to/from Page, is increasing, resulting in a decreased level of service (LOS) on the highway. A roundabout was designed for this intersection due to current traffic conflicts and incidence of crashes.

1.2 Project Location and Background

Figure 1-1 below presents the location of Page within Arizona relative to Phoenix and Flagstaff.

Figure 1-1: Location of Page within Arizona. Image credit Google Maps

The current intersection is a four-way intersection with stop signs on the North Lake Powell Boulevard and Scenic View Road, while traffic travelling North and South on US-89 does not stop.

Figure 1-2 shows the roads near the intersection, marked with curves of different colors, and shows the name of the road. The site is marked with a blue pin.

Figure 1-2: Location of the project within Page. Image credit Google Maps

The current traffic volume is 7500 vehicles daily (2019), with an annual growth rate of 20% since 2015 [1]). Highway 89 is a 4-lane highway and there is a substantial speed limit difference between Highway 89 (65mph) and North Lake Powell Boulevard (40mph) [2].

Figure 1-3 shows a detailed view of the intersection. Since there is no traffic signal on Highway 89 at the intersection, stopped traffic at North Lake Powell Blvd attempting to enter Hwy 89 encounters high-speed traffic. This is not safe for any pedestrians and bicycles needing to cross Highway 89. There is a slip lane into Highway 89 northbound (NB) from Lake Powell Blvd. The Scenic View road has two lanes. At the westbound (WB) of the site, the Scenic View road has a right turn lane/straight lane and a left turn-only lane. Lake Powell Blvd is a three-lane road. There are two lanes from west to east and one lane from east to west.

Figure 1-3: Aerial view of the study intersection. Image credit Google Maps

2.0 Existing Data

2.1 Traffic Data

Traffic count data were obtained from historical traffic data (AADT) for ADOT – maintained roadways [3]. The location of the proposed project was found on the map of the software and the TCD was turned on for the intersection to give the pre-existing traffic counts from 2020. They are shown below in Table 2-1; these are the traffic counts for vehicles traveling along US 89 through the Lake Powell Rd. intersection.

Table 2-1: Traffic Counts Along US 89

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

Table 2-2 below shows the existing traffic data for vehicles travelling along Lake Powell Blvd / Scenic Blvd through the Hwy 89 intersection.

Table 2-2: Traffic Counts Along N Lake Powell Blvd

Location ID	3101
Located	SR-89L
Direction	2-Way
AADT	2,389
EB Count	625
WB Count	1,764

Table 2-3 shows the K, D and T factors from the ADOT Average Annual Daily Traffic Reports of 2020 for Hwy 89 in Page [4]. The K-factor is defined as the proportion of annual average daily traffic (AADT) occurring in an hour at the hour of highest traffic. This factor is used for designing and analyzing the flow of traffic on highways. K is generally highest near recreational facilities, next highest in rural and suburban areas, and lowest in urban areas. Maximum K-factors can be larger than 11%; areas with stable or consistent traffic flow have the lowest K-factors, which are usually less than 6%. For Highway 89, a K-factor of 9% indicates consistent and heavy flows for many hours of the day. This shows that the traffic flow observed in 2020 in the project area is relatively stable throughout the day. The project site is located in the city of Page, so this K-factor is reasonable.

The Directional factor (D-factor) is the ratio of traffic volume moving in the higher volume direction during the peak hour to the combined volume in both directions. It is usually expressed as a percentage. It represents the directional distribution of hourly traffic volumes [5]. D-factors for one-way roadways is always 100%. In some special situations such as road blockade, D-factor may be 0%. This means that there are no vehicles in the peak direction. For the project area, the D-factor is 52%. Hwy 89 has a large amount of traffic driving towards the city in the morning and far away from the city at night, so the directional flow is balanced. Directional distribution of traffic may significantly affect the LOS of a facility. Therefore, D-factor plays an important role in highway design by considering the directional split of traffic [5].

The T-factor represents the percentage of trucks on a daily basis. The value of T factor mainly depends on the pavement design of the road. The structural design of commercial traffic and civil traffic roads are different. Commercial roads can carry more trucks and thus have a higher T-factor. According to 2020 ADOT monitoring of similar highways, the T-factor can range from less than 4% to 45% [4]. For the project area, the T-factor is 6.4% which includes houseboat and trailer type vehicles. This means that the number of trucks passing the site every day is 6.4% of the total volume.

Table 2-3: K, D and T factor

Route	Start	End	K Factor (%)	D Factor (%)	T Factor (%)
US 89	Lake Powell Blvd (South Leg) - Page	Wahweap Rd and Visitor Center entrance	9	52	6.4

The Peak Hour Factor (PHF) compares the traffic volume during the busiest 15-minutes of the peak hour to the total volume during the peak hour [6]. Equation 2-1 shows the calculation of the PHF. The result of PHF should be between 0 to 1 and indicates how consistent traffic volume is during the peak hour. A higher PHF value illustrates consistent flow and a lower PHF value indicates more variable traffic flows. ADOT did not collect the hourly volume and four peak 15 minutes volume within the hour at the project intersection, which means the PHF for this site must be estimated. The PHF equation is listed below for reference. According to the 2010 Highway Capacity Manual (HCM), the default value of PHF for urban areas is 0.92 [7]. The PHF default values for urban and rural areas are included in Appendix A. This means there is a lot of traffic present, but the road is not overly congested. Based on the current performance of this intersection, it is estimated that this facility has a current level of service (LOS) of C because roadway users experience some delay with regards to time spent waiting.

Equation 2-1 Peak Hour Factor (PHF)

$$PHF = \frac{V}{4V_{peak}}$$

$$V = total\ hourly\ volume$$

$$V_{peak} = peak\ 15\ minutes\ volume\ within\ the\ hour$$

Table 2-4 shows the estimated turning movement counts based on the 2020 AADT. The counts are calculated based on the existing traffic count data. The table shows that 50-60% of north-south Hwy 89 traffic is through traffic, while 80-85% of east/west traffic is turning either north or south onto Hwy 89.

Table 2-4: Estimate of 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

Table 2-5 shows conservative estimates of turning movement counts for 2040, using the existing percentages. The 2040 future AADT volumes from ADOT [4] were used to make these estimates.

Table 2-5: 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

Table 2-6 shows the comparison between the current and future turning counts. In most cases, the volumes are almost nearly doubled except for EB Scenic View Rd, which is expected to increase by ~550% due to future urbanization along Scenic View Rd.

Table 2-6: Current and Future Turning Volumes

Approach	Movement	Current Volume	2040 Volume
NB US 89	Left	508	948
	Thru	2030	3791
	Right	846	1580
SB US 89	Left	1043	1973
	Thru	1738	3288
	Right	695	1315
WB N Lake Powell Blvd	Left	617	1210
	Thru	353	691
	Right	794	1555
EB Scenic View Rd	Left	250	1395
	Thru	94	523
	Right	281	1570

2.2 City Codes and Standards

The design must follow the Arizona Department of Transportation (ADOT) guidelines for roundabout designs along with the city of Page specifications for traffic design. The city codes for this project are as follows:

- ADOT Guidelines [8] pages 400-06 to 400-10 (design specifications for Arizona roadways and highways).
- The Coconino County Engineering Design and Construction manual [9] section 5.3.10 (refers back to the ADOT Guidelines).
- The ADOT Derivation Code of US 89 from South Lake Powell Blvd to North Lake Powell Blvd is 3 and the location ID is 102080 [4], which is a design related code.
- Subgrade materials are suitable as outlined in Section 203-3.03 (D) of the ADOT Construction Manual [10].
- The Aggregate Base shall be Class 2 and shall be as specified in Section 303 of the Standard Specifications, and Contracts and Specifications Stored Spec. “303SALV” [10].
- The tack coat shall be as specified in Section 404 of the Standard Specifications, and Contracts and Specifications Stored Spec. “404BITUM” [10].
- The asphaltic concrete shall be as specified in Section 409 of the Standard Specifications, and Contracts and Specifications Stored Spec. "409AGGR” [10].
- The fog coat shall be as specified in Section 404 of the Standard Specifications, and Contracts and Specifications Stored Spec. "404BITUM" [10].
- Materials sources shall be as specified in Contracts and Specifications Stored Specifications "1001MATL" and "104ENVIR" [10].
- Bedding materials shall meet the requirements of Section 501 of the specifications [10].
- The work under this Item consists of removing the existing bituminous pavement as specified in Section 202 of the Standard Specifications [10].

2.3 Survey Data

Existing topographic data helps with identifying elevations, grading, curb faces, edge of the pavement, roadway lane markings, existing bike lanes, nearby crosswalks, drainage structures, right-of-way constraints and roadway alignments. The survey data were obtained through US Topo Maps for America [11]. The term "US Topo" specifically refers to the quadrilateral topographic maps released in 2009 and later. These maps are modeled on the familiar 7.5-minute quadrilateral maps from 1947 to 1992. Many USGS websites can download US Topo maps for free, such as Map Locator on the USGS store, Topo View and the Geographic Names Information System (GNIS) [12]. Figure 2-1 below shows a topographic map of the surrounding area of the intersection of US-89 and N Lake Powell Blvd; the site intersection is indicated with a star. Figure 2-2 below shows a site-specific topographic map. The grey lines indicate 10’ contours.

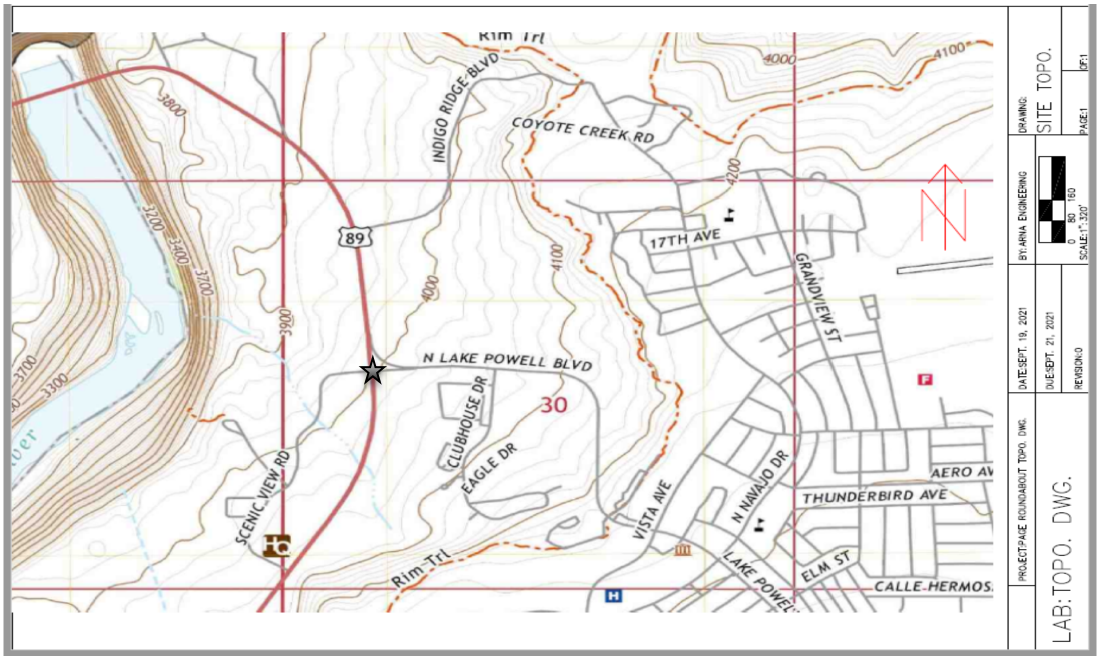


Figure 2-1: Topographic Map of Surrounding Area [12]

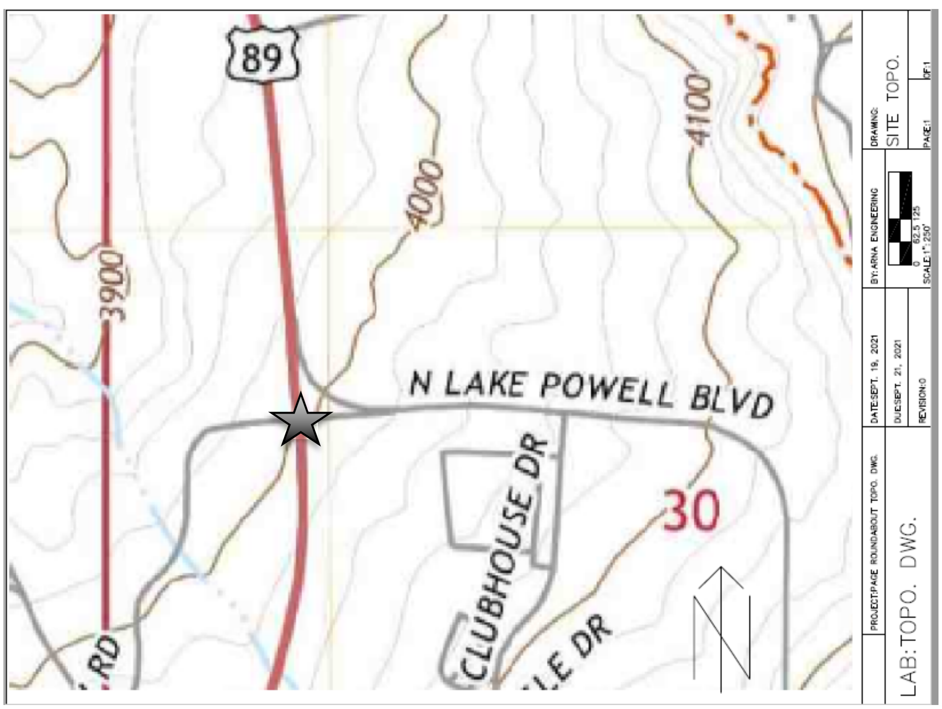


Figure 2-2: Site Specific Topographic Map

2.4 Geotechnical Data

An Earthwork Report for a roundabout design located on US 89 and Haul Road, about a mile south of the proposed roundabout site, was provided by the client. The report was prepared by Stanley Consultants Inc. in December of 2014. In the report, it states the common excavation, common embankment, drainage-related excavation, backfill required, and compaction information. A Materials Work Report was also provided by the client, prepared by Paul Burch on November 26, 2012 with the project number 12-77. Appendix B provides specific information of material report. The material report describes the material requirements for the main structural parts and material sources that constitute the roundabout. They include pavement structure, base, surface treatment, material sources and miscellaneous (temporary connections and detours, etc.). Please refer to Section 2.2 above for material standards.

Figure 2-3 illustrates the acceptable ranges for a subgrade material based on the soil's plasticity index and its percentage of soil passing through a No. 200 sieve. For this area, the percent of soil passing through a No. 200 sieve is 23% and the Plasticity Index is 10 [13]. The Plasticity Index indicates how fine the soil is and its capacity to change shape without altering volume [13].

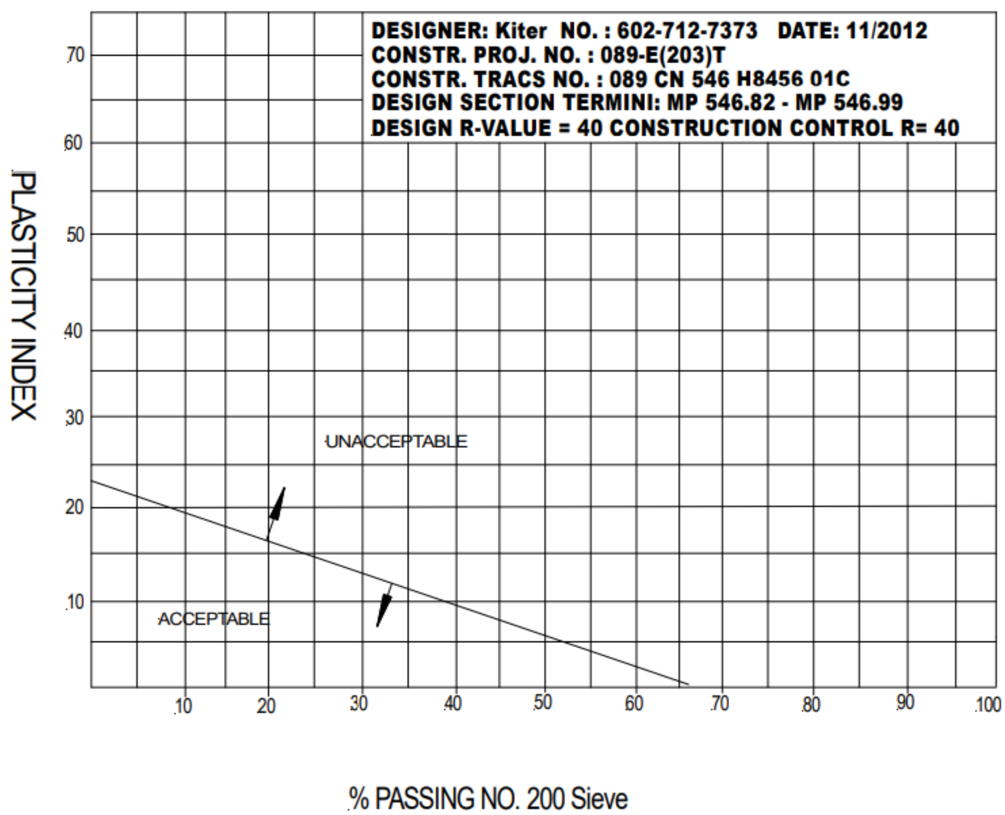


Figure 2-3: Subgrade Acceptance Chart

Table 2-6 shows that the site soils are a granular material because less than 35% is passing through a No. 200 sieve. With a plasticity index of 10, the soil falls in group A-2-4 or A-2-5 of the AASHTO soil classification system [13]. The soil types are silty or clayey gravel and sand. The subgrade's rank rating is good to excellent because the site's soil is composed of sand and silty or clayey gravel rather than medium to coarse gravel. This indicates that the local soils are suitable subgrade material.

Table 2-6: AASHTO Soil Classification System

General classification	Granular materials (35% or less of total sample passing No. 200 sieve)						
	A-1			A-2			
Group classification	**A-1-a**	**A-1-b**	**A-3**	**A-2-4**	**A-2-5**	**A-2-6**	**A-2-7**
Sieve analysis (% passing)							
No. 10 sieve	50 max						
No. 40 sieve	30 max	50 max	51 min				
No. 200 sieve	15 max	25 max	10 max	35 max	35 max	35 max	35 max
For fraction passing No. 40 sieve							
Liquid limit (LL)				40 max	41 min	40 max	41 min
Plasticity index (PI)	6 max		Nonplastic	10 max	10 max	11 min	11 min
Usual type of material	Stone fragments, gravel, and sand		Fine sand	Silty or clayey gravel and sand			
Subgrade rating	Excellent to good						

According to Table 2-7 below, the soils at the site have a hydraulic conductivity between $10^{-3} to\ 10^{-5}$ cm/s, so runoff will very slowly infiltrate into the soil at a rate of $10^{-3}\ to\ 10^{-5}$ cm/s.

Table 2-7: Range of Hydraulic Conductivity for Various Soil

Type of soil	Hydraulic conductivity, k (cm/s)
Medium to coarse gravel	Greater than 10^{-1}
Coarse to fine sand	10^{-1} to 10^{-3}
Fine sand, silty sand	10^{-3} to 10^{-5}
Silt, clayey silt, silty clay	10^{-4} to 10^{-6}
Clays	10^{-7} or less

Figure 2-4 shows the intersection for the proposed roundabout design along with an area of interest (AOI) that consists of the existing intersection and nearby native soil types. This area of interest was used to determine the soil type and soil classification.

Tables — AASHTO Group Classification (Surface) — Summary By Map Unit

Summary by Map Unit — Coconino County Area, Arizona, North Kaibab Part (AZ629)

Summary by Map Unit — Coconino County Area, Arizona, North Kaibab Part (AZ629)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
31	Needle-Sheppard complex, 2 to 12 percent slopes	A-2	0.6	12.7%
45	Sheppard loamy fine sand, 5 to 15 percent slopes	A-2	3.8	87.3%
Totals for Area of Interest			**4.3**	**100.0%**

Figure 2-4: Soil Unit Symbols [13]

Figure 2-4 shows the classification of map unit symbols 31 and 45.

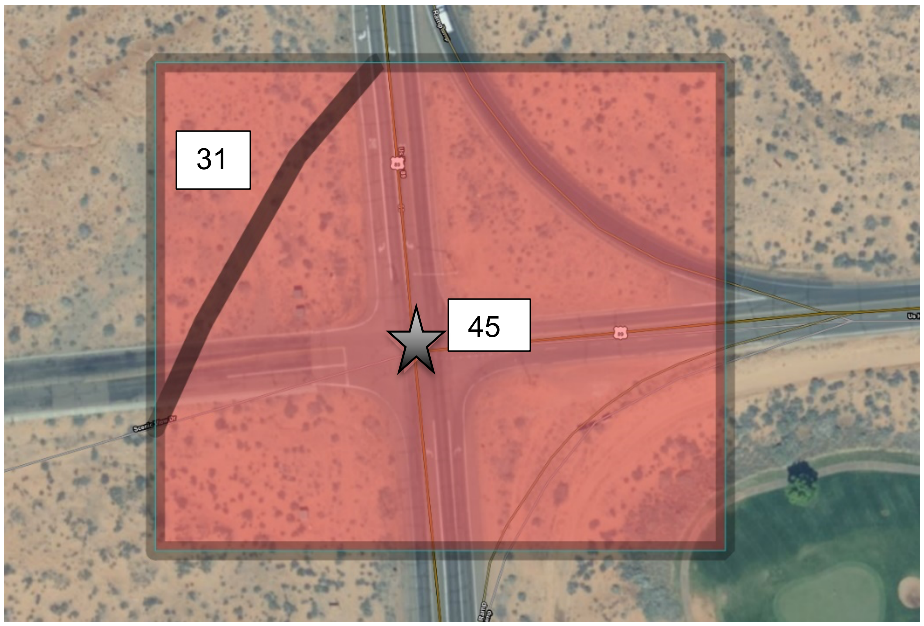


Figure 2-5: AOI Soil Sections [13]

The area of interest that is shown is labeled and divided into two different sections based on the different types of soil. The area marked 31 consists of a Needle-Shepard complex soil types, and represents only 13% of the AOI. The area marked 45 consists of a soil classification of Shepard Loamy fine sand and represents the majority of the area (87%). These data are generally consistent with the above AASHTO data.

3.0 Hydrology Assessment

3.1 Time of Concentration

Figure 3-1 shows a modified map of the watershed for the location surrounding the current intersection from USGS Stream Stats [12]. Most of the area within the yellow boundaries represents parks and foothills, which provide surfaces that allow water to infiltrate quickly. The green boudary represents a modified watershed that meets the 2014 ADOT Hydrology Manual's standards of analyzing a watershed less than 160 acres.

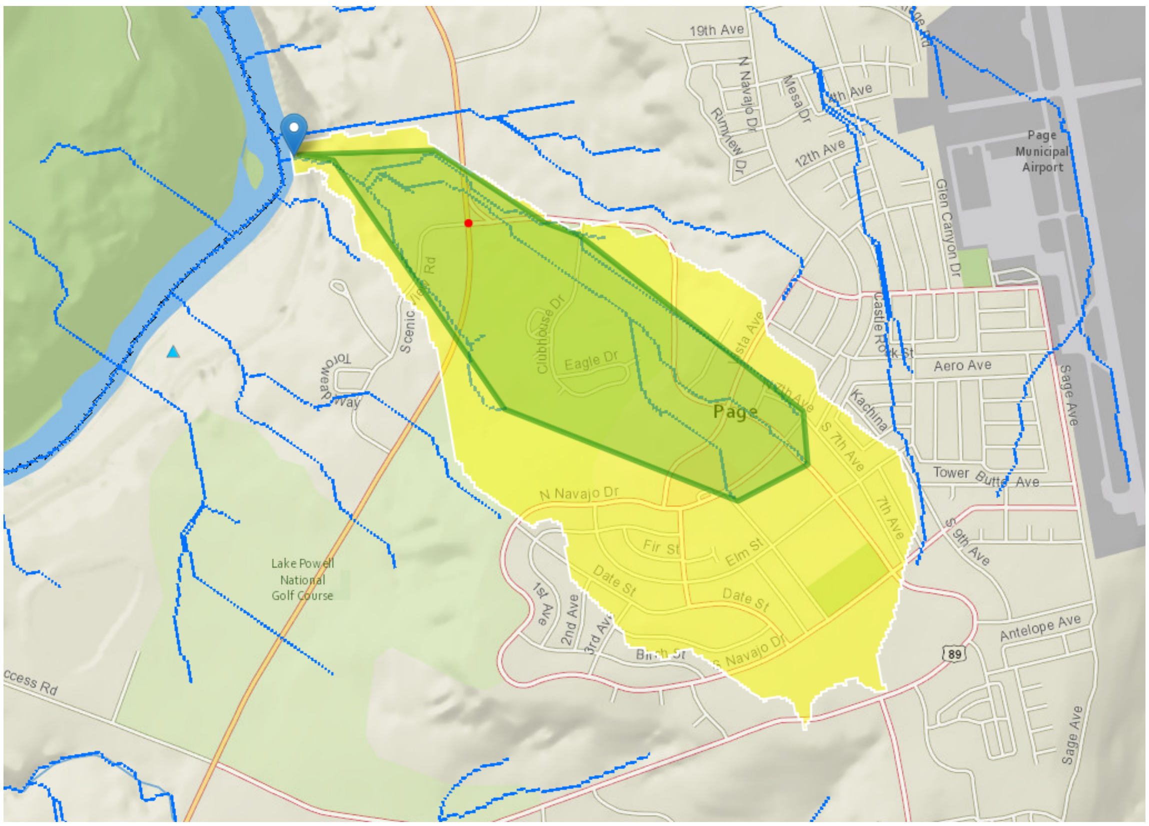


Figure 3-1: USGS Watershed

The time of concentration was determined using rainfall intensity values from the 10- and 100-year storm events. The time of concentration is defined as the time required for runoff to travel from the most hydraulically remote point of the watershed to the outlet. Equation 3-1 below is the time of concentration equation for the rational method from the 2014 ADOT Hydrology Manual [15]. The equation below utilizes an overall watershed coefficient and analyzes the longest flow path rather than various flow types. A watershed resistance coefficient of 0.20 was used to account for foothills and parks in the area that represents relatively smooth surfaces [8]. Table 3-1 shows the time of concentration for the 10- and 100-year storm events. A graphical representation of the precipitation frequency can be seen in Appendix C.

Equation 3-1: Time of Concentration

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

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

Table 3-1: Time of Concentration

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**

3.2 Weighted Runoff Coefficient

A weighted runoff coefficient was calculated that considered the different surface types within the watershed for the study intersection. The three significant surface types include streets, clay soils, and sandy soils. The runoff coefficients were found in the Coconino County Drainage Design Criteria Manual [16]. The runoff that forms in this watershed drains into the Colorado River located east of the US-89 and North Lake Powell Blvd Intersection. It was determined that stormwater is directed through culverts located on the North and South sides of the intersection, then drained into the Colorado River. The total weighted runoff coefficient was calculated using Equation 3-2, and can be seen in Table 3-2.

Equation 3-2: Weighted Runoff Coefficient

$$C_w = \frac{\Sigma C_i * A_i}{A_{tot}}$$

$$C_w = Area\ Weighted\ Runoff\ Coefficient$$
$$C_i = Runoff\ Coefficient\ for\ Specific\ Surface\ Type$$
$$A_i = Area\ of\ Specific\ Surface\ Type\ (acres)$$
$$A_{tot} = Total\ Area\ (acres)$$

Table 3-2: 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**

3.3 Runoff

The runoff or discharge was calculated using the rational method. 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 3-3 from the 2014 ADOT Hydrology Manual [15] was used to calculate runoff for the 10- and 100-year storm events. Table 3-3 shows the amount of discharge through the watershed.

Equation 3-3: Rational Equation

$$Q = C_w iA$$

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

Table 3-3: 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

Although no major changes will be seen at the intersection regarding hydraulic analysis, it’s recommended that the culverts be upgraded to the existing 18” diameter per Coconino County Drainage Design Manual Section 5.2.5.3.

4.0 Roundabout Design

4.1 Alternative Designs

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. Other 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. Relative flow is the percentage of vehicles entering and exiting certain approaches, similar to turning movement counts. The oncoming speed was set to 25 miles per hour and the roundabout speed was set to 15 miles per hour for each alternative.

The first alternative was a two-lane roundabout, with two lanes from each approach, and two right-turn slip lanes. One slip lane connects NB US 89 to EB Scenic View Road and the other existing slip lane connects WB N Lake Powell Boulevard to NB US 89 as seen in Figure 4-1 below. This alternative allows vehicles to completely bypass the roundabout if a right turn were to be made by the roadway user. The purpose of a slip lane is to reduce clutter, congestion, and relieve traffic within the roundabout for vehicles needing to make different turning movements. This alternative was created because of the projected high right turn traffic count from NB US 89 to EB Scenic View Rd, which is 1580 vehicles.

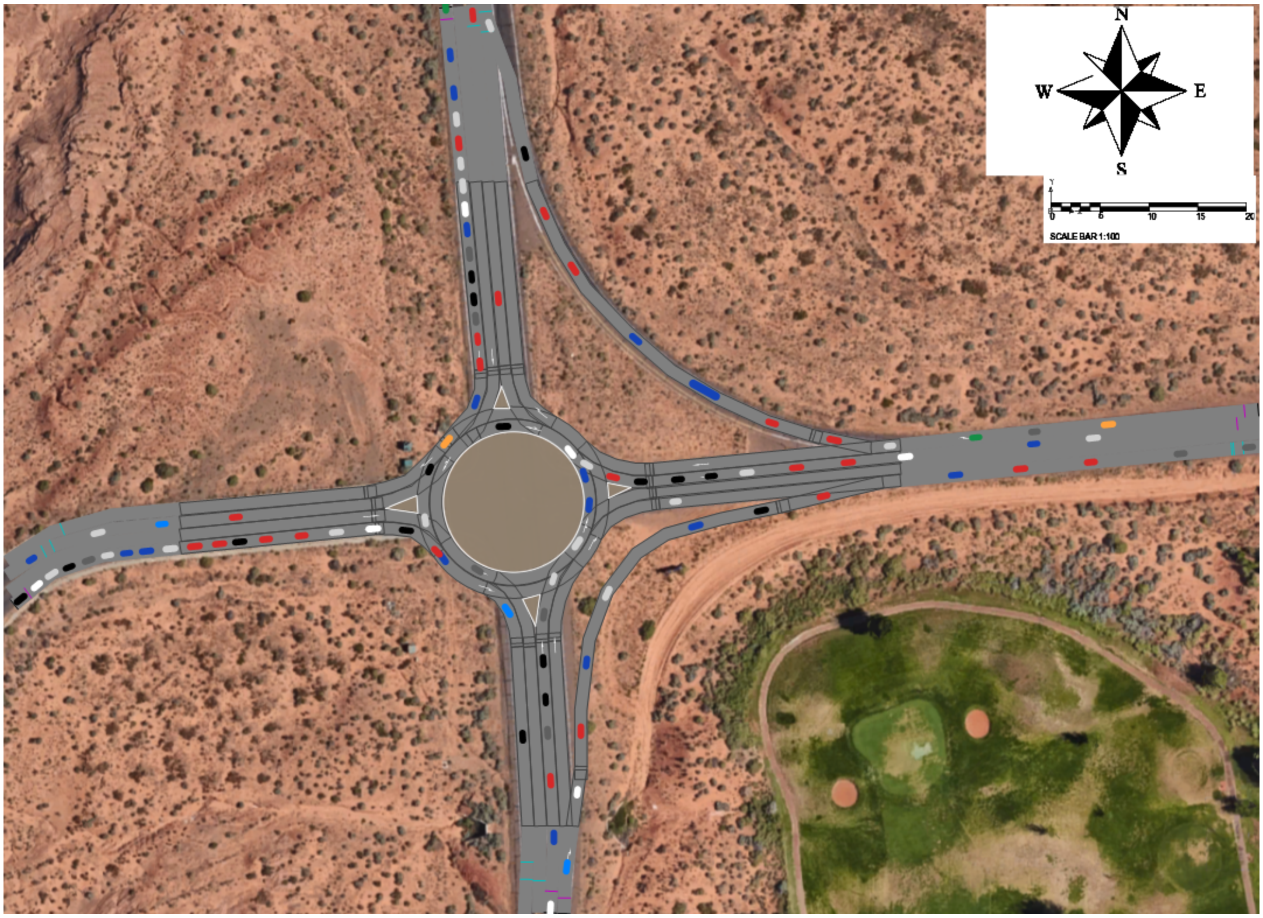


Figure 4-1: 2-Lane, 2-Slip Alternative

The second alternative was a two-lane roundabout, with two lanes from each approach, and the existing single right-turn slip lane. The one slip lane connects WB N Lake Powell Boulevard to NB US 89 as seen in figure 4-2 below. This alternative works similarly to the previous one, except that it doesn't handle the projected 20-year traffic volumes as well. Vehicles traveling on NB US 89 cannot bypass the roundabout due to the absence of a slip lane to EB Scenic View Road; therefore, the right lane approach coming from NB US 89 experiences quite a bit of congestion.

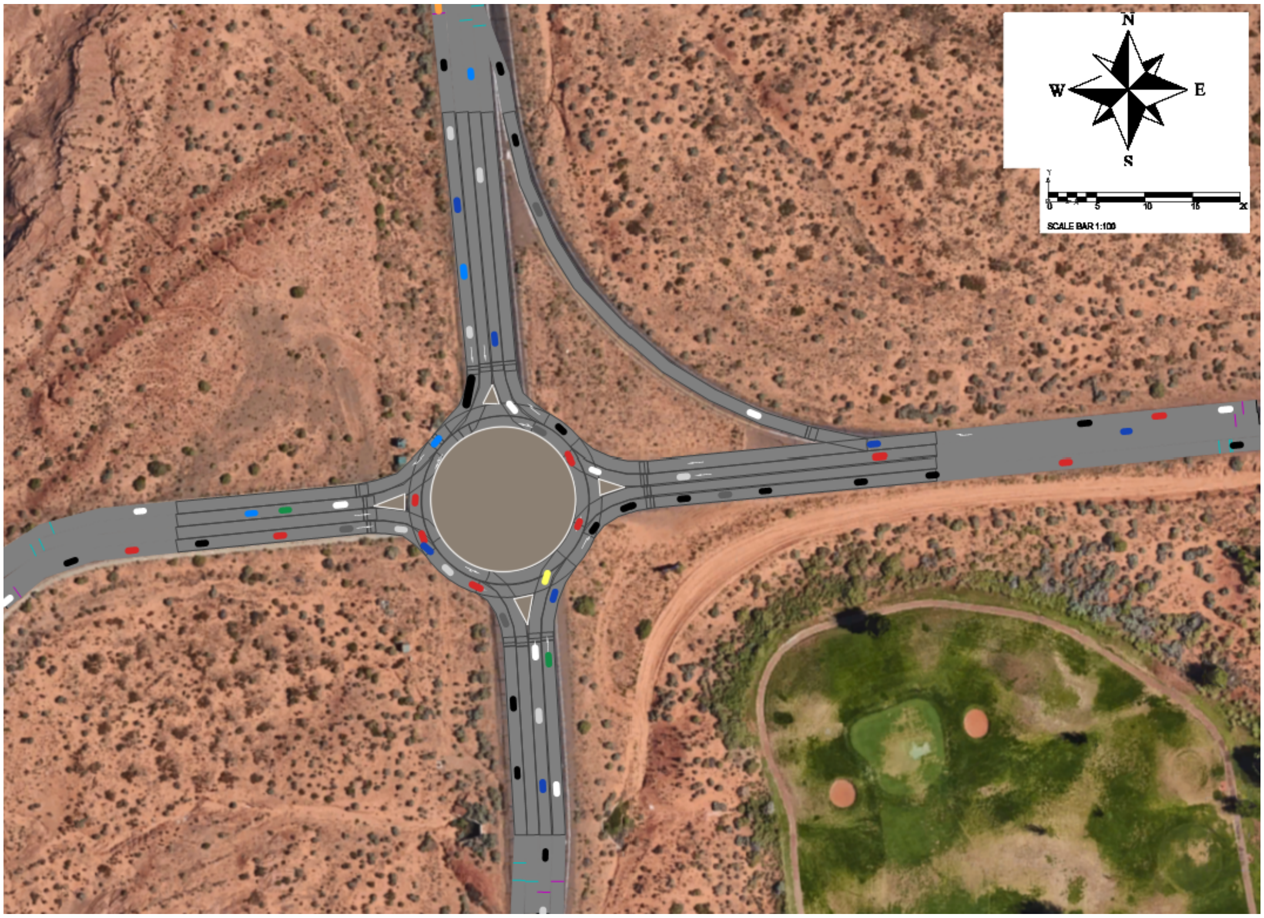


Figure 4-2: 2-Lane, 1-Slip Alternative

The third alternative was a single-lane roundabout, with one lane from each approach, and two right-turn slip lanes as in alternative one. Figure 4-3 below diagrams this alternative. This alternative was found to be problematic due to the fact that the projected 20-year traffic counts are exceptionally high. The approaches become very congested resulting in minimal movement within the roundabout itself.

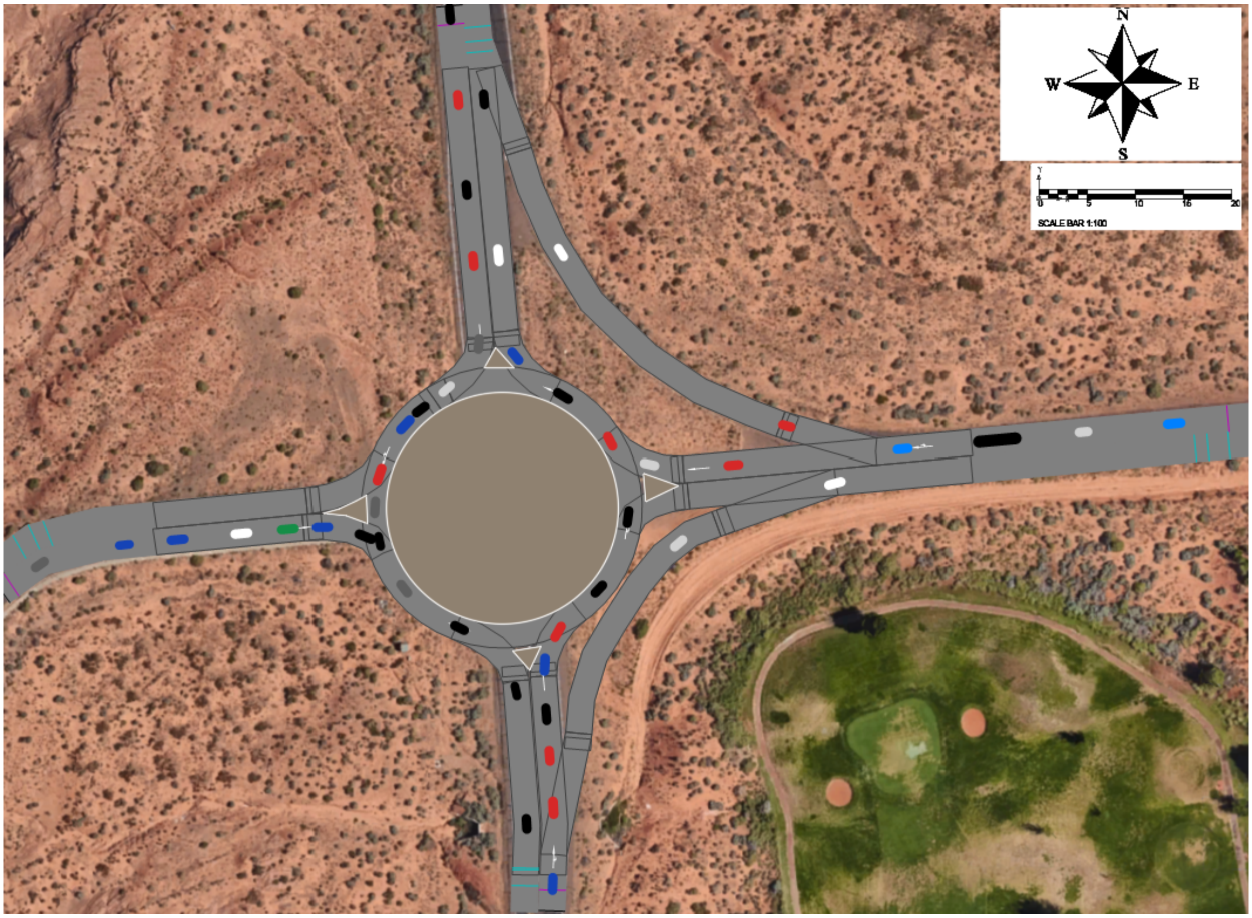


Figure 4-3: 1-Lane, 2-Slip Alternative

Table 4-1 shows the VISSIM results for each alternative. The overall LOS of Alternative 1 is A, Alternative 2 is A, and Alternative 3 is D. The table uses six colors to indicate the LOS results in each direction.

Table 4-1 Level of Service Comparison of Each Alternative

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	A	A	A
	Thru	B	B	F
	U	A	A	A
	Right	A	A	A
SB US 89	Left	B	D	F
	Thru	B	B	E
	U	A	A	A
	Right	A	B	E
WB N Lake Powell Blvd	Left	B	B	E
	Thru	B	B	D
	U	A	A	A
	Right	B	A	A
EB Scenic View Rd	Left	C	C	A
	Thru	C	A	F
	U	A	A	F
	Right	A	B	E
Overall LOS		**A**	**A**	**D**

4.2 Selection of Preferred Alternative

4.2.1 Design Criteria

Design criteria were developed to evaluate the three alternatives (2-Lane 2-Slip, 2-Lane 1-Slip, and 1-Lane 2-Slip). The design criteria were:

- Level of Service (LOS) – The survey and project background results show that Highway 89 is located on the edge of Page city with a mountainous terrain. According to the highway design guide of the Arizona Department of Transportation in 2021 [17], the level of service in this project area should range from LOS B to LOS D. LOS B indicates a reasonable free flow; LOS C is stable operation; LOS D is a lower range of stable flow. Please refer to Appendix E for the relationship between highway type and design level of service. Level of service results obtained by VISSIM were assigned scores for this design criteria category.
- Construction costs – This category only focuses on the actual construction cost. The existing slip lane from N Lake Powell Road to Highway 89 does not impact these costs. The scores for this design criteria category are as follows: roundabout design

cost, roundabout construction material cost (see Appendix B for materials that may be required), ornamental facilities cost and lighting equipment cost.

- Maintenance costs – Roundabouts typically have a slightly higher illumination power and maintenance cost compared to signalized or sign-controlled intersections due to a larger number of illumination poles. Roundabouts have slightly higher signing and pavement marking maintenance costs due to a higher number of signs and pavement markings. Roundabouts also introduce additional costs associated with the maintenance of any landscaping in and around the roundabout [18]. The criteria for assigning scores for this category are as follows: landscaping maintenance cost, lighting facility maintenance cost and pavement marking maintenance cost.

4.2.2 Decision Matrix

A decision matrix was developed to evaluate each design alternative and select the best one. Weighting factors and valuing scores were used to rank each alternative.

Weighting was established for each criteria category. The following weighting factors were assigned:

- Level of service (LOS) = 60
- Construction costs = 20
- Maintenance costs = 20

The reason for the 60-20-20 breakdown is because LOS plays a key role in determining whether the selected roundabout is suitable for current and future traffic volumes. LOS is the most important factor for the design; whereas, construction and maintenance costs are of less importance.

Table 4-2 below shows the average construction cost for each alternative. The number of lanes and slip lanes directly correlates to how expensive the construction and maintenance costs will be. If there is more asphalt and concrete being poured, the project will be more expensive to build and maintain. The scoring of the maintenance cost is also based on the total number of lanes and slip lanes. Fewer lanes require less manpower and material resources. The addition of slip lanes will increase these values as well.

Table 4-2 Roundabout Average Construction Cost [19]

Roundabout Type	Average Construction Cost
Single lane Roundabout	$464,137
Double-lane Roundabout	$1,977,270
Triple-lane Roundabout	$1,957,854

Table 4-3 below shows the criteria used to evaluate and score the alternatives.

Table 4-3 Modeling Values

Modeling Values	Overall 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

4.2.3 Decision Matrix Scoring

Table 4-4 below shows the results of the decision matrix.

Table 4-4 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

The recommended design alternative is alternative 2, the 2-lane, 1-slip lane alternative. This alternative preserves the auxiliary road from N Lake Powell Boulevard to NB US 89 and uses it as a slip lane for the roundabout. This alternative also improves the service level of vehicles turning left from SB US 89 into N Lake Powell Boulevard.

4.3 Final Roundabout Design

4.3.1 Roundabout Geometry

Figure 4-4 below shows a detailed drawing of the roundabout geometry. The lane widths are 12 feet, the truck apron is 50 feet, the inner island is 28.2 feet in diamter, and the entire diameter of the roundabout is 175 feet. The pavement section includes a 3-inch AC special mix and a 4-inch class 2 aggregate base. See Appendices F-1 through F-6 for the typical roadway cross sections and profile views.

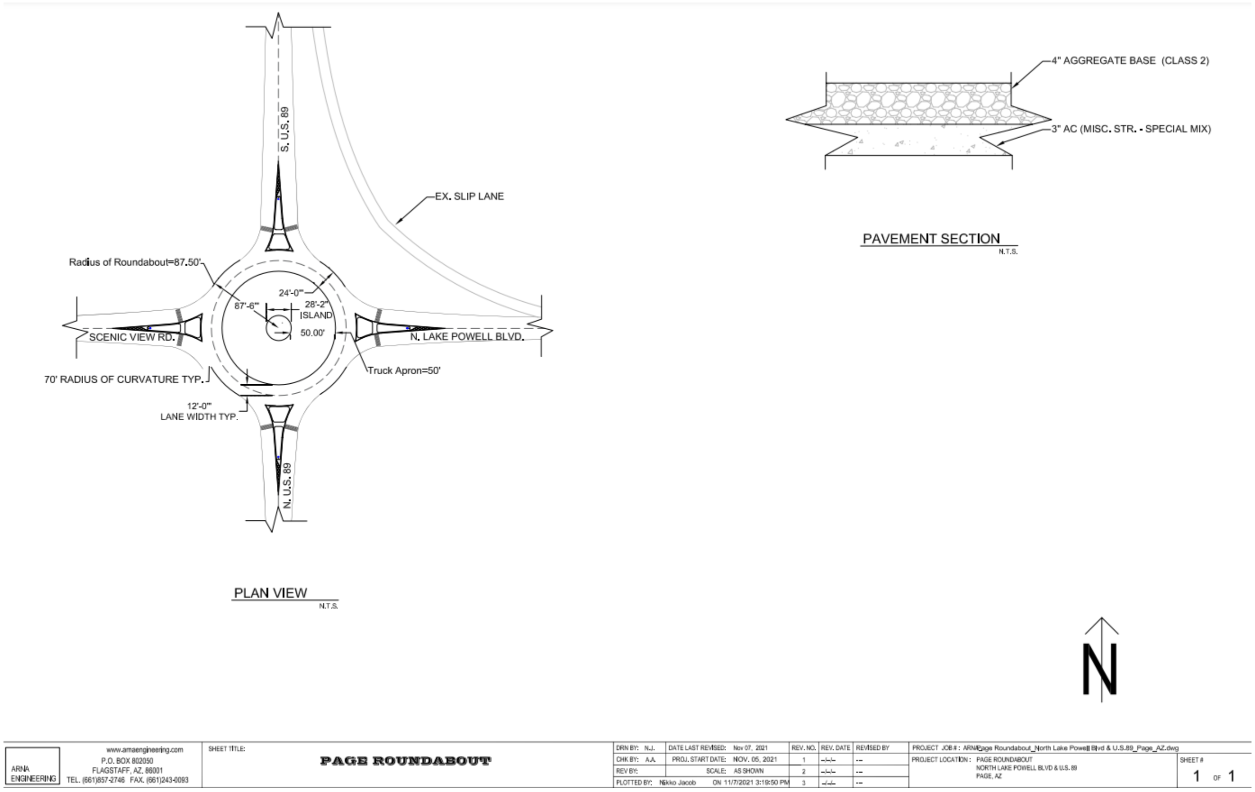


Figure 4-4: Roundabout Plan View

4.3.2 Stopping Sight Distance

Stopping sight distance (SSD) is defined as the necessary distance required on a roadway for the driver to perceive and react to an object in the roadway and to brake to a complete stop before hitting that object [20]. Roundabout SSD is calculated differently than intersection SSD. There are several assumed values that are used to determine the SSD. Equation 4-1 below from the National Cooperative Highway Research Program [20] was used to calculate the SSD for each approach where the perception-reaction time is assumed to be 2.5 seconds and driver acceleration is assumed to be 11.2 feet per second squared. Table 4-5 shows the required SSD for each approach of the roundabout.

Equation 4-1: Roundabout SSD

$$d = (1.468)(t)(V) + 1.087\left(\frac{V^2}{a}\right)$$

$$d = stopping\ sight\ distance\ (ft)$$

$$t = perception - reaction\ time\ (s)$$

$$V = initial\ speed\ (mph)$$

$$a = driver\ acceleration\ \left(\frac{ft}{s^2}\right)$$

Table 4-5 Stopping Sight Distance

Approach	$t\ (s)$	$a\ \left(\frac{ft}{s^2}\right)$	$V\ (mph)$	$d\ (ft)$
NB US 89	2.5	11.2	65	648.60
SB US 89	2.5	11.2	65	648.60
WB N Lake Powell Blvd	2.5	11.2	40	302.09
EB Scenic View Rd	2.5	11.2	40	302.09

This information is used in the design for spacing signage the correct distance away in the plan set. Since the stopping sight distance is 648.60 feet for the US 89 approaches, the signage will be placed approximately 1000 feet away from the entrance of the roundabout. Signage for the minor approaches will be placed approximately 500 feet away from the entrance of the roundabout.

4.3.3 Pedestrian and Bicycle Considerations

The pedestrian and bicycle considerations below in Figure 4-5 are considered for future development when they are needed. They are unnecessary at the moment but due to future urban development and increased traffic volumes, cross walks and bike lanes are considered for the overall layout. The basic layout for pedestrian and bicycle considerations includee a 6-foot sidewalk, 5-foot planter, and a 4-foot bike lane.

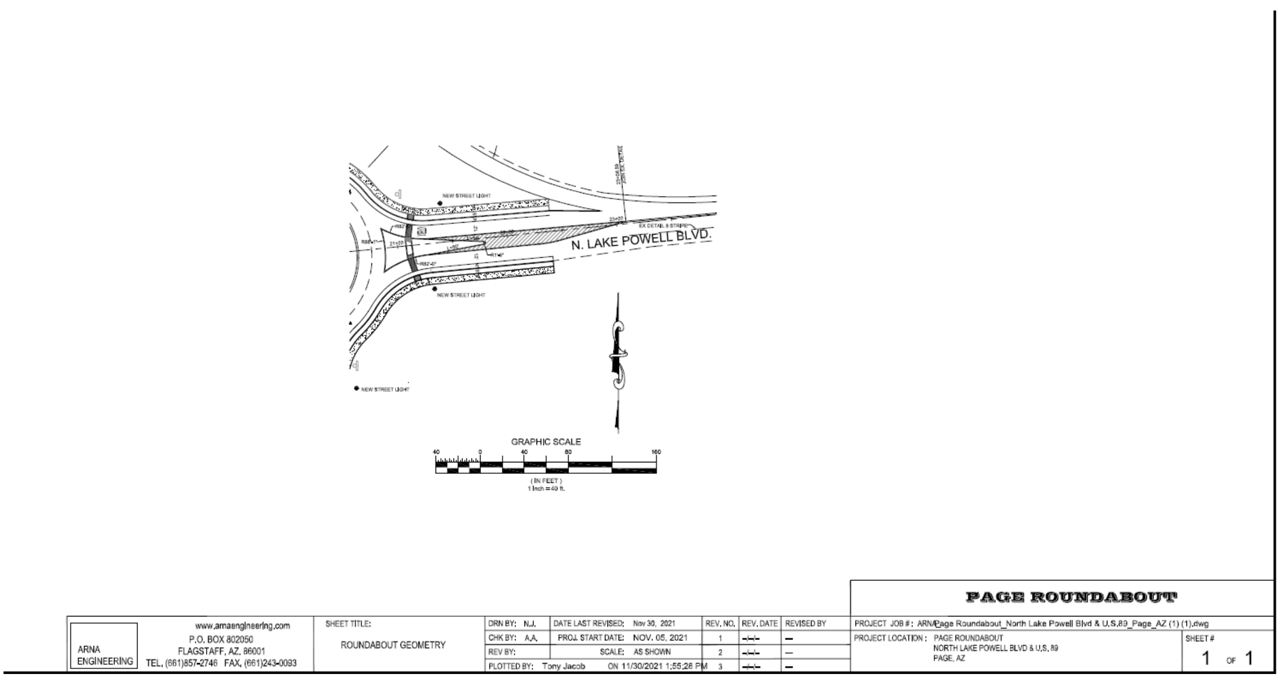


Figure 4-5: Pedestrian & Bicycle Considerations

4.4 Plan Set

A complete Plan Set has been created for the roundabout, and can be found in Appendix G.

5.0 Project Impacts

5.1 Social Impacts

The main short-term negative social impact is traffic disruption (wait times, congestion) and the safety of construction site personnel during construction Additionally, noise and dust will be generated during construction. This may have a negative impact on travelers and residents. The expected solution is to install barriers and dust mitigation such as daily watering.

Long-term social impacts are primarily positive, in that a roundabout is a traffic calming device used to slow down and control the flow of vehicles. Roundabouts are a great way to enhance public spaces, beautify streets, and create iconic gateways. The construction of the roundabout significantly reduces the speed of vehicles entering the intersection and reduces the damage to users after a collision because the speed is low enough. Additionally, for pedestrians, cyclists, and public transportation users, a roundabout is safer and helps to create a fair travel experience for all users.

5.2 Economic Impacts

For the expected project, the main short-term positive economic impact is the addition of local jobs. The main short-term negative economic impact is its initial construction, labor, and material costs. Taxpayers need to bear the initial construction and service costs of the project. Construction delays may affect tourism; however, this is unlikely.

From a long-term economic perspective, the roundabout will reduce commuting time of local residents and tourists and allow for improved traffic flow. This may result in a benefit of increased tourism and its related economic boost. Although it will take some time for the cost of the project to be recovered, the long-term economic benefits will offset the costs and create benefits. At the same time, reducing accidents means reducing users' economic losses and avoiding congestion on the entire road section due to accidents. This will not lead to a reduction in the efficiency of people's daily attendance and thus affect the economy.

5.3 Environmental Impacts

The primary long-term positive environmental impact of the roundabout is that there will be fewer emissions from idling vehicles. Slowing traffic may also reduce the negative consequences of wildlife-vehicle accidents.

The short-term negative environmental impacts of the project construction includes the removal of surrounding vegetation, dust emission and pollution from heavy equipment vehicles. With the construction of barriers and dust mitigation such as watering and nets, the negative impact of emission pollution and dust will be reduced. The loss of vegetation may cause soil erosion; erosion controls are required during construction to minimize erosion and contaminated runoff from the site. Vegetation will be planted at the central point of the island.

6.0 Summary of Engineering Work

This project consisted of designing a roundabout for Scenic View Rd and US89 in Page, Arizona. The current traffic layout of the intersection consists of the through traffic on US89 while the traffic travelling east and west through the intersection have stop signs. No field survey/mapping was performed for the project; a base was generated utilizing using Google Earth for vertical and horizontal alignment.

The project evaluated three different alternatives based on LOS, construction costs, and maintenance costs. The three alternatives consisted of a single-lane roundabout with two slip lanes, a double-lane roundabout with one slip lane, and a double-lane roundabout with two slip lanes. The preferred alternative that was selected for implementation was the double-lane roundabout with one slip lane that will cost approximately $1,500,000 to construct. A Plan Set was created for the preferred alternative. The prepared plans show existing intersection conditions, pavement limits, striping, as well as all signage, cross sections, grading, and profile section views for the designed roundabout.

7.0 Summary of Engineering Costs

The initial estimate for costs of engineering services for the Page Roundabout design project was $63,817. A breakdown of the original estimates is shown in Table 7-1.

Table 7-1: Original Staffing Costs

Positions	Classification	Rate/Hour	Quantity	Cost
[redacted]	Project Engineer (PE)	$180.00	103	$18,540
	Engineer in Training (EIT)	$125.00	177	$22,125
	Intern (INT)	$40.00	206	$8,240
[redacted]	Technician (TCN)	$95.00	134	$12,730

	Total			$61,635
Travel	**Classification**	**Rate/Mile**	**Miles**	**Cost**
	1 Vehicles, 1 Round Trip, 260 miles round trip	$0.57	260	$148
	Total			$148
Supplies	**Classification**	**Rate/Day**	**Days**	**Cost**
	Lab Access for 20 Days	$100.00	20	$2,000
	NAU Rental Vehicle	$34.00	1	$34
	Total			$2,034
Total Cost of Engineering Services				**$63,817**

The final costs for engineering services is shown in Table 7-2. The final cost was $39,513. Over the course of the project, the team lost an employee and didn't need to complete a site visit. So, with the combination of not requiring travel, accessing the traffic lab for five fewer days than anticipated, and losing an employee, the team completed the project under budget.

Table 7-2: Updated Staffing Costs

Positions	Classification	Rate/Hour	Quantity	Cost
	Project Engineer (PE)	$180.00	102.2	$18,396
	Engineer in Training (EIT)	$125.00	114.75	$14,344
	Technician (TCN)	$95.00	55.5	$5,273
	Total			$38,013
Supplies	**Classification**	**Rate/Day**	**Days**	**Cost**
	Lab Access for 20 Days	$100.00	15	$1,500
	Total			$1,500
Total Cost of Engineering Services				**$39,513**

8.0 Conclusion

In conclusion, ARNA Engineering evaluated three different options to implement a roundabout at the US-89 and N Lake Powell Blvd intersection due to delay and congestion around the area. The 2-Lane 1-Slip roundabout that was selected experiences a LOS of A with the projected 20-year traffic counts. This design will resolve traffic concflicts and lower the incidence of crashes overall.

9.0 References

[1] "Page, Arizona," [Online]. Available: https://en.wikipedia.org/wiki/Page,_Arizona. [Accessed 18 February 2021].

[2] "City of Page Small Area Transportation Study," 2007. [Online]. Available: https://cityofpage.org/images/planning_and_zoning/General-Information/Page-Transportation-Study.pdf. [Accessed 22 February 2021].

[3] "Transportation Data Management System," [Online]. Available: https://adot.public.ms2soft.com/tcds/tsearch.asp?loc=Adot&mod=TCDS. [Accessed 22 September 2021].

[4] ADOT, "Average Annual Daily Traffic Report 2020," 2020.

[5] FHWA, "Traffic Data Computation Method," 8 2018. [Online]. Available: https://www.fhwa.dot.gov/policyinformation/pubs/pl18027_traffic_data_pocket_guide.pdf. [Accessed 16 10 2021].

[6] Miovision, "Peak Hour Factor (PHF) Explained," 2020. [Online]. Available: https://help.miovision.com/s/article/Peak-Hour-Factor-PHF-Explained?language=en_US. [Accessed 16 10 2021].

[7] T. R. Board, "Highway Capacity Manual," 2010, p. 135.

[8] Azdot.gov, 2021.

[9] Coconino.az.gov, 2021. [Online]. Available: https://www.coconino.az.gov/DocumentCenter/View/25925/2021-Engineering-Design-and-Construction-Manual-EDCM?bidId=. [Accessed 9 September 2021].

[10] P. Burch, "Materials Design Letter," 26 11 2012. [Online]. Available: file:///C:/Users/Ruoxi%20Zhu/Downloads/H8456%20Materials%20Design%20Letter%20(1).pdf. [Accessed 16 10 2021].

[11] "US Topo: Maps for America," USGS.

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

[13] AASHTO, "Web Soil Survey," United States Department of Agriculture, 2016.

[14] J. F. H. a. G. Inc., "Highway Drainage Design Manual," AZDOT, 2014.

[15] "USGS Streamstats," usgs.gov, [Online]. Available: https://streamstats.usgs.gov/ss/.

[16] "Coconino County Drainage Design Criteria Manual," [Online]. Available: https://www.flagstaff.az.gov/DocumentCenter/View/58133/SWMgmtDesignManual-3-09?bidId=.

[17] A. D. o. Transportation, "Roadway Design Guidelines," ADOT, 1 2021. [Online]. Available: https://azdot.gov/sites/default/files/media/2021/01/2021-roadway-design-guidelines.pdf. [Accessed 17 10 2021].

[18] U. D. o. Transportion, "Roundabouts: An Informational Guide," FHWA, 6 2000. [Online]. Available: https://www.fhwa.dot.gov/publications/research/safety/00067/00067.pdf. [Accessed 17 10 2021].

[19] K. R. C. &. B. McIntosh, "Evaluating the performance and safety effectiveness of roundabouts," RC-1566, 2011.

[20] J. B. C. T. J. K. E. M. Lee Rodegerdts, "National Cooperative Highway Research Program," National Academy of Sciences, Washington, D.C., 2010.

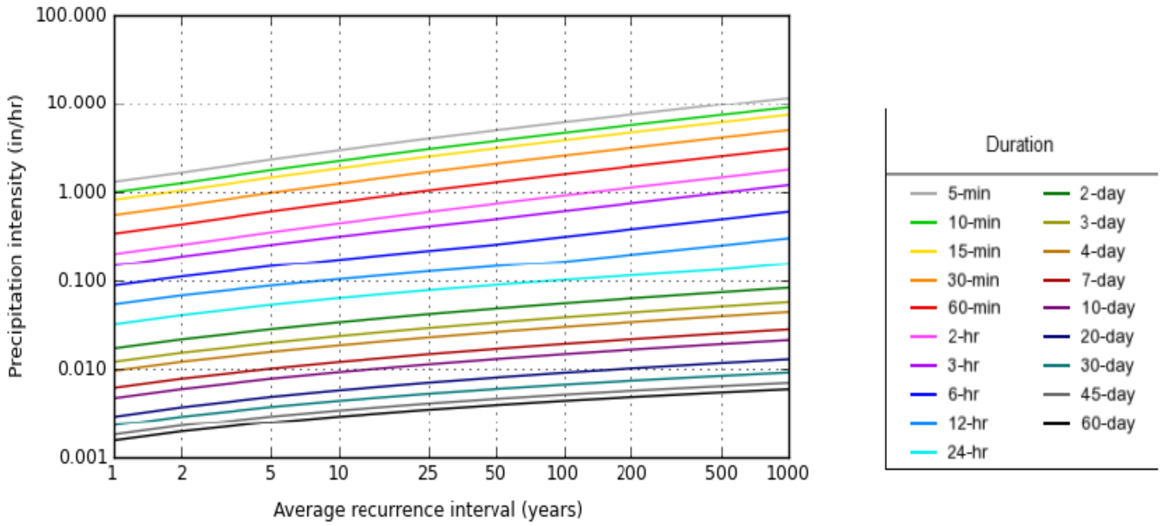
Appendix A: Typical Default Values for PHF

Factor	Area	
	Urban	Rural
PHF	0.92	0.88
K	0.09	0.10
D	0.60	0.60

Appendix B: Specific Information of the Project Material Report

Section	Item					
	1	2	3	4	5	6
Pavement Structure	Structural Thickness					
Subgrade, Subbases and bases	Subgrade Construction Control	Aggregate Base				
Surface Treatments and Pavements	Tack Coat	Asphaltic Concrete	Fog Coat			
Material Sources	Material Sources	Borrow Requirments	Earthwork Factors and Slopes	Ground Compaction	pH and Resistivity	Water
Miscellaneous	Temporary Connections and Detours	Bituminous Pavement Removal	Disposal of Existing Asphaltic Concrete			

Appendix C: PF Graphical



Appendix D-1: LOS Alternative 1

1 - 3: SB US 89@171.0 - 16: WB N Lake Powell Blvd@236.0	LOS_D
1 - 3: SB US 89@171.0 - 17: SB US 89@178.9	LOS_A
1 - 3: SB US 89@171.0 - 28: NB US 89@175.0	LOS_D
1 - 3: SB US 89@171.0 - 36: EB Scenic View Rd@180.0	LOS_A
1 - 4: SB US 89@171.0 - 15: WB N Lake Powell Blvd@239.2	LOS_A
1 - 4: SB US 89@171.0 - 18: SB US 89@180.0	LOS_A
1 - 4: SB US 89@171.0 - 27: NB US 89@175.0	LOS_A
1 - 4: SB US 89@171.0 - 35: EB Scenic View Rd@187.4	LOS_A
1 - 8: WB N Lake Powell Blvd@350.5 - 12: Slip Lane@383.0	LOS_A
1 - 8: WB N Lake Powell Blvd@350.5 - 16: WB N Lake Powell Blvd@2...	LOS_A
1 - 8: WB N Lake Powell Blvd@350.5 - 17: SB US 89@178.9	LOS_A
1 - 8: WB N Lake Powell Blvd@350.5 - 28: NB US 89@175.0	LOS_A
1 - 8: WB N Lake Powell Blvd@350.5 - 36: EB Scenic View Rd@180.0	LOS_A
1 - 9: WB N Lake Powell Blvd@352.6 - 15: WB N Lake Powell Blvd@2...	LOS_A
1 - 9: WB N Lake Powell Blvd@352.6 - 18: SB US 89@180.0	LOS_A
1 - 9: WB N Lake Powell Blvd@352.6 - 27: NB US 89@175.0	LOS_C
1 - 9: WB N Lake Powell Blvd@352.6 - 35: EB Scenic View Rd@187.4	LOS_C
1 - 21: NB US 89@85.9 - 16: WB N Lake Powell Blvd@236.0	LOS_A
1 - 21: NB US 89@85.9 - 17: SB US 89@178.9	LOS_A
1 - 21: NB US 89@85.9 - 28: NB US 89@175.0	LOS_A
1 - 21: NB US 89@85.9 - 36: EB Scenic View Rd@180.0	LOS_A
1 - 22: NB US 89@84.9 - 15: WB N Lake Powell Blvd@239.2	LOS_A
1 - 22: NB US 89@84.9 - 18: SB US 89@180.0	LOS_C
1 - 22: NB US 89@84.9 - 27: NB US 89@175.0	LOS_A
1 - 22: NB US 89@84.9 - 35: EB Scenic View Rd@187.4	LOS_A
1 - 29: EB Scenic View Rd@176.5 - 16: WB N Lake Powell Blvd@236.0	LOS_D
1 - 29: EB Scenic View Rd@176.5 - 17: SB US 89@178.9	LOS_E
1 - 29: EB Scenic View Rd@176.5 - 28: NB US 89@175.0	LOS_A
1 - 29: EB Scenic View Rd@176.5 - 36: EB Scenic View Rd@180.0	LOS_A
1 - 30: EB Scenic View Rd@179.8 - 15: WB N Lake Powell Blvd@239.2	LOS_A
1 - 30: EB Scenic View Rd@179.8 - 18: SB US 89@180.0	LOS_A
1 - 30: EB Scenic View Rd@179.8 - 27: NB US 89@175.0	LOS_A
1 - 30: EB Scenic View Rd@179.8 - 35: EB Scenic View Rd@187.4	LOS_A
1 - 10021: Slip Lane@52.8 - 16: WB N Lake Powell Blvd@236.0	LOS_A

Appendix D-2: LOS Alternative 2

1 - 3: SB US 89@108.0 - 16: WB N Lake Powell Blvd@274.5	LOS_E
1 - 3: SB US 89@108.0 - 17: SB US 89@241.9	LOS_A
1 - 3: SB US 89@108.0 - 28: NB US 89@183.1	LOS_D
1 - 3: SB US 89@108.0 - 36: EB Scenic View Rd@174.1	LOS_C
1 - 4: SB US 89@108.0 - 15: WB N Lake Powell Blvd@277.8	LOS_A
1 - 4: SB US 89@108.0 - 18: SB US 89@242.9	LOS_A
1 - 4: SB US 89@108.0 - 27: NB US 89@183.0	LOS_A
1 - 4: SB US 89@108.0 - 35: EB Scenic View Rd@181.4	LOS_A
1 - 8: WB N Lake Powell Blvd@311.9 - 12: Slip Lane@447.5	LOS_A
1 - 8: WB N Lake Powell Blvd@311.9 - 16: WB N Lake Powell Blvd@2...	LOS_A
1 - 8: WB N Lake Powell Blvd@311.9 - 17: SB US 89@241.9	LOS_A
1 - 8: WB N Lake Powell Blvd@311.9 - 28: NB US 89@183.1	LOS_A
1 - 8: WB N Lake Powell Blvd@311.9 - 36: EB Scenic View Rd@174.1	LOS_A
1 - 9: WB N Lake Powell Blvd@314.0 - 15: WB N Lake Powell Blvd@2...	LOS_A
1 - 9: WB N Lake Powell Blvd@314.0 - 18: SB US 89@242.9	LOS_A
1 - 9: WB N Lake Powell Blvd@314.0 - 27: NB US 89@183.0	LOS_B
1 - 9: WB N Lake Powell Blvd@314.0 - 35: EB Scenic View Rd@181.4	LOS_C
1 - 21: NB US 89@77.8 - 16: WB N Lake Powell Blvd@274.5	LOS_A
1 - 21: NB US 89@77.8 - 17: SB US 89@241.9	LOS_A
1 - 21: NB US 89@77.8 - 28: NB US 89@183.1	LOS_A
1 - 21: NB US 89@77.8 - 36: EB Scenic View Rd@174.1	LOS_A
1 - 22: NB US 89@76.8 - 15: WB N Lake Powell Blvd@277.8	LOS_A
1 - 22: NB US 89@76.8 - 18: SB US 89@242.9	LOS_C
1 - 22: NB US 89@76.8 - 27: NB US 89@183.0	LOS_A
1 - 22: NB US 89@76.8 - 35: EB Scenic View Rd@181.4	LOS_A
1 - 29: EB Scenic View Rd@182.5 - 16: WB N Lake Powell Blvd@274.5	LOS_A
1 - 29: EB Scenic View Rd@182.5 - 17: SB US 89@241.9	LOS_E
1 - 29: EB Scenic View Rd@182.5 - 28: NB US 89@183.1	LOS_D
1 - 29: EB Scenic View Rd@182.5 - 36: EB Scenic View Rd@174.1	LOS_A
1 - 30: EB Scenic View Rd@185.8 - 15: WB N Lake Powell Blvd@277.8	LOS_A
1 - 30: EB Scenic View Rd@185.8 - 18: SB US 89@242.9	LOS_A
1 - 30: EB Scenic View Rd@185.8 - 27: NB US 89@183.0	LOS_A
1 - 30: EB Scenic View Rd@185.8 - 35: EB Scenic View Rd@181.4	LOS_A

Appendix D-3: LOS Alternative 3

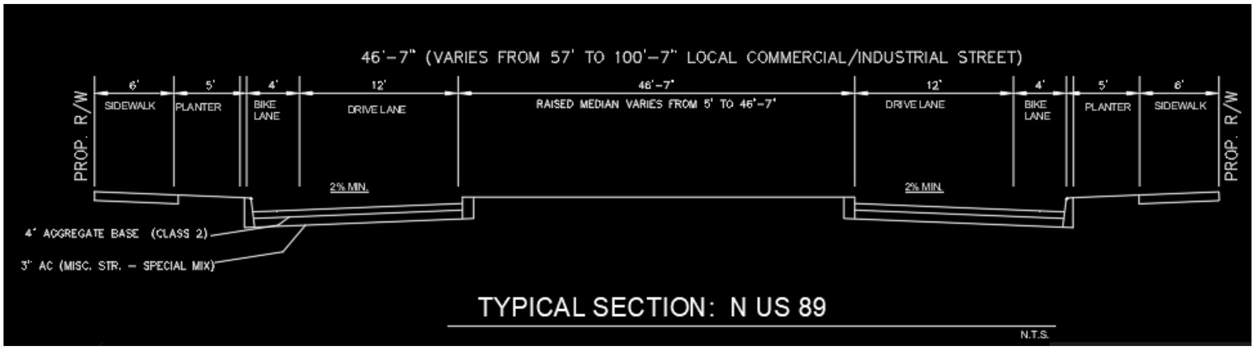
1 - 2: NB US 89@25.0 - 13: SB US 89@104.5	LOS_F
1 - 2: NB US 89@25.0 - 14: WB N Lake Powell Blvd@194.8	LOS_A
1 - 2: NB US 89@25.0 - 19: NB US 89@133.9	LOS_A
1 - 2: NB US 89@25.0 - 20: SB US 89@181.8	LOS_A
1 - 4: WB N Lake Powell Blvd@192.8 - 13: SB US 89@104.5	LOS_E
1 - 4: WB N Lake Powell Blvd@192.8 - 14: WB N Lake Powell Blvd@1...	LOS_A
1 - 4: WB N Lake Powell Blvd@192.8 - 19: NB US 89@133.9	LOS_D
1 - 4: WB N Lake Powell Blvd@192.8 - 20: SB US 89@181.8	LOS_A
1 - 4: WB N Lake Powell Blvd@192.8 - 10012: SB US 89@60.8	LOS_E
1 - 5: SB US 89@43.3 - 13: SB US 89@104.5	LOS_F
1 - 5: SB US 89@43.3 - 14: WB N Lake Powell Blvd@194.8	LOS_F
1 - 5: SB US 89@43.3 - 19: NB US 89@133.9	LOS_E
1 - 5: SB US 89@43.3 - 20: SB US 89@181.8	LOS_A
1 - 8: EB Scenic View Rd@113.6 - 13: SB US 89@104.5	LOS_A
1 - 8: EB Scenic View Rd@113.6 - 14: WB N Lake Powell Blvd@194.8	LOS_F
1 - 8: EB Scenic View Rd@113.6 - 19: NB US 89@133.9	LOS_E
1 - 8: EB Scenic View Rd@113.6 - 20: SB US 89@181.8	LOS_F

Appendix E: Design LOS

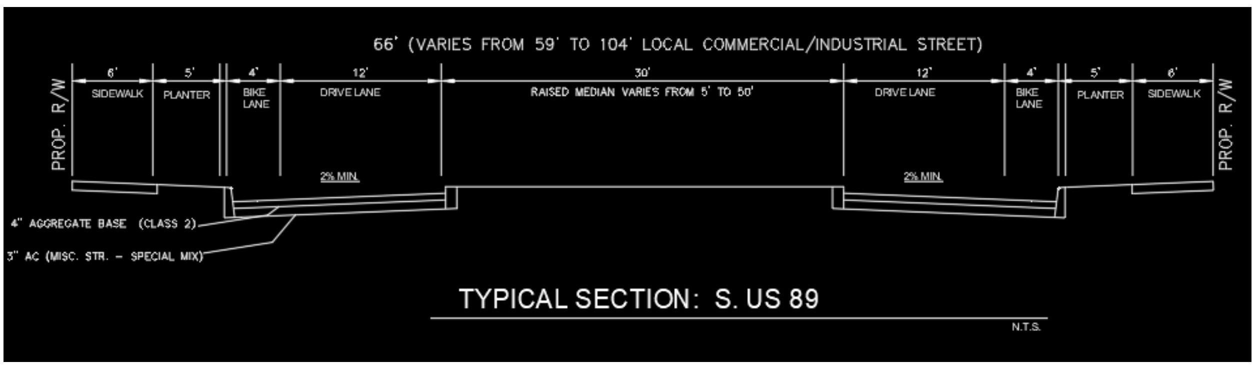
Relation of Highway Type to Design Levels of Service

Highway Type	Design Levels of Service
Controlled-Access Highways	
Level Terrain	B
Rolling Terrain	B
Mountainous Terrain	B – C
Urban/Fringe Urban Areas	C – D
Rural Highways	
Level Terrain	B
Rolling Terrain	B
Mountainous Terrain	B – C
Urban/Fringe Urban Highways	C – D*

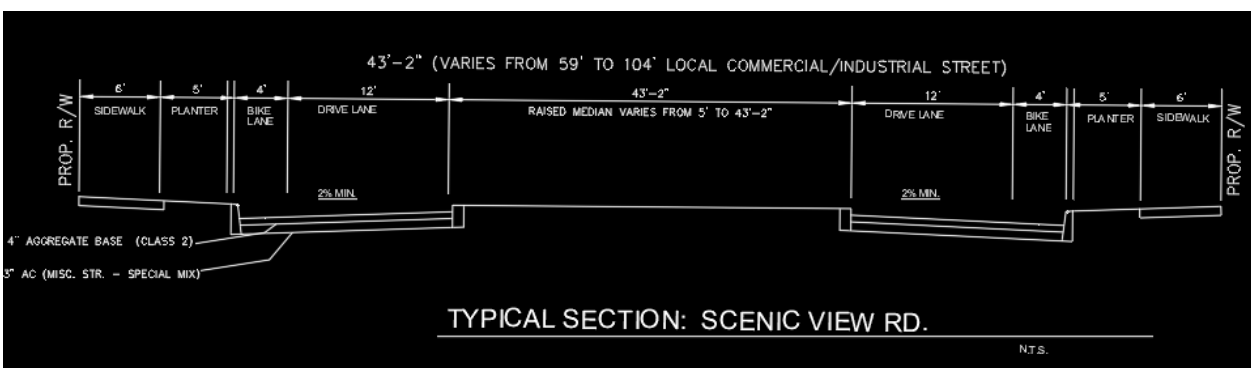
Appendix F-1: NB US 89 X-Section



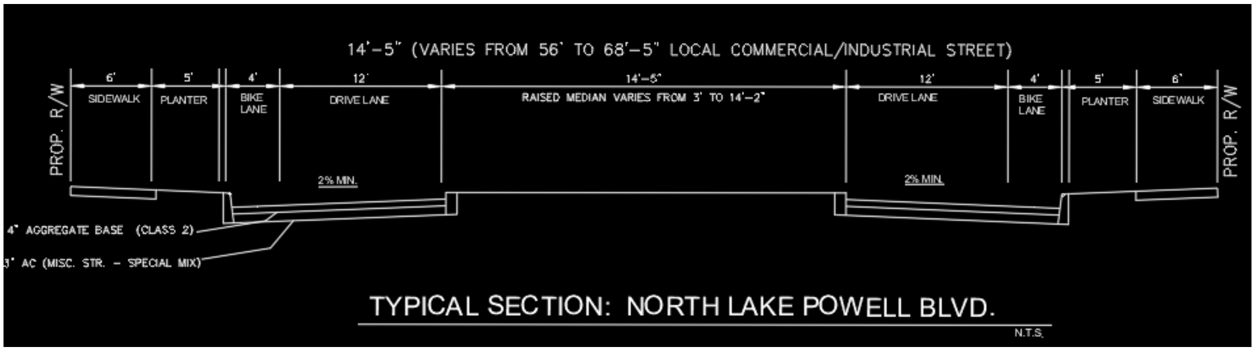
Appendix F-2: SB US 89 X-Section



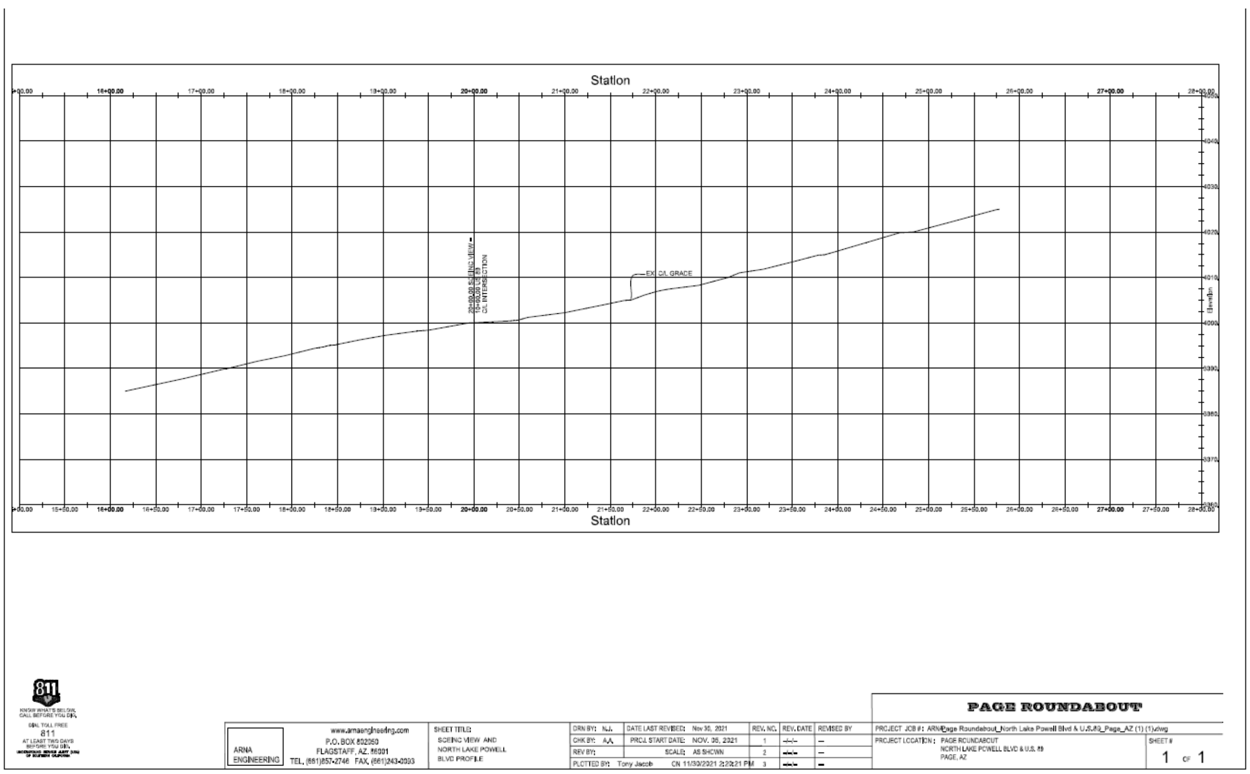
Appendix F-3: Scenic View Rd X-Section



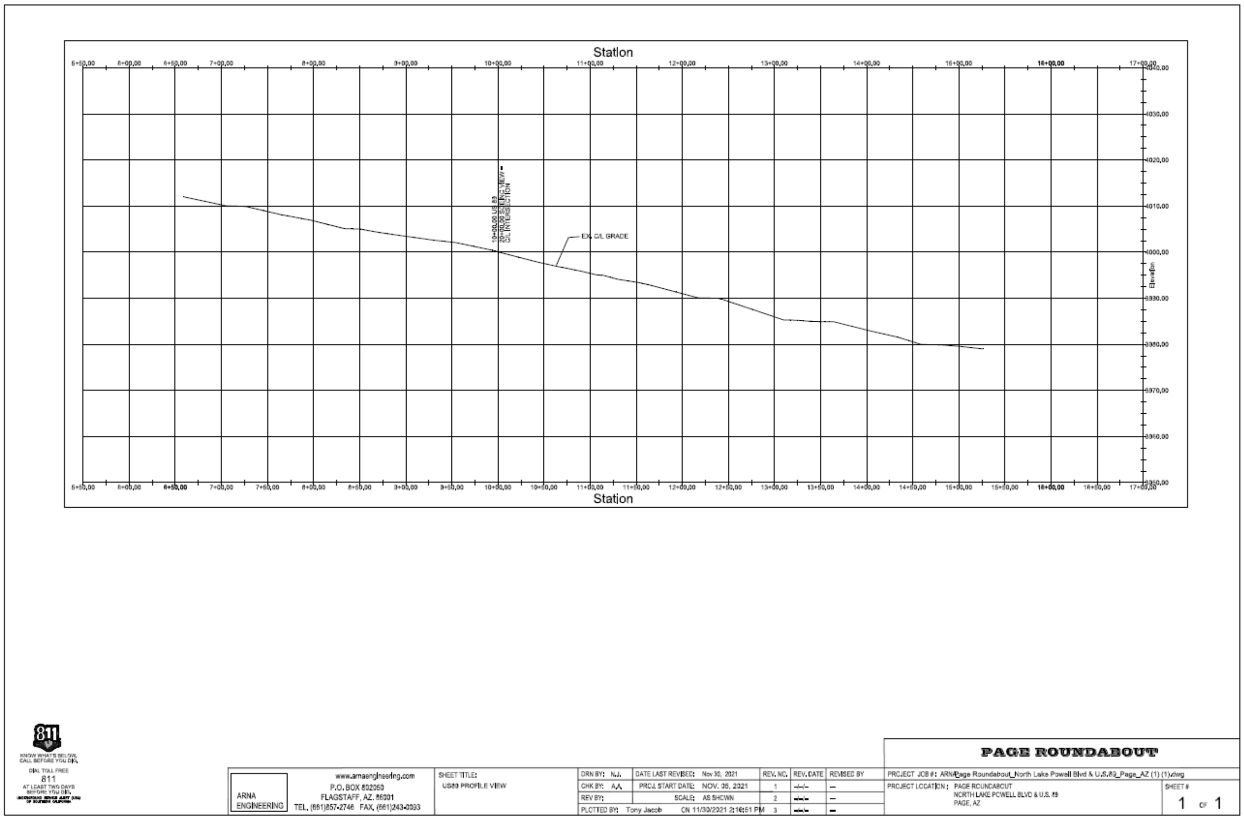
Appendix F-4: N Lake Powell Blvd X-Section



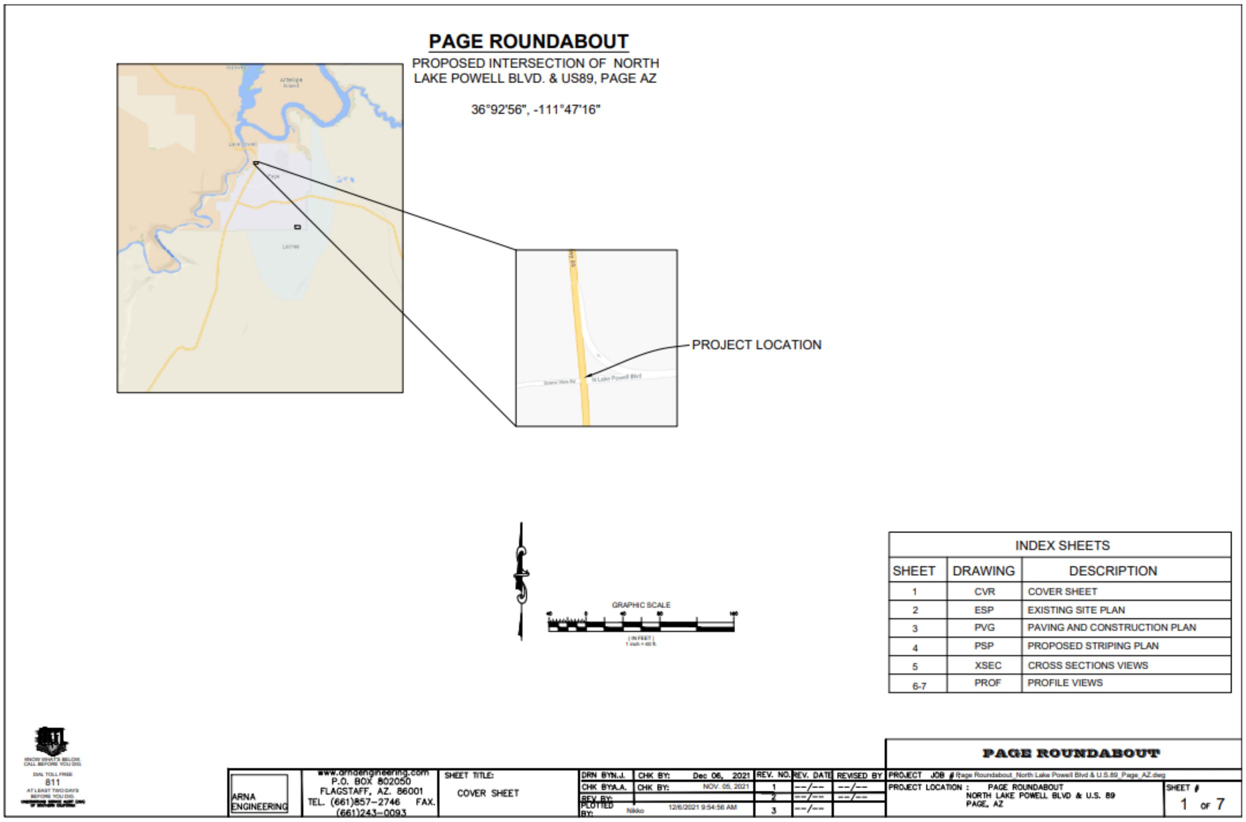
Appendix F-5: Scenic View Rd & N Lake Powell Blvd Profile View

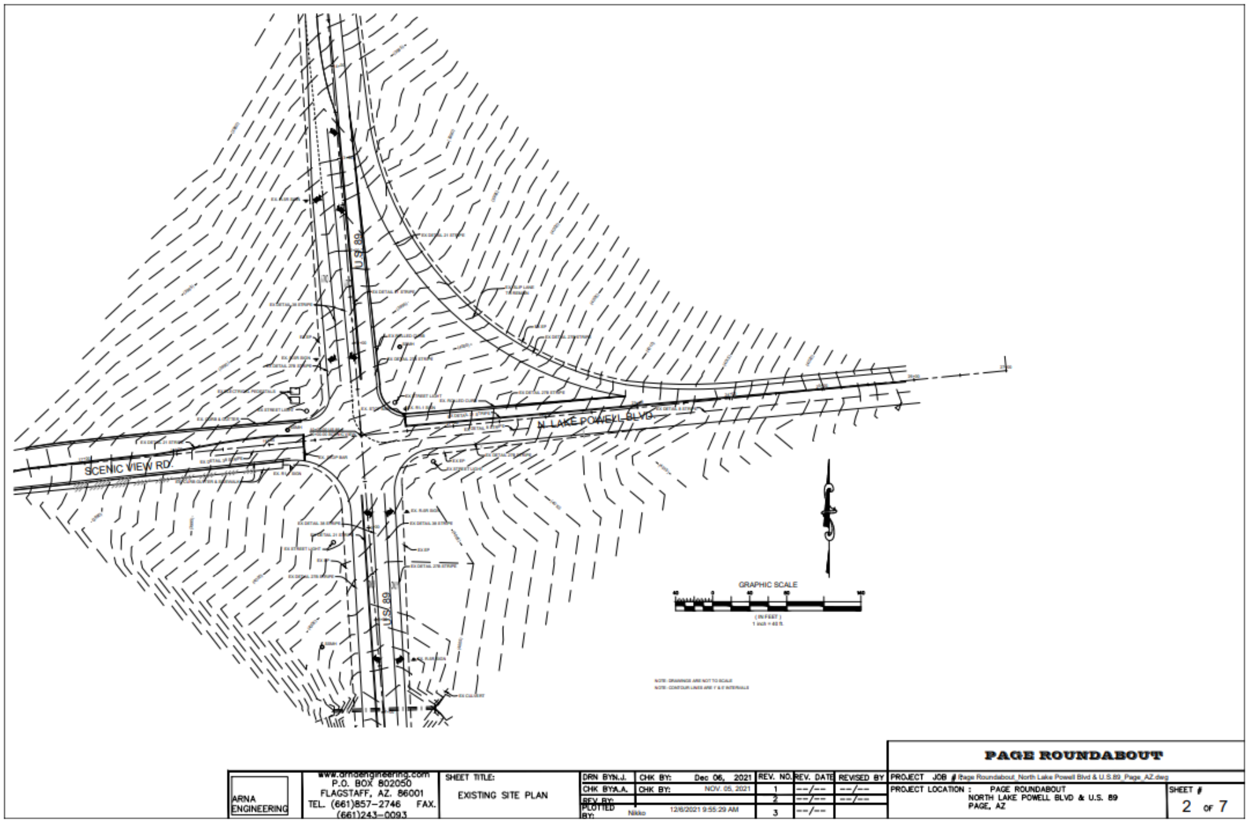


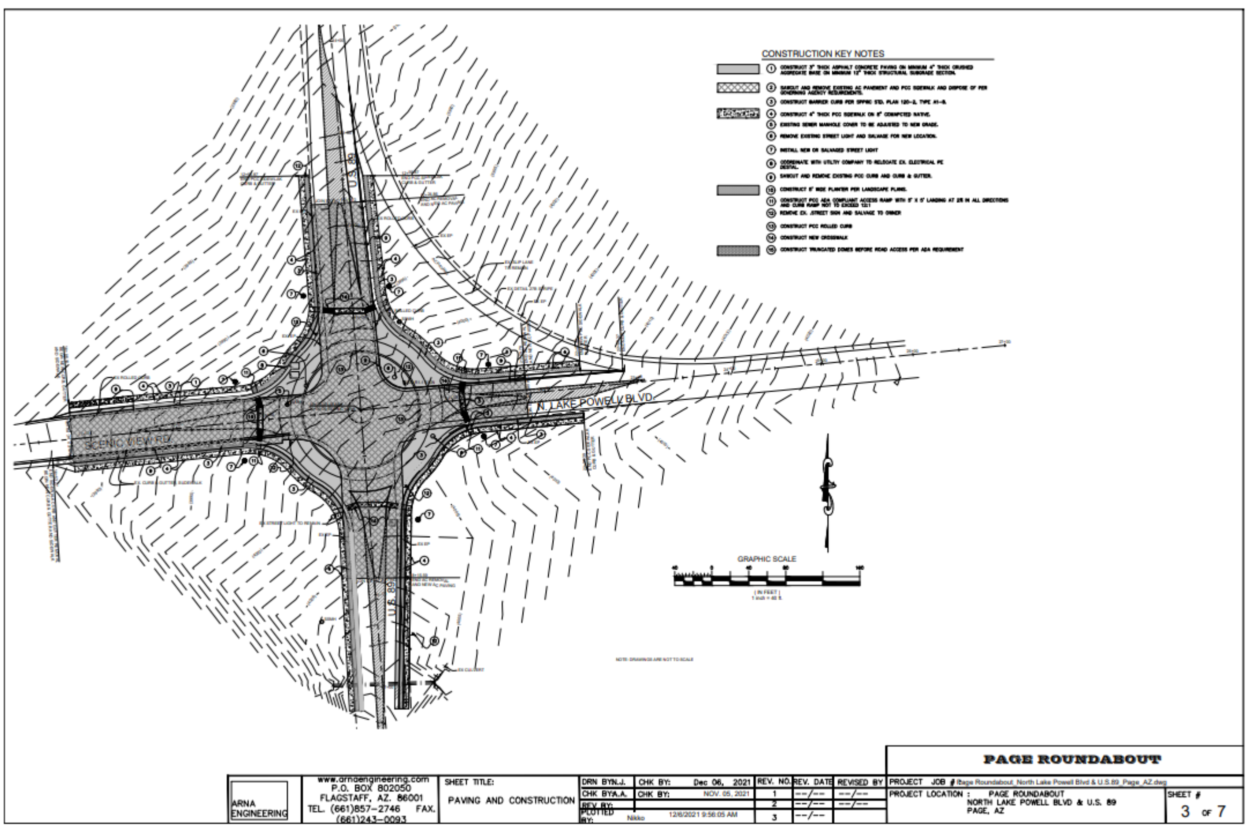
Appendix F-6: US 89 Profile View

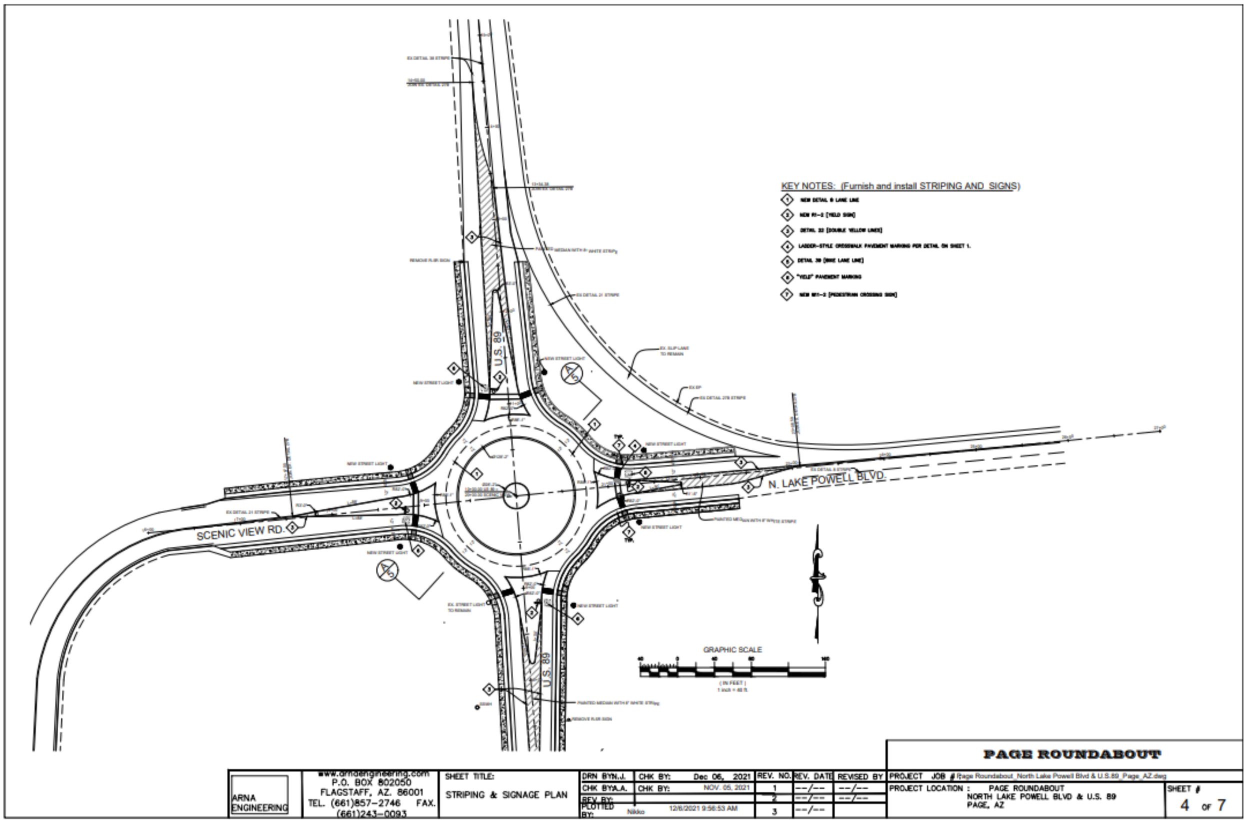


Appendix G: Plan Set

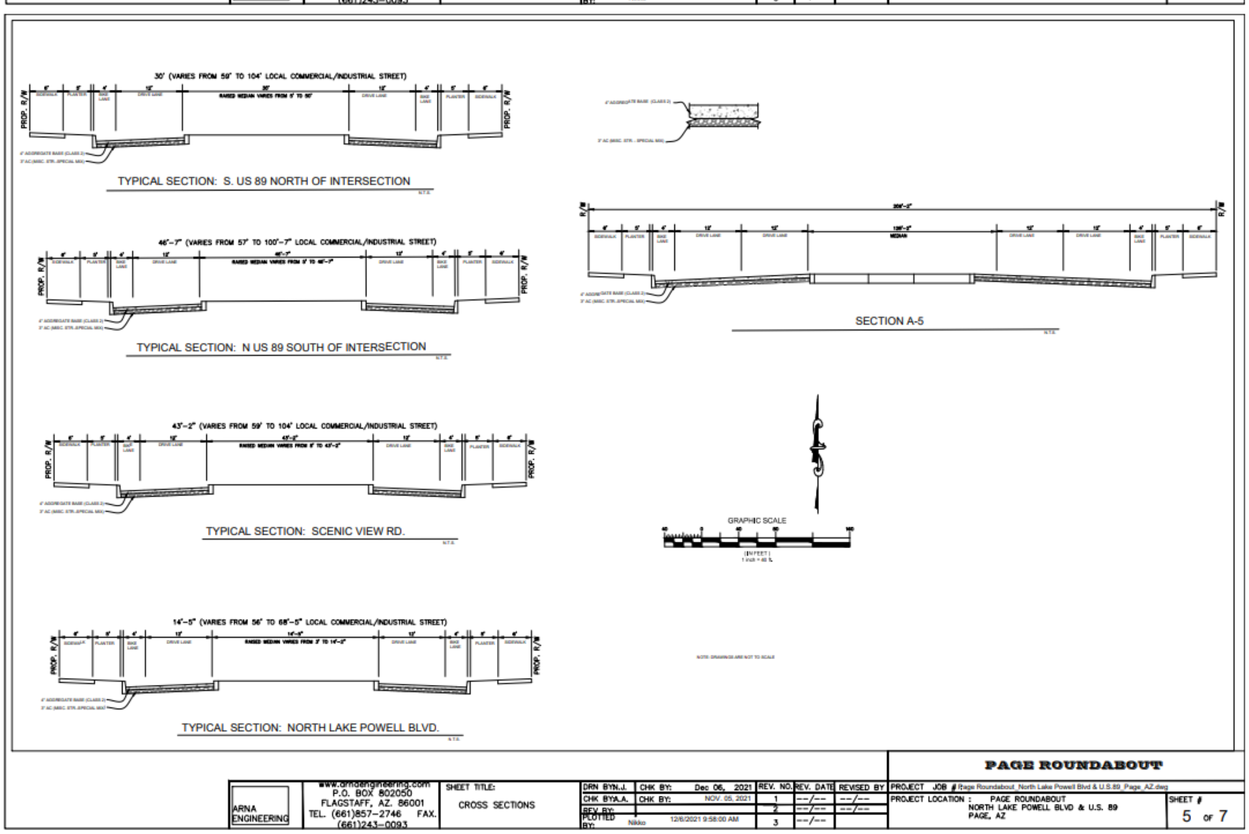



U.S. 89
N. LAKE POWELL BLVD
SCENIC VIEW RD
GRAPHIC SCALE
PAGE ROUNDABOUT
ARNA ENGINEERING
www.arnaengineering.com
P.O. BOX 802050
FLAGSTAFF, AZ. 86001
TEL. (661)857-2746 FAX. (661)243-0093
SHEET TITLE:
EXISTING SITE PLAN
DRN BY: N.J.
CHK BY: A.A.
CHK BY: Dec 06, 2021
CHK BY: NOV. 05, 2021
REV. BY:
PLOTTED BY: Nikko 12/6/2021 9:55:29 AM
REV. NO.
REV. DATE
REVISED BY
PROJECT JOB # Page Roundabout_North Lake Powell Blvd & U.S.89_Page_AZ.dwg
PROJECT LOCATION : PAGE ROUNDABOUT
NORTH LAKE POWELL BLVD & U.S. 89
PAGE, AZ
SHEET # 2 OF 7

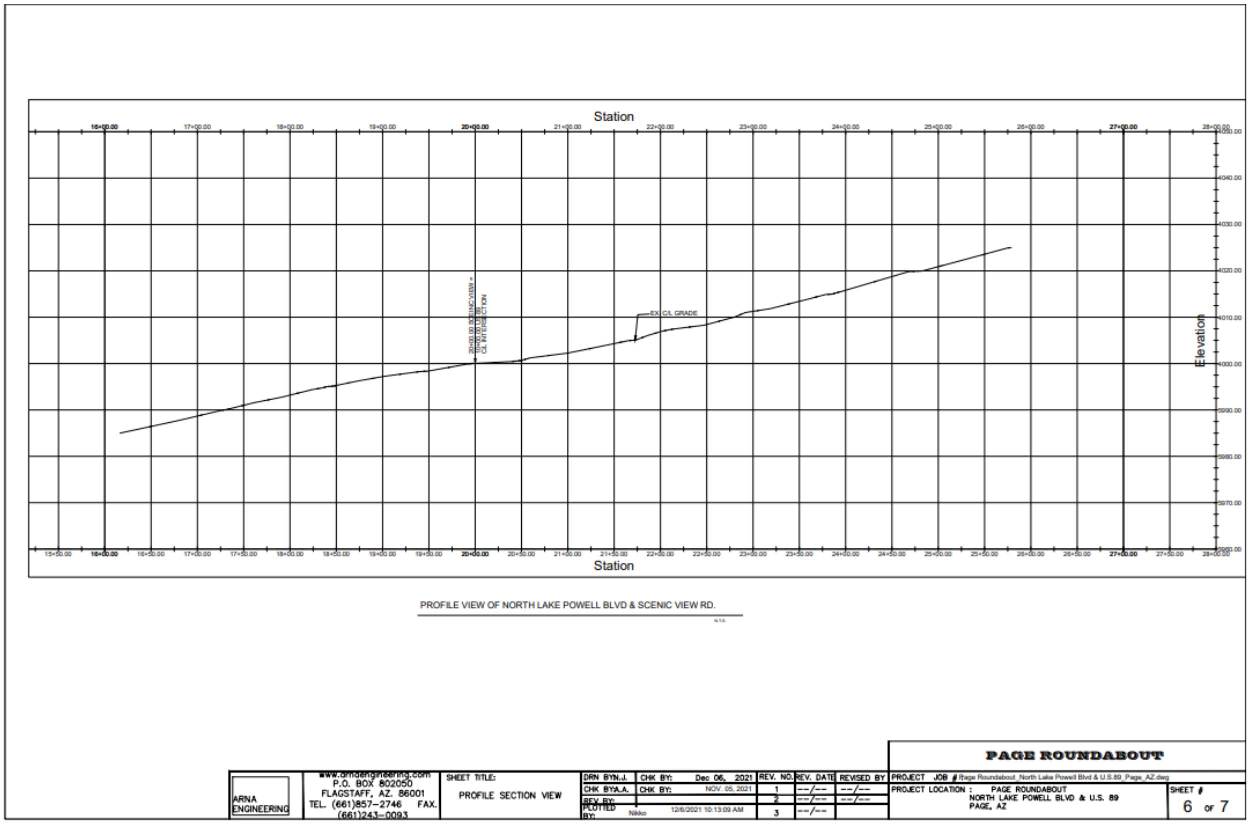

CONSTRUCTION KEY NOTES
U.S. 89
N. LAKE POWELL BLVD
SCENIC VIEW RD
GRAPHIC SCALE
PAGE ROUNDABOUT
ARNA ENGINEERING
www.arnaengineering.com
P.O. BOX 802050
FLAGSTAFF, AZ. 86001
TEL. (661)857-2746 FAX. (661)243-0093
SHEET TITLE:
PAVING AND CONSTRUCTION
DRN BY: N.J.
CHK BY: A.A.
CHK BY: Dec 06, 2021
CHK BY: NOV. 05, 2021
REV. BY:
PLOTTED BY: Nikko 12/6/2021 9:56:05 AM
REV. NO.
REV. DATE
REVISED BY
PROJECT JOB # Page Roundabout_North Lake Powell Blvd & U.S.89_Page_AZ.dwg
PROJECT LOCATION : PAGE ROUNDABOUT
NORTH LAKE POWELL BLVD & U.S. 89
PAGE, AZ
SHEET # 3 OF 7

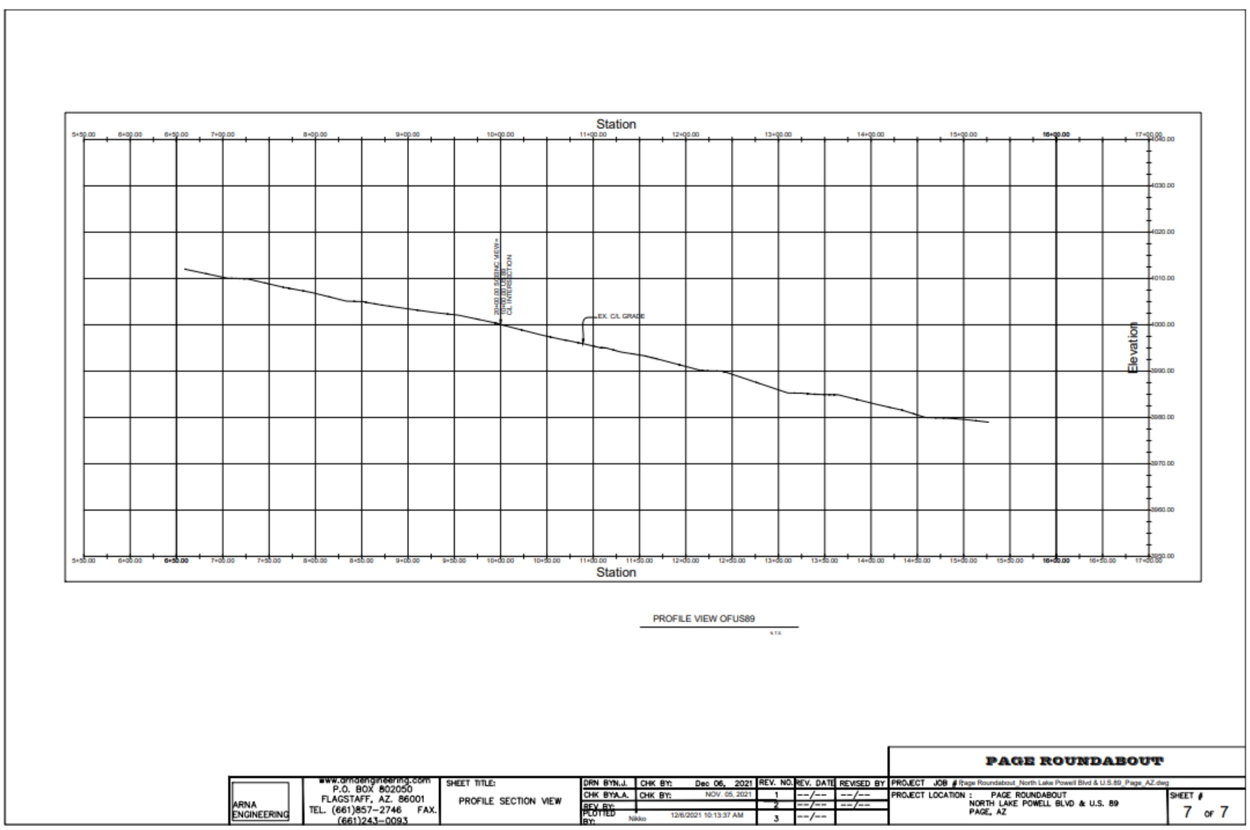


KEY NOTES: (Furnish and install STRIPING AND SIGNS)
U.S. 89
N. LAKE POWELL BLVD.
SCENIC VIEW RD.
GRAPHIC SCALE
PAGE ROUNDABOUT
ARNA ENGINEERING
www.arnaengineering.com
P.O. BOX 802050
FLAGSTAFF, AZ. 86001
TEL. (661)857-2746 FAX. (661)243-0093
SHEET TITLE: STRIPING & SIGNAGE PLAN
DRN BY N.J.
CHK BY A.A.
Dec 06, 2021
NOV. 05, 2021
PLOTTED BY: Nikko 12/6/2021 9:56:53 AM
PROJECT LOCATION : PAGE ROUNDABOUT NORTH LAKE POWELL BLVD & U.S. 89 PAGE, AZ
SHEET # 4 OF 7



TYPICAL SECTION: S. US 89 NORTH OF INTERSECTION
TYPICAL SECTION: N US 89 SOUTH OF INTERSECTION
TYPICAL SECTION: SCENIC VIEW RD.
TYPICAL SECTION: NORTH LAKE POWELL BLVD.
SECTION A-5
GRAPHIC SCALE
PAGE ROUNDABOUT
ARNA ENGINEERING
www.arnaengineering.com
P.O. BOX 802050
FLAGSTAFF, AZ. 86001
TEL. (661)857-2746 FAX. (661)243-0093
SHEET TITLE: CROSS SECTIONS
DRN BY N.J.
CHK BY A.A.
Dec 06, 2021
NOV. 05, 2021
PLOTTED BY: Nikko 12/6/2021 9:58:00 AM
PROJECT LOCATION : PAGE ROUNDABOUT NORTH LAKE POWELL BLVD & U.S. 89 PAGE, AZ
SHEET # 5 OF 7


Station
Elevation
EX C/L GRADE
PROFILE VIEW OF NORTH LAKE POWELL BLVD & SCENIC VIEW RD.
PAGE ROUNDABOUT
ARNA ENGINEERING
P.O. BOX 802050
FLAGSTAFF, AZ. 86001
TEL. (661)857-2746 FAX. (661)243-0093
SHEET TITLE:
PROFILE SECTION VIEW
PROJECT LOCATION : PAGE ROUNDABOUT NORTH LAKE POWELL BLVD & U.S. 89 PAGE, AZ
SHEET # 6 OF 7


Station
Elevation
EX. C/L GRADE
PROFILE VIEW OFUS89
PAGE ROUNDABOUT
ARNA ENGINEERING
P.O. BOX 802050
FLAGSTAFF, AZ. 86001
TEL. (661)857-2746 FAX. (661)243-0093
SHEET TITLE:
PROFILE SECTION VIEW
PROJECT LOCATION : PAGE ROUNDABOUT NORTH LAKE POWELL BLVD & U.S. 89 PAGE, AZ
SHEET # 7 OF 7