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FINAL MEMORANDUM

TO: James Carothers, Jim Hodges, Justin Monsrud, City of Camas

FROM: Jason Irving, Gregory Oehley, MacKay Sposito

Justin Sheets, Alex Correa, DKS Associates

RE: **NW Lake Road and NW Sierra Street Intersection - Alternatives Analysis**

DATE: November 12th, 2023

Overview

The NW Lake Rd. and NW Sierra St. intersection is currently a 3-legged non-signalized intersection with a stop sign on NW Sierra Street located in Camas, Washington. A project area map is included below in Figure 1. NW Lake Rd. is an east-west arterial that runs from the western city limits to NE Everett St. NW Sierra St. is a north-south collector that runs from NW Lake Rd. to NW 43rd Ave. and primarily serves nearby residential properties. Average daily traffic (two-way) entering the intersection is approaching 16,000.

The City of Camas is considering intersection improvements to address vehicle queuing and delays while also improving safety and multimodal connectivity. This memorandum provides an alternatives analysis to evaluate the following eight criteria for comparing the two options of a new traffic signal versus a new roundabout.

Alternatives Analysis Criteria

1. Traffic Safety (vehicular, pedestrian, and bicyclist)
2. Traffic Operations (delay, Level of Service (LOS))
3. Right of Way Impacts and Costs
4. Project Cost
5. Construction Phase Impacts (e.g., impacts to the traveling public)
6. Project Schedule

7. Impacts to Steep Slopes and Need for Retaining Walls
8. Public and Private Utility Impacts
9. City Operation and Maintenance Considerations

Figure 1- Project Area Map

A. Proposed Project Improvements

The proposed options to improve intersection safety, efficiency, and LOS are the signalization of the intersection or construction of a roundabout. Both options will significantly improve the intersection LOS and reduce delays, but each has their unique challenges. Some of the challenges include vertical and horizontal constraints, steep slopes, private property impacts as well as the presence of existing private and public utilities. The two options are briefly described below:

Signalization

This improvement would replace the current stop-controlled intersection with a traffic signal and add an eastbound right turn lane with 300’ of vehicle storage. Based on the traffic analysis, this intersection meets the requirements to warrant a signal. The LOS for the AM and PM peak hour will improve to a LOS of C and B respectively.

Roundabout

This improvement would replace the current stop-controlled intersection with a single lane roundabout, add an eastbound right turn lane on NW Lake Road, and a northbound right turn slip lane on NW Sierra Street. The biggest challenge for the roundabout option is the geometric constraints which in turn make it the lesser cost-effective option. The 2045 projected LOS for the AM and PM peak hour will improve from LOS of F (no-build scenario) to a LOS of B.

Notably, the roundabout option would generally serve off peak traffic better when compared to the signalized option, particularly on the minor approach (Sierra Street). Roundabouts typically treat all intersection movements equally, whereas a traffic signal may cause vehicle wait time, even during off peak hours, while the traffic signal detects the vehicle and cycles to a green light.

Although both options can accommodate the projected traffic in 2045 with relatively low delays when compared with the no build option, each option also presents challenges under the future traffic volume projections.

B. Traffic Operations and Safety Analysis Results

DKS Associates completed an evaluation for the two selected options and a no-build alternative in regard to traffic operations, multi-modal facilities, and safety. The following section details the results of the traffic operations analysis and safety evaluation for each alternative. The full traffic analysis memorandum, which primarily focuses on traffic operations of the two options, is included in Appendix C.

The traffic analysis and subsequent alternative evaluation concluded that each proposed alternative would provide the following benefits for the overall intersection operations:

- Significant reduction to overall intersection vehicle delay and queuing, with the exception of through traffic on NW Lake Road which will experience minor increased delays with both options
- Potential for decreased crash frequency and/or severity
- Improvements to multimodal travel

Safety Performance

Both the signalized and roundabout options have potential to improve safety compared with the existing condition, by reducing the risk that motorists traveling from NW Sierra St. will conflict with either the westbound or eastbound uncontrolled movements on NW Lake Road., Crash data sampled from the last five years (2018-2022) indicates that crashes are infrequent and low severity at this intersection under existing conditions. There were four crashes reported in the five-year period, with all four being property damage only crashes. It is also worth noting that crash risk is correlated with traffic volumes and traffic volumes at this intersection are expected to increase significantly over the next 20 years. It is expected that without improvements at this intersection, there will be fewer gaps and more potential conflicts between vehicles on NW Lake Rd. and turning vehicles into and out of NW Sierra St.

Signalized Option

The conversion of the stop-controlled intersection to a signal will primarily reduce the speed and frequency of the conflict between motorists turning from NW Sierra St. onto NW Lake Rd. In particular, a signal provided with a protected northbound left turn phase will reduce the risk of high-speed angle collisions. Using data sourced from the Federal Highway Administration's Crash Modification Factors (CMF) Clearinghouse, the conversion of a 3-leg stop-controlled intersection to a signal has a CMF of 0.86, corresponding to a crash reduction of 14% over the existing condition.

Roundabout Option

The conversion of the stop-controlled intersection to a roundabout would slow speeds for approaching vehicles, particularly on NW Lake Rd., by creating horizontal deflection on the approaches. By slowing vehicles, crashes are more likely to be lower severity. Using data sourced from CMF Clearinghouse, an online repository for CMFs of different transportation countermeasures, the conversion of a 3-leg or 4-leg stop-controlled intersection to a mini-roundabout has a CMF of 0.8 for all crashes[1]. A CMF of 0.8 corresponds to a 20% decrease in crash frequency for all crashes over the existing condition.

Multimodal Travel

Under existing conditions, pedestrians and cyclists utilize the study intersection, however there are gaps in those facilities and areas for improvement in terms of quality, connectivity, and comfort. Today, a 5-foot curb-tight sidewalk runs west of the study intersection on the south side of NW Lake Rd., but this sidewalk terminates at a curb ramp just east of the study intersection. There is no sidewalk on the north side of NW Lake Rd. near the intersection. North-side residential properties to the west on NW Lake Rd. do not have continuous sidewalk access to the intersection or nearby options to cross NW Lake Rd. The nearest NW Lake Rd. crossing is approximately 1,800 feet to the west at NW Leadbetter Drive. A five-foot curb-tight sidewalk

[1] https://www.cmfclearinghouse.org/detail.php?facid=11240

exists on both sides of NW Sierra St. NW Lake Rd. includes a westbound bike lane through the study intersection but does not include an eastbound bike lane. An existing eastbound bike lane on NW Lake Rd. terminates approximately 600 feet west of NW Sierra St. No dedicated bike facilities exist on NW Sierra St.

Signalized Option

This option would improve the safety and comfort of pedestrians crossing Sierra St. by adding a protected signalized crossing, pavement markings, and reconstructing curb ramps to improve accessibility. The eastbound bike lane on NW Lake Rd. will be extended to the study intersection by combining with the existing sidewalk and widening it to 10ft. as a multi-use path. The bike lane will then merge into general traffic east of the study intersection. Alternatively, the bike lane can be configured to direct eastbound bicycles south onto NW Sierra St. and to the local road network. The westbound bike lane on NW Lake Rd. will remain and continue through the study intersection. Additional analysis, design, and coordination will be required to determine the best treatments for eastbound cyclists at the study intersection under this alternative. Possible treatments for cyclists include the addition of a conventional bike lane to the left of the eastbound right turn lane, a combined bike lane/turn lane, or terminating the eastbound bike lane prior to the signalized intersection. Based on the steep wooded slopes along the southwest side of Lake Road, it is not anticipated that continuing the bike lane east of the intersection is feasible with either option.

Roundabout Option

The roundabout option would add marked crossings across NW Sierra St. with islands separating traffic movements. This would break the existing 60-foot unmarked crossing into three 10–15-foot marked crossings divided by raised medians, thereby increasing pedestrian comfort and safety. This option would add facilities for eastbound cyclists on NW Lake Rd. by combining with the existing sidewalk which will be widened to 10ft. to the intersection of NW Sierra St. as a multi-use path. Given geometric limitations east of the intersection, the lack of a dedicated bicycle lane for eastbound cyclists from NW Sierra St. to NE Everett St. will remain. It is anticipated that eastbound bicyclists may utilize NW Sierra St. and nearby local streets to continue traveling east to NE Everett Street. The westbound bike lane on NW Lake Rd. will transition to a buffered bike lane at the roundabout, which could be constructed as a grade-separated path for additional cyclist protection and separation from vehicular traffic or at-grade buffered with pavement markings (See Figure 2 below for a sample grade-separated cycle path).

Figure 2: Grade Separated Cycle Track Example

Source: National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide

Traffic Operations Analysis

Traffic analysis was conducted for three future scenarios: 2045 no build, 2045 roundabout, and 2045 signalized. In both the 2045 roundabout and 2045 signalized scenarios, the City of Camas operating standard of Level of Service (LOS) D or better is met during the peak hours. Table 1 below details the intersection delay and LOS for each alternative.

Table 1: NW Lake Rd./NW Sierra St. Future Scenario (2045) Traffic Operations

INTERSECTION CONTROL	OPERATING STANDARD	AM PEAK HOUR[A]			PM PEAK HOUR[A]		
		V/C RATIO	DELAY (SECS)	LOS	V/C RATIO	DELAY (SECS)	LOS
STOP-CONTROL (NO BUILD)	LOS D	0.29/2.83	11.8/>100	B/F	0.36/3.63	15.4/>100	C/F
SIGNALIZED	LOS D	0.93	20.5	C	0.73	12.3	B
ROUNDABOUT	LOS D	0.78	11.9	B	0.83	13.0	B

[A] Results shown for two way stop controlled intersections are shown as major approach results/minor approach results.

Another important operational measure analyzed is the amount of queuing present under each build alternative. For each approach in the roundabout alternative, queuing does not exceed the storage capacity that will be present at the intersection. For the signalized alternative, most movements can fit into the existing storage capacity with some minor striping alterations that will not require any pavement widening. However, the northbound right queues will exceed the available storage capacity and is expected to have queuing in the a.m. peak hour that will spillback through the NW 45th Ave. intersection.

C. Conceptual Intersection Designs and Engineer's Estimate of Probable Construction Cost

Conceptual intersection designs (see Appendix A) were prepared by the project team for both options to develop preliminary geometrics and to assess construction costs and impacts to right of way, steep slopes, and utilities.

Project cost estimates, including estimates of probable construction cost and associated soft costs (design, permitting, etc.) were also prepared for each option and are summarized below. See Appendix B for the detailed cost estimates.

New Traffic Signal - $1,675,000

New Roundabout - $3,115,000

D. Alternatives Analysis and Results

Analysis Summary

The following table summarizes the results of the alternatives analysis and is followed by a more detailed analysis related to each of the eight analysis criteria.

Table 2 – Alternative Analysis Evaluation Summary

Analysis Criteria	**Traffic Signal**	**Roundabout**	**No Build**
Traffic Safety	**Med**	**High**	**Low**
Level of Service (Lake Rd/Sierra St) AM Peak	**C**	**B**	**B/F**

Analysis Criteria	Traffic Signal	Roundabout	No Build
PM Peak	**B**	**B**	**C/F**
Vehicle Capacity Ratio (Lake Rd/Sierra St) AM Peak PM Peak	 **0.93** **0.73**	 **0.78** **0.83**	 **0.29/2.83** **0.36/3.63**
Vehicle Delay (secs.) (Lake Rd/Sierra St) AM Peak PM Peak	 **20.5** **12.3**	 **11.9** **13.0**	 **11.8/>100** **15.4/>100**
Right of Way Impacts/Costs	**Low**	**High**	**N/A**
Project Cost	**$1.67M**	**$3.12M**	**N/A**
Construction Phase Impacts	**Med**	**High**	**N/A**
Schedule	**Low**	**High**	**N/A**
Impacts to Steep Slopes and Need for Retaining Walls	**Low**	**High**	**N/A**
Private Utility Impacts	**Med**	**High**	**N/A**

1. Traffic Safety

Please refer to Section B on page 3 for a discussion and comparison of traffic safety for the two options.

2. Traffic Operations

Please refer to Section B on page 5 for a discussion and comparison of traffic operations for the two options.

3. Right of Way Impacts and Costs

Based on the preliminary traffic signal conceptual design, right of way acquisition is not anticipated for the signal option. A temporary construction easement may be needed to reconstruct the retaining wall on the southwest corner of the intersection, but further design development is needed to confirm.

The roundabout option is very likely to require right of way acquisition on the north side and the southeast and southwest corners of the intersection. This is due to the need for a northbound right turn slip lane on the southeast corner, eastbound right turn lane on the southwest corner, and the roundabout footprint extending to the north of the intersection, impacting the existing steep slope and requiring construction of a retaining wall. Right-of-way acquisition costs are estimated at approximately $150,000 and the right-of-way acquisition process typically takes nine months to one year to complete.

4. Project Cost

Project cost is a primary determining factor for selecting the preferred option and ensuring a fully funded and feasible project. Conceptual project cost estimates, including engineer's estimates of probable construction cost (see Appendix B) were developed for each option based on the conceptual designs provided in Appendix A. Other hard and soft costs were then considered including:

- Design and permitting
- Public engagement
- Right of way acquisition
- Construction management and inspection
- Escalation to the anticipated time of bidding for construction (fall 2024)

Traffic Signal - The total estimated project cost for the traffic signal option is $1,675,000. Primary cost factors for this option include:

1. $155,000 - Traffic signal equipment, poles, and foundations
2. $30,000 - Vehicle Detection and preemption
3. $110,0000 - Conduit, wiring, trenching and backfill, and associated junction boxes
4. $305,000 - Roadway and multi-use path construction
5. $145,000 - Retaining wall on southwest corner

Operations and Maintenance – The following are anticipated items that would incur costs over the lifetime of a traffic signal for maintenance.

1. Routine timing adjustments
2. Energy consumption
3. Preventative maintenance (replacing LEDs, etc.)

Roundabout - The total estimated project cost for the roundabout option is $3,115,000. Primary cost factors for this option include:

1. $900,000 - Road/roundabout and multi-use path construction
2. $260,000 - Retaining wall southwest corner and north side
3. $150,000 - ROW acquisition and costs
4. $140,000 - Stormwater treatment
5. $333,000 - Construction cost escalation (2 years)

Operations and Maintenance – The following are anticipated items that would incur costs over the lifetime of a roundabout for maintenance.

1. Lighting inspection and maintenance
2. Pavement, sign and pavement marking maintenance
3. Inspection and maintenance of structural elements of the roundabout, such as retaining walls, curbs, and center island features

It is assumed that there will be no landscaping and vegetation to be maintained since the center of the roundabout will be paved in this case.

Note that the conceptual project cost estimates assume local funding and that Federal Highway Administration or Washington State Department of Transportation funding will not be utilized for the project. Additional costs may be incurred if these or other funding sources are utilized that require additional studies, permits, etc. such as completing National Environmental Policy Act (NEPA) requirements and approvals. It is worth noting that if future funding triggers NEPA requirements, recent changes to NEPA requirements may add as much as one to two years to the project schedule, primarily dependent on whether the project increases the amount of pollution generating impervious surfacing.

5. Construction Phase Impacts

While impacts on the traveling public and adjacent residents are not typically primary considerations when selecting the preferred option, they must be considered. In general, the roundabout option will have the greatest impact to the traveling public due to limited roadway width to allow for vehicle access during construction activities within the intersection. Roundabout construction must occur in the center of the intersection and will disrupt vehicle access on NW Lake Rd. Additionally, there are limited detour options available due to nearby Lacamas Lake, the local topography and roadway network. The most direct and likely feasible detour option for NW Lake Rd. traffic is to turn south on NW Sierra St., east on NW 45th Ave./NW Oregon St, south east on NW 44th Ave., then north on NW Lacamas Ln. to NW Lake Rd. Note this detour route is mostly a residential neighborhood that may not be well positioned to support a significant increase in traffic volumes for long periods of time. Prior to approving this detour, an in-depth public outreach is recommended to be completed with impacted residents. While the traffic signal option will also impact NW Lake Rd. traffic, it is very likely that at least one lane of traffic on NW Lake Rd. would remain open throughout construction and a long duration detour would not likely be required.

6. Project Schedule

For each option, the anticipated project schedule for design, permitting, public engagement, and construction is similar, likely within a few months of each other. A potential schedule driver for both options will be the likely need for private natural gas and fiber utility relocations, primarily on the southwest corner of the intersection, in order to construct a new dedicated right turn lane for east bound traffic on NW Lake Rd. The roundabout option will likely increase the project schedule by one to two years due to the need for right of way acquisition, more significant private utility relocations, and to secure additional funding to fully fund the project. Section 3 Right of Way Impacts and Costs above describes the need for right of way to construct the roundabout and Section 8 Private Utility Impacts below discusses the required private utility relocations.

7. Impacts to Steep Slopes and Need for Retaining Walls

There is an existing two- to three-foot-tall retaining wall west of the intersection along the south side of NW Lake Rd. Both options will require reconstructing and increasing the height of this retaining wall and relocating it adjacent to the ROW line in order to construct a new right turn lane for eastbound traffic on NW Lake Rd. Additionally, the roundabout option will require widening of NW Lake Rd. to the north and southeast at the intersection and require new retaining walls. On the north side of the intersection the widening will impact an existing 2:1 steep slope down to residential properties and require constructing a new eight to ten foot tall and estimated 130 foot long retaining wall and guardrail or concrete barrier. It may also require a critical areas slope permit, geotechnical review for slope stability and wall foundation considerations, and structural engineering design. It is estimated that the north side retaining wall may cost an estimated additional $200,000 to design, permit, acquire the necessary right of way or easement, and construct.

8. Private Utility Impacts

Private utility impacts are similar for both options on the southwest corner of the intersection and west on NW Lake Rd. Existing private utilities anticipated to be impacted include both an existing 12-inch-high pressure and 4-inch natural gas mains and gate station as well as fiber optic lines. While further design and coordination is needed with Northwest Natural for relocation of their facilities, oftentimes the relocation of high pressure mainlines must be completed during warmer months when natural gas demand is lower. This can impact the timing of when the City's intersection improvements can be constructed. In the southeast corner of the intersection, the roundabout option will require the relocation of a large transformer. The existing power transformer has heavy circuits to the south and west, and smaller circuits to the south and northeast. If possible, we recommend that all private utility locations be completed prior to the City's construction contractor beginning their work in order to prevent conflicts between multiple contractors and to reduce risk. Public utility impacts are relatively minimal, primarily consisting of relocating or constructing new stormwater catch basins and piping.

9. City Operation and Maintenance Considerations

Traffic signals require electricity to operate, contributing to ongoing operational costs. The costs can vary based on the efficiency of the signal system. Traffic signals have more mechanical and electrical components, including signal lights and control systems. This can result in higher maintenance and replacements costs compared to roundabouts. Also, traffic signals and associated control systems can be damaged by traffic collisions which can be very costly to repair and render the intersection inoperable. Power outages, which can be more frequent in heavily forested and high wind areas such as Camas, may impact traffic signals and render them inoperable.

Roundabouts are generally associated with improved safety, leading to potential cost savings related to motor vehicle damage. While roundabouts may have higher initial construction costs, they often result in lower ongoing operational and maintenance costs compared to traffic signals without the potential of losing operation during a power outage or after a traffic incident.

E. Conclusions and Recommendation

In conclusion, as compared to a traffic signal the operational benefits of the roundabout option include a higher LOS, less delay and a higher level of safety. Undesirable aspects of the roundabout option include the need to acquire right of way, a much higher project cost, greater impacts to traffic during construction, a longer project schedule, steep slope impacts, and more significant private utility relocations.

Traffic signals require electricity to operate, contributing to ongoing operational costs. The costs can vary based on the efficiency of the signal system. Traffic signals have more mechanical components, including signal lights and control systems. This can result in higher maintenance costs compared to roundabouts.

Roundabouts are generally associated with improved safety, leading to potential cost savings related to accidents and emergency response. Roundabouts often provide smoother traffic flow, reducing congestion and potentially lowering overall costs related to delays and fuel consumption.

In summary, while roundabouts may have higher initial construction costs, they often result in lower ongoing operational and maintenance costs compared to traffic signals without the potential of losing operation during a power outage or after a traffic incident.

The following provides a high-level summary of key findings of the traffic safety and operations analysis and the alternatives analysis.

- LOS - Both options will significantly improve the LOS of the intersection over the no build condition, with the roundabout option having a slight advantage in LOS for the peak AM condition (LOS C for a signal vs LOS B for the roundabout).
- Vehicle Delays - Both options will significantly reduce delays for traffic on NW Sierra St. Delays are very similar for both options, with the roundabout providing slightly less delay in the peak AM condition (11.9 seconds for a roundabout vs 20.5 seconds for a signal).
- Safety - Both options will improve intersection safety. Roundabouts typically provide a higher level of safety than a traffic signal by reducing conflict points and vehicle speeds, which reduces crash severity.
- Right of Way - Right of way is likely not required for the traffic signal. Impacts are higher for the roundabout option and anticipated to add $150,000 to the project cost and up to a year to the project schedule.
- Project Cost - The estimated roundabout cost is $1.44M higher than the signalized option (an 86% increase in cost).
- Construction Impacts - During construction the roundabout is anticipated to impact traffic operations more than the traffic signal and will likely require a one-to-two-month detour.
- Schedule - The roundabout may add one to two years to the project schedule in order to acquire right of way, complete significant private utility relocations, and to secure additional funding.
- Impacts to Steep Slopes/Retaining Walls - Both options will require reconstructing an existing retaining wall on the southwest corner. The roundabout will require steep slope analysis, structural design, and additional right of way acquisition to construct a new retaining wall on the north side and southeast corner of the intersection.
- Private Utility Impacts - Both options will likely require private utility relocations. The roundabout has greater utility impacts and will likely require relocating an existing power transformer on the southeast corner of the intersection.

F. Next Steps

Following selection of the preferred intersection improvement alternative, traffic signal or roundabout, the design team will prepare a scope and fee to complete public outreach, design, permitting, and right of way acquisition (if needed). Once approved by the city, the design and public outreach team will progress with the work with a goal of completing design and permitting in time to start construction in winter 2024/spring 2025.

Appendix

Appendix A - Conceptual Design Plans

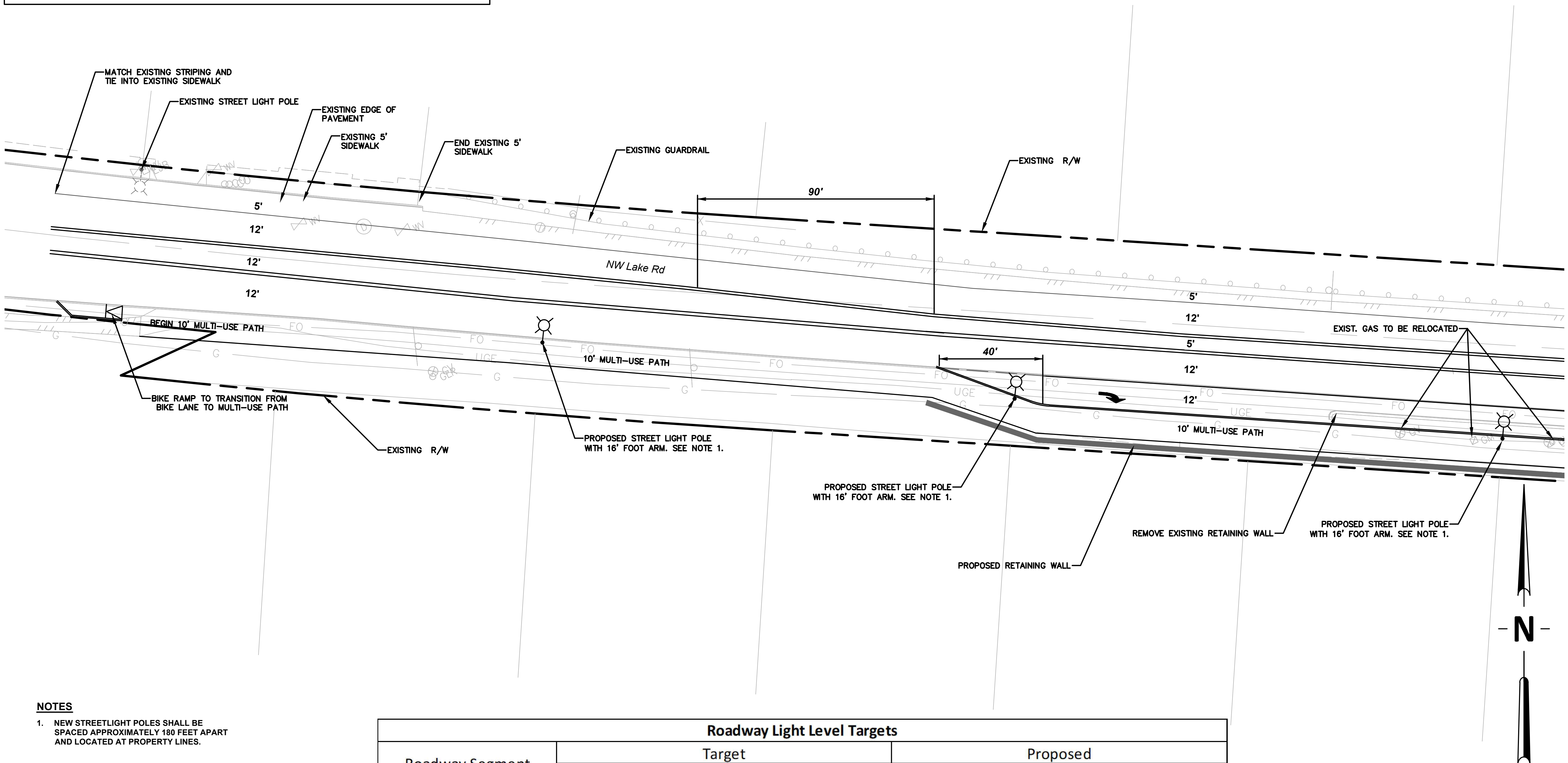
Appendix B - Conceptual Project Cost Estimates

Appendix C - DKS Traffic Analysis Memo September 2023

Appendix A

Conceptual Design Plans

Lake Road/Sierra Street
Signalized Alternative 30% Design Exhibit
Page 1 of 2



NOTES

1. NEW STREETLIGHT POLES SHALL BE SPACED APPROXIMATELY 180 FEET APART AND LOCATED AT PROPERTY LINES.

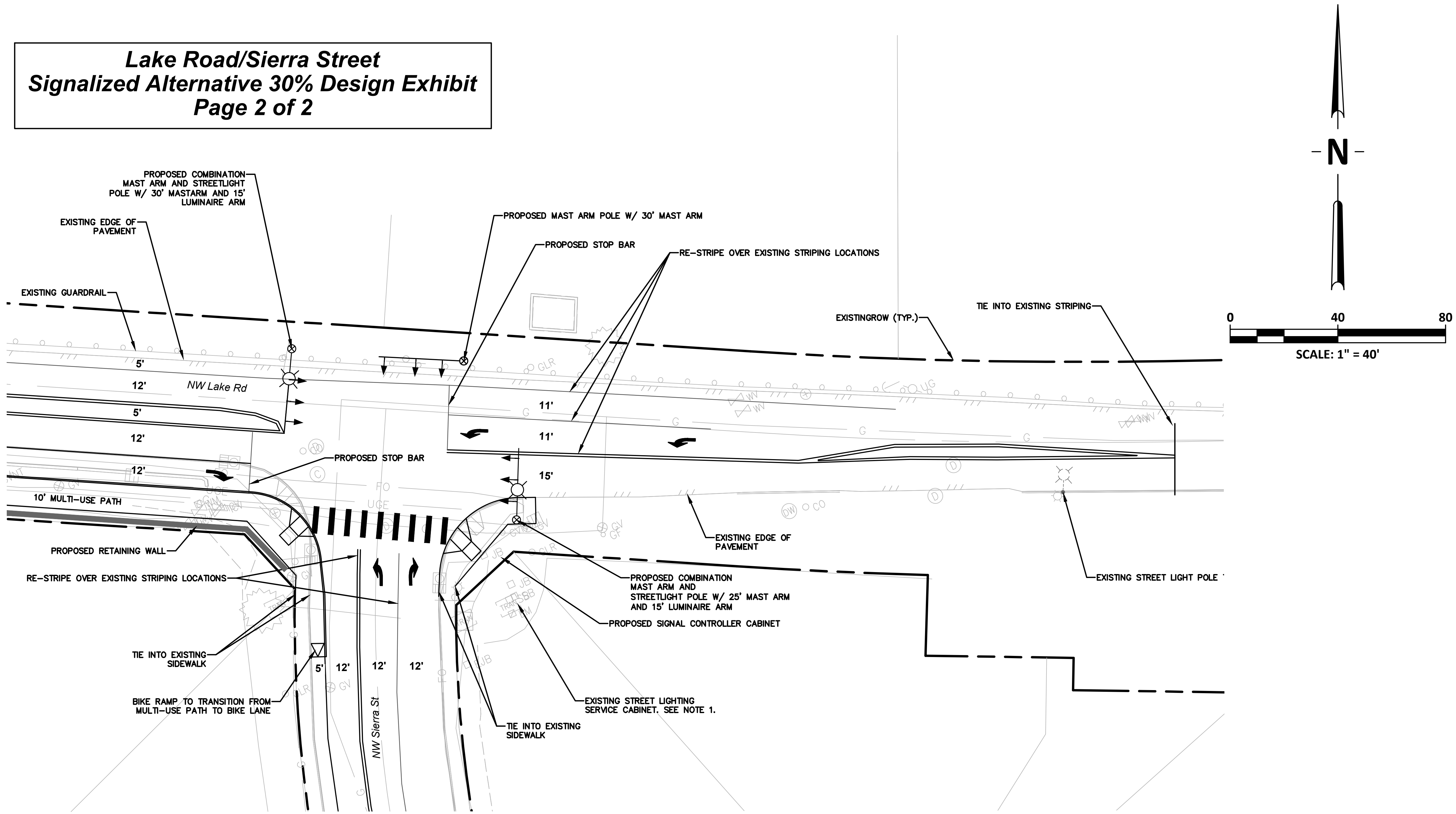
Roadway Light Level Targets

Roadway Segment	Target		Proposed	
	Avg Luminance (cd/m^2)	Uniformity (Avg/Min)	Avg Luminance (cd/m^2)	Uniformity (Avg/Min)
Lake Rd West of Sierra St	0.9	3	1.0	3

0 40 80

SCALE: 1" = 40'

Lake Road/Sierra Street
Signalized Alternative 30% Design Exhibit
Page 2 of 2



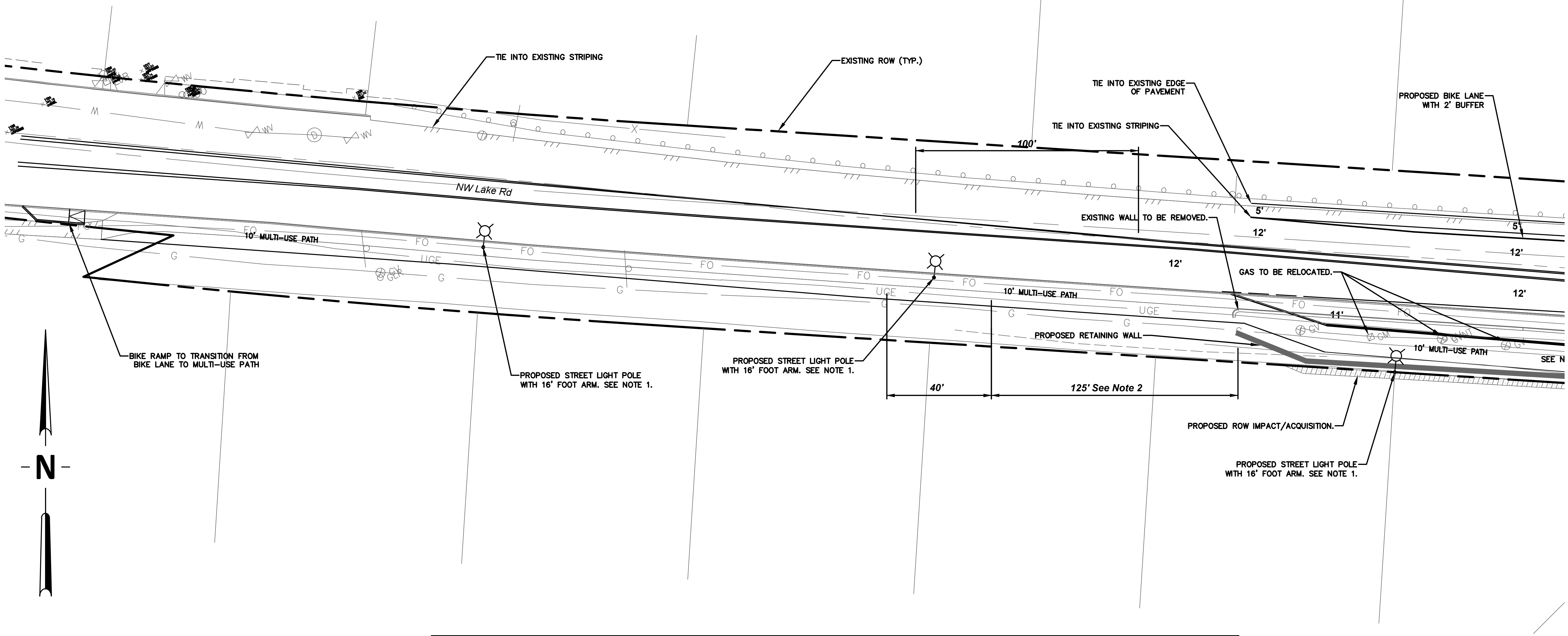
NOTES

1. ALL PROPOSED STREETLIGHTS WILL BE POWERED VIA EXISTING STREET LIGHTING SERVICE CABINET. ADDITIONAL INVESTIGATION WILL BE REQUIRED TO DETERMINE IF THIS IS POSSIBLE.

Intersection Light Level Targets (Signalized Alternative)

Intersection	Target		Proposed	
	Avg Illuminance (fc)	Uniformity (Avg/Min)	Avg Illuminance (fc)	Uniformity (Avg/Min)
Lake Rd/Sierra St	1.4	3	1.8	3

Lake Road/Sierra Street Roundabout Alternative 30% Design Exhibit Page 1 of 2



NOTES

1. NEW STREETLIGHT POLES SHALL BE SPACED APPROXIMATELY 180 FEET APART AND LOCATED AT PROPERTY LINES.
2. 125' TAPER CONTINUES TO NEXT SHEET.

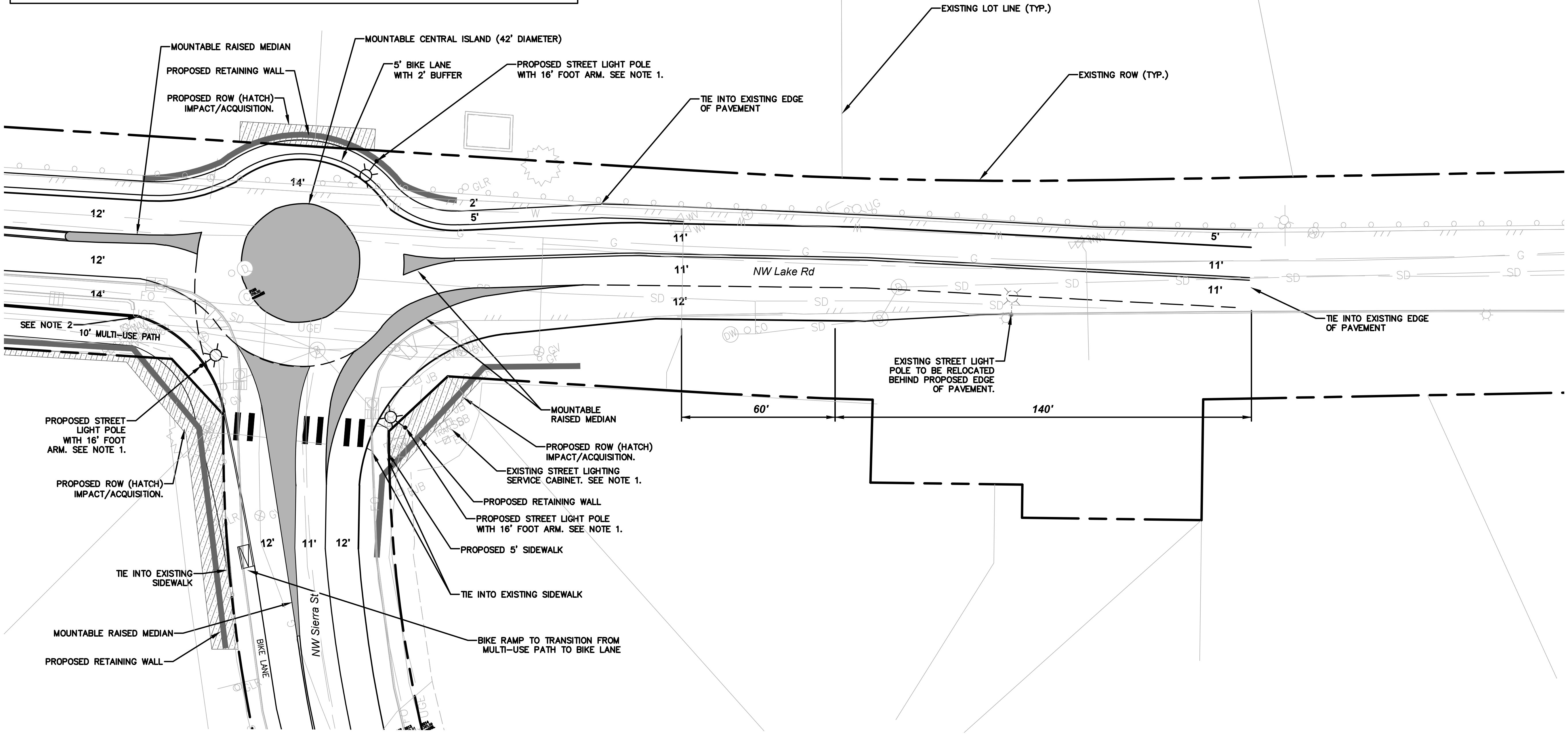
Roadway Light Level Targets

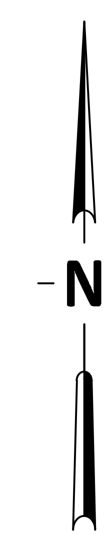
Roadway Segment	Target		Proposed	
	Avg Luminance (cd/m^2)	Uniformity (Avg/Min)	Avg Luminance (cd/m^2)	Uniformity (Avg/Min)
Lake Rd West of Sierra St	0.9	3	1.0	3

0 40 80

SCALE: 1" = 40'

Lake Road/Sierra Street
Roundabout Alternative 30% Design Exhibit
Page 2 of 2





NOTES

1. ALL PROPOSED STREETLIGHTS WILL BE POWERED VIA EXISTING STREET LIGHTING SERVICE CABINET. ADDITIONAL INVESTIGATION WILL BE REQUIRED TO DETERMINE IF THIS IS POSSIBLE.
2. END OF 125' TAPER.

0 40 80

SCALE: 1" = 40'

Intersection Light Level Targets (Roundabout Alternative)

Intersection	Target		Proposed	
	Avg Illuminance (fc)	Uniformity (Avg/Min)	Avg Illuminance (fc)	Uniformity (Avg/Min)
Lake Rd/Sierra St	1.4	3	1.9	2

Appendix B

Conceptual Project Cost Estimates

MacKay Sposito

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NW Lake Road and NW Sierra Street Intersection Improvements

ROM Project Cost Estimates

10/30/2023

Roundabout Option

PROJECT COSTS					
Item #	**Description**	**Unit**	**Quantity**	**Unit Price ($)**	**Total ($)**
1	ROW acquisition	L.S.	1	$150,000	$150,000
2	Survey/Design/Permitting/Public Involvement	L.S.	1	$250,000	$250,000
3	Construction	L.S.	1	-	$1,650,000
	General Conditions	L.S.	1	$350,000	$350,000
	Road Improvements	L.S.	1	$700,000	$700,000
	Roundabout	L.S.	1	$200,000	$200,000
	Stormwater Treatment	L.S.	1	$140,000	$140,000
	Steep Slope Impacts/Retaining Walls	L.S.	1	$260,000	$260,000
4	Construction Management/Inspection	L.S.	1	$90,000	$90,000
				Sub Total	$2,140,000
				Contingency (30%)	$642,000
				Escalation (6%)	$333,840
				TOTAL	**$3,115,840**

Assumptions
1. Two years of escalation and an October 2024 construction bid date
2. Survey, design, permitting, and public involvement costs assumed at approximately 15% of construction
3. Construction management and inspection costs assumed at approximately 5% of construction
4. Right of way costs include ROW consultant services and easement and land purchase.
5. Assumes no federal or WSDOT funding for design or construction

Traffic Signal Option

PROJECT COSTS					
Item #	**Description**	**Unit**	**Quantity**	**Unit Price ($)**	**Total ($)**
1	TCE acquisition	L.S.	1	$20,000	$20,000
2	Survey/Design/Permitting/Public Involvement	L.S.	1	$150,000	$150,000
3	Construction				$995,000
	General Conditions	L.S.	1	$200,000	$200,000
	Road Improvements	L.S.	1	$305,000	$305,000
	Traffic Signal Equipment, Poles, Foundations	L.S.	1	$155,000	$155,000
	Vehicle Detection, Preemption	L.S.	1	$30,000	$30,000
	Conduit, Wiring, Trenches, Junction Boxes	L.S.	1	$110,000	$110,000
	Stormwater Treatment	L.S.	1	$50,000	$50,000
	Retain Wall	L.S.	1	$145,000	$145,000
4	Construction Management/Inspection	L.S.	1	$50,000	$50,000
				Sub Total	$1,215,000
				Contingency (30%)	$364,500
				Escalation (6%)	$94,770
				TOTAL	**$1,674,270**

Assumptions
1. One year of escalation and an October 2024 construction bid date
2. Survey, design, permitting, and public involvement costs assumed at approximately 15% of construction
3. Construction management and inspection costs assumed at approximately 5% of construction
4. Right of way costs include ROW consultant services and easement and land purchase.
5. Assumes no federal or WSDOT funding for design or construction

Appendix C

DKS Traffic Analysis Memo September 2023

TECHNICAL MEMORANDUM

DATE: September 22nd, 2023

TO: James E. Carothers, PE | City of Camas

FROM: Justin Sheets, PE, Alex Correa, EIT | DKS Associates

SUBJECT: NW Lake Road/NW Sierra Street Traffic Analysis Project #24032-000

The following memorandum documents the traffic analysis performed at the NW Lake Road/NW Sierra Street intersection in Camas, Washington. This memorandum summarizes the existing conditions of the transportation facilities near the study intersection, existing operational conditions of the study intersection, safety analysis at the study intersection, and evaluates year 2045 operational conditions under different intersection improvement scenarios.

EXISTING CONDITIONS

This section summarizes existing conditions of the NW Lake Road/NW Sierra Street study intersection, including discussion of existing transportation facilities, traffic data, safety analysis, and traffic operations.

EXISTING TRANSPORTATION FACILITIES

The study intersection is located at NW Lake Road and NW Sierra Street in Camas, Washington. NW Lake Road is an east-west arterial that runs from the western city limits to NE Everett Street. NW Sierra Street is a north-south collector that runs from NW Lake Road to NW 43rd Avenue. The study intersection is located near several key vehicle trip generators to the east, such as two parks (Heritage Park, Lacamas Park) and three schools (Camas High School, Woodburn Elementary School, and Camas Community Education).

Today, the NW Sierra Street corridor has two five-foot curb-tight sidewalks on each side of the street. NW Lake Road includes a five-foot sidewalk on the south side of the street, west of the study intersection. East of the study intersection, NW Lake Road does not include any pedestrian facilities. There is currently a westbound bike lane on NW Lake Road, but there are no bike facilities along the other approaches to the study intersection. However, NW Lake Road does include an eastbound bike lane located west of the study intersection that terminates east of the NW Lake Road/NW Leadbetter Drive intersection.

The study intersection currently operates as stop-controlled on the minor approach (NW Sierra Street) with two northbound approach lanes (northbound left, northbound right), one eastbound approach lane (eastbound through/right), and two westbound approach lanes (westbound through, westbound left). The NW Lake Road approaches have a posted speed of 35 miles per hour (mph) and the NW Sierra Street approach has a posted speed of 25 mph. There are no transit facilities at or nearby the study intersection.

TRAFFIC DATA

24-hour Average Daily Traffic (ADT) data was collected at the study intersection on June 6th, 2023 and June 7th 2023 while school was still in session. Turning Movement Counts (TMC) were also collected at the study intersection on the same day as the ADT counts were collected during the a.m. peak (7-9 a.m.) and p.m. peak (4-6 p.m.) hours. Table 1 below summarizes the ADT counts collected and Table 2 summarizes the highest vehicular volume hour of TMC counts collected. All raw count sheets are included in the Appendix.

TABLE 1: 2023 AVERAGE DAILY TRAFFIC COUNT SUMMARY (2-DAY AVERAGE)

ROADWAY	ADT (TWO-WAY)
LAKE ROAD	10,392
SIERRA STREET	5,258

TABLE 2: 2023 TURNING MOVEMENT COUNT SUMMARY

INTERSECTION	TURNING MOVEMENT COUNT					
	NBL	NBR	EBT	EBR	WBL	WBT
A.M. PEAK HOUR						
LAKE ROAD/SIERRA STREET	103	251	371	89	96	357
P.M. PEAK HOUR						
LAKE ROAD/SIERRA STREET	91	125	504	148	93	318

As seen in the TMC data, the a.m. peak hour generally has less traffic than the p.m. peak hour, except on the northbound approach, where a.m. northbound right turn volumes are twice that of the p.m. peak hour.

In addition to the ADT and TMC counts, speed data was obtained at the intersection on the same day that counts were collected. The 85th percentile and 50th percentile speeds near the intersection are summarized in Table 3.

TABLE 3: 2023 SPEED DATA SUMMARY

ROADWAY	POSTED SPEED (MPH)	85TH PERCENTILE SPEED (MPH)	50TH PERCENTILE SPEED (MPH)
LAKE ROAD (WEST OF SIERRA ST)	35	39	36
LAKE ROAD (EAST OF SIERRA ST)	35	39	34
SIERRA STREET	25	32	27

SAFETY ANALYSIS

Crash data was obtained for the last five years of crash data available (2018-2022). The crash data was sourced from the City of Camas Crash Data online repository[1]. The crash data is summarized in Table 4.

TABLE 4: CRASH DATA SUMMARY

INTERSECTION	FATAL	SERIOUS INJURY	MINOR INJURY	POSSIBLE INJURY	PROPERTY DAMAGE ONLY	TOTAL
LAKE ROAD/SIERRA ST	0	0	0	0	4	4

As shown in Table 4, four crashes occurred at the intersection in the last five years, none of which resulted in injury. All crashes had different listed contributing circumstances, and no crashes indicated involvement with a pedestrian or cyclist. One crash involved a motorist exceeding the speed limit, another involved a motorist making an improper turn/merge, one involved a motorist failing to grant the right of way to another vehicle, and the last involved a driver becoming distracted while driving.

[1] https://www.arcgis.com/apps/webappviewer/index.html?id=1f0770574b0b4a0b8749ca2e52713612

EXISTING TRAFFIC OPERATIONS

Level of service (LOS) ratings and volume-to-capacity (v/c) ratios are two commonly used performance measures to describe the operations of an intersection.

- **Level of Service (LOS):** A "report card" rating (A through F) based on the average delay experienced by vehicles at the intersection. LOS A, B, and C indicate conditions where traffic moves without significant delays over periods of peak hour travel demand. LOS D and E are progressively worse operating conditions. LOS F represents conditions where average vehicle delay has become excessive, and demand has exceeded capacity.

- **Volume-to-capacity (v/c) ratio:** A decimal representation (typically between 0.00 and 1.00) of the proportion of capacity that is being used at a turn movement, approach leg, or intersection. It is determined by dividing the peak hour traffic volume by the hourly capacity of a given intersection or movement. A lower ratio indicates smooth operations and minimal delays. As the ratio approaches 1.00, congestion increases, and performance is reduced. If the ratio is greater than 1.00, the turn movement, approach leg, or intersection is oversaturated and usually results in excessive queues and long delays.

The study intersection is under the jurisdiction of the City of Camas, which requires an operating standard of LOS D at arterial/collector intersections, such as the study intersection[2].

Existing traffic operations at the study intersection was determined for the a.m. and p.m. peak hours based on the Highway Capacity Manual (HCM) 6th Edition methodology.[3] The results were then compared with the City of Camas' minimum acceptable operating standards. Table 5 lists the estimated v/c ratio, delay, and LOS of the study intersection. HCM 6 worksheets are included in the appendix.

TABLE 5: EXISTING (2023) INTERSECTION OPERATIONS

INTERSECTION	OPERATING STANDARD	AM PEAK HOUR[A]			PM PEAK HOUR[A]		
		V/C RATIO	DELAY (SECS)	LOS	V/C RATIO	DELAY (SECS)	LOS
LAKE ROAD/SIERRA STREET	LOS D	0.23/0.51	8.8/36.4	A/E	0.20/0.49	9.4/39.4	A/E

[A] Results shown for two way stop controlled intersection are shown as major approach results/minor approach results.

As shown, the existing operations for the minor approach at the study intersection does not meet the City of Camas' operating standards.

[2] https://www.cityofcamas.us/sites/default/files/fileattachments/public_works/page/9501/transportation_impact_study.pdf

[3] Highway Capacity Manual, 6th Edition, Transportation Research Board, 2016.

FUTURE 2045 CONDITIONS

This section summarizes future conditions of the Lake Road/Sierra Street study intersection, including discussion of methods and assumptions used to discuss the planning scenarios used and traffic volumes forecasts, and a discussion about the operations and feasibility for each of the build options analyzed.

METHODS AND ASSUMPTIONS

The following section details the methods and assumptions utilized to develop conditions for the future scenarios analyzed.

DESIGN YEAR AND SCENARIOS

The design year for all future scenarios is 2045 - 20 years from the assumed year of opening. The following scenarios were analyzed as potential future options for intersection control at Lake Road/Sierra Street in the a.m. and p.m. peak hours.

1. No Build – This scenario maintains the current configuration of the study intersection, with a stop-controlled leg for the northbound movement and free flowing conditions on the east and west legs.
2. Signalization – This scenario would replace the current intersection control with a traffic signal at the study intersection and add an eastbound right turn lane with 200 feet of storage.
3. Roundabout – This scenario would replace the current intersection control with a single lane roundabout with an additional eastbound right turn lane and a northbound right turn slip lane.

VOLUME FORECAST

Year 2045 scenario analysis utilized volumes developed for the 2023 Camas Transportation System Plan (TSP) update as a baseline for the forecast. The 2023 Camas TSP update volume forecasts use the SWRTC regional model to assign traffic volumes to the transportation system and considered the diversion effects of financially constrained projects to be built in the city by the TSP planning horizon. For the 2023 Camas TSP update, 2040 p.m. peak hour volumes were forecast. To adjust these to 2045 for the p.m. peak, a 1% growth rate was assumed between 2040 and 2045.

A.m. peak volumes were developed using the following steps:

1. Determine the percentage growth rate for each turning movement at the study intersection during the p.m. peak between the 2023 p.m. peak volumes collected for this project and the 2040 forecast volumes from the Camas TSP update.
2. Apply this growth rate to the 2023 a.m. peak volumes collected for this project.
3. Adjust to 2045 using a 1% growth rate for the 5 years between 2040 and 2045.

The 2045 a.m. and p.m. peak hour volume forecasts are shown in Table 6.

TABLE 6: 2045 VOLUME FORECASTS

PEAK HOUR	TURN MOVEMENT VOLUMES					
	NBL	NBR	EBT	EBR	WBL	WBT
A.M. PEAK HOUR	170	540	685	175	190	455
P.M. PEAK HOUR	150	270	930	290	185	405

FUTURE SCENARIO OPERATIONS ANALYSIS

The following section details the operational results and geometric needs for each future scenario.

SCENARIO 1: NO BUILD

This scenario shows the operational results of the intersection if no mitigations were made at the intersection in the design year.

No Build traffic operations at the study intersection was determined for the a.m. and p.m. peak hours based on the Highway Capacity Manual (HCM) 6th Edition methodology.[4] The results were then compared with the City of Camas' minimum acceptable operating standards. Table 7 lists the estimated v/c ratio, delay, and LOS of the study intersection. HCM 6 worksheets are included in the appendix. Table 8 shows the 95th percentile queuing that would be present under these conditions. Queuing information is obtained by averaging queues for 10 runs of SimTraffic (11th edition).

TABLE 7: SCENARIO 1 (NO BUILD) INTERSECTION OPERATIONS

INTERSECTION	OPERATING STANDARD	AM PEAK HOUR[A]			PM PEAK HOUR[A]		
		V/C RATIO	DELAY (SECS)	LOS	V/C RATIO	DELAY (SECS)	LOS
LAKE ROAD/SIERRA STREET	LOS D	0.29/2.83	11.8/>100	B/F	0.36/3.63	15.4/>100	C/F

[A] Results shown for two way stop controlled intersection are shown as major approach results/minor approach results.

[4] Highway Capacity Manual, 6th Edition, Transportation Research Board, 2016.

TABLE 8: SCENARIO 1 (NO BUILD) QUEUING RESULTS

SCENARIO	NBL	NBR	EBT	EBR	WBL	WBT
STORAGE SPACE	175'	400'	1750'	1750'	125'	1780'
A.M. PEAK HOUR 95TH PERCENTILE QUEUE	**250'**	**>1000'**	50'	50'	100'	150'
P.M. PEAK HOUR 95TH PERCENTILE QUEUE	**250'**	**>1000'**	50'	50'	150'	1175'

BOLD AND RED indicate queue that exceeds storage.

As shown in Tables 7 and 8, under No Build conditions the operating standards would fail to be met, and the 95th percentile queues for the northbound right, northbound left, and westbound through movements are expected to surpass the amount of storage.

SCENARIO 2: SIGNALIZATION

This scenario shows the operational results of the intersection if the existing intersection control were replaced with a traffic signal in the design year.

Signal Warrant Analysis

A necessary pre-requisite to the consideration of this alternative is determining whether the study intersection would meet traffic signal warrants per the Manual for Uniform Traffic Control Devices (MUTCD)[5]. The signal warrants evaluated include Warrant 1: Eight-Hour Vehicular Volumes and Warrant 2: Four-Hour Vehicular Volumes. To determine if these warrants are met, the 24-hour ADT counts collected for this study were used to determine the vehicular traffic on both the major and minor roadway.

Warrant 1 is met if either/both conditions are satisfied from Table 4C-1 of the MUTCD for eight hours of vehicle volume. The geometry of the existing intersection indicates that the volume thresholds necessary for meeting Condition A of this warrant are 500 on the major approach (total of both approaches) and 150 on the minor approach (one direction only). The volumes thresholds for Condition B are 750 on the major approach (total of both approaches) and 75 for the minor approach. Table 9 below shows the number of hours in the day that these thresholds are met at the intersection.

[5] https://mutcd.fhwa.dot.gov/htm/2009/part4/part4c.htm

TABLE 9: WARRANT 1 RESULTS

WARRANT CONDITION	HOURS EXCEEDING VOLUME THRESHOLDS	HOURS REQUIRED TO MEET WARRANT
CONDITION A	9	8
CONDITION B	4	8

Warrant 2 is met if 4 hours of the vehicle volumes, when plotted on the graph presented in MUTCD Figure 4C-1, fall above the appropriate curve. Figure 1 shows the hourly volumes at the study intersection plotted on Figure 4C-1.

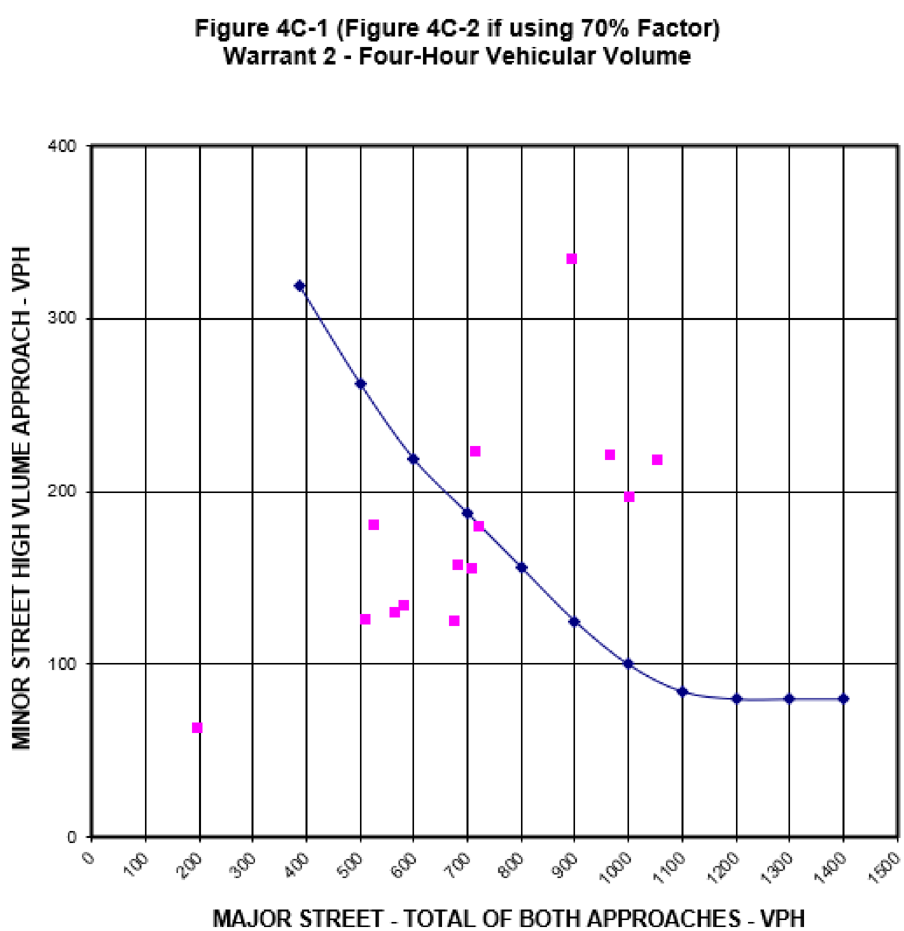

FIGURE 1: SIGNAL WARRANT 2 RESULTS

Utilizing MUTCD methodology for Signal Warrant Analysis, both Warrant 1 and Warrant 2 are met under existing conditions without reduction factors.

Geometric Requirements

Intersection operations analysis revealed necessary changes to the intersection geometry that would be necessary to see operations that meet mobility standards. Namely, it will be vital to widen the west leg of Lake Road to include a dedicated eastbound right turn lane approaching the new signalized intersection. This dedicated right turn lane is necessary because of the high volume of eastbound through movements present at the intersections, particularly in the p.m. peak.

Signalization Assumptions

The following signal timing assumptions were made for the operations analysis of the signalized intersection scenario:

- 100 second cycle length.
- Minimum recall on eastbound and westbound through movements.
- Protected-permissive phasing for westbound left movements.
- Protected with overlap phasing for northbound right movements.
- Right-turn-on-red is allowed.

Intersection Operations

Signalized traffic operations at the study intersection were determined for the a.m. and p.m. peak hours based on the Highway Capacity Manual (HCM) 6th Edition methodology. The results were then compared with the City of Camas' minimum acceptable operating standards. Table 11 lists the estimated v/c ratio, delay, and LOS of the study intersection. HCM 6 worksheets are included in the appendix. Table 12 shows the 95th percentile queuing that would be present under these conditions. Queuing information is obtained by averaging queues for 10 runs of SimTraffic (11th edition).

TABLE 10: SCENARIO 2 (SIGNALIZATION) INTERSECTION OPERATIONS

INTERSECTION	OPERATING STANDARD	AM PEAK HOUR[A]			PM PEAK HOUR[A]		
		V/C RATIO	DELAY (SECS)	LOS	V/C RATIO	DELAY (SECS)	LOS
LAKE ROAD/SIERRA STREET	LOS D	0.93	20.5	C	0.73	12.3	B

TABLE 11: SCENARIO 2 (SIGNALIZATION) QUEUING RESULTS

SCENARIO	NBL	NBR	EBT	EBR	WBL	WBT
STORAGE SPACE	175′	400′	1750′	300′	125′	1780′
A.M. PEAK HOUR 95TH PERCENTILE QUEUE	**275′**	**550′**	800′	275′	**150′**	600′
P.M. PEAK HOUR 95TH PERCENTILE QUEUE	150′	225′	800′	300′	**150′**	350′

BOLD AND RED indicate queue that exceeds storage.

As shown in Tables 11, under signalized conditions the expectation is that operating standards would be met. Based on the results in Table 12, the new eastbound right turn lane must be at least 300 feet to meet queuing needs, and the northbound left turn lane needs to be extended to accommodate storage needs. Moreover, the westbound left turn lane should be extended by at least 25 feet to meet queuing needs and the northbound right turn lane 95th percentile a.m. peak hour queue will spill back past 45th Avenue.

SCENARIO 3: ROUNDABOUT

This scenario shows the operational results of the intersection if the existing intersection control were replaced with a roundabout in the planning horizon year.

Geometric Requirements

The geometric design requirements for a roundabout are a very important consideration any time a roundabout is being considered as an intersection control type. At the site of the study intersection, there is a significant grade drop that makes it challenging to widen to the north, and widening south of the intersection is also challenging due to utility conflicts and right of way constraints. In testing the type of roundabout that would meet operational needs in 2045, the first iteration was a single lane roundabout on all approaches. This approach was determined to fail in the p.m. peak because there is not enough capacity under these conditions to accommodate eastbound traffic (1.16 v/c ratio on west leg). Failure would also occur in the a.m. peak because there is not enough capacity to accommodate northbound traffic (1.56 v/c). The high level of eastbound through movements do not provide enough gaps for northbound traffic, resulting in significant delays and queuing.

In order to meet mobility standards, additional lanes were added to the roundabout to alleviate the capacity constraints given the site characteristics and context of surrounding roadways. The final roundabout layout includes an additional eastbound right turn only lane, and an additional northbound right turn slip lane. Figure 2 below shows a snip from the Sidra model used for analysis of the final layout.

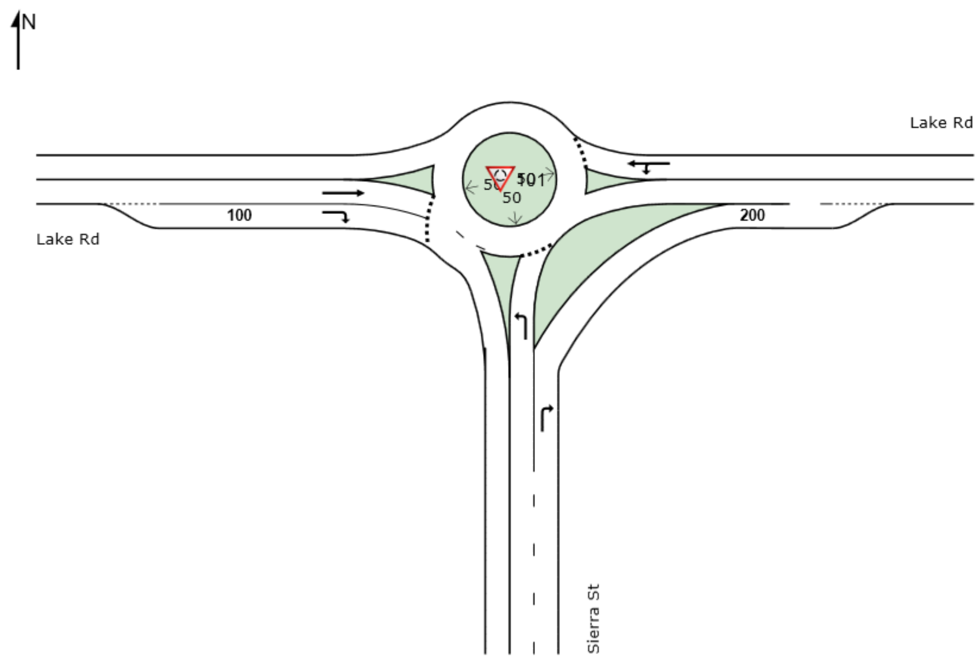

FIGURE 2: SCENARIO 3 ROUNDABOUT LAYOUT

Storage lengths shown for turn lanes in Figure 2 were used as placeholders and should be refined based on site conditions in the design phase. The northbound right turn slip lane shown is schematic, the radius of the median separating the slip lane from the roundabout is shown for illustrative purposes only. The specific geometrics will be determined in the conceptual design section of the alternatives analysis.

Intersection Operations

Roundabout traffic operations at the study intersection were determined for the a.m. and p.m. peak hours based on the Highway Capacity Manual (HCM) 6th Edition methodology. The results were then compared with the City of Camas' minimum acceptable operating standards. Table 13 lists the estimated v/c ratio, delay, and LOS of the study intersection. HCM 6 worksheets are included in the appendix. Table 14 shows the 95th percentile queuing that would be present under these conditions. Queuing information is obtained by using queues reported in the movement summary of Sidra 9th Edition Reports.

TABLE 12: SCENARIO 3 (ROUNDABOUT) INTERSECTION OPERATIONS

INTERSECTION	OPERATING STANDARD	AM PEAK HOUR[A]			PM PEAK HOUR[A]		
		V/C RATIO	DELAY (SECS)	LOS	V/C RATIO	DELAY (SECS)	LOS
LAKE ROAD/SIERRA STREET	LOS D	0.78	11.9	B	0.83	13.0	B

TABLE 13: SCENARIO 3 (ROUNDABOUT) QUEUING RESULTS

SCENARIO	NBL	NBR	EBT	EBR	WBT/L
STORAGE SPACE	175'	400'	1750'	50'	1780'
A.M. PEAK HOUR 95TH PERCENTILE QUEUE	30'	0'	425'	20'	200'
P.M. PEAK HOUR 95TH PERCENTILE QUEUE	30'	0'	650'	50'	100'

BOLD AND RED indicate queue that exceeds storage.

As shown in Table 11, operating standards would be met under the proposed roundabout design. Based on the results in Table 12, the new eastbound right turn lane must be at least 50 feet to meet queuing needs but should be built out to the maximum length feasible to benefit operations in the p.m. peak.

CONCLUSIONS

Overall, based on intersection operational analyses alone, both Build Scenario 2 and Build Scenario 3 would be able to accommodate the projected traffic in 2045 at the NW Lake Road/NW Sierra Street intersection under the assumed geometric layouts. However, while both options operate in 2045 with relatively low delays, especially compared with the No Build, each option presents challenges under the future volume projections.

Due to the high amount of northbound right turning traffic, this movement is expected to have queuing in the a.m. peak hour that will spillback through the NW 45th Avenue intersection under a traffic signal configuration. For the roundabout alternative, a northbound right turn slip lane is critical for intersection operations. However, given the geometric constraints and existing roadway width east of the intersection along NW Lake Road, this option has additional physical challenges and is more expensive financially.

Lastly, it is worth noting that this report is meant to summarize the results of the traffic operational performance of the proposed scenarios. Further detailed alternatives analysis between Build Scenario 2 and Build Scenario 3 is needed to determine the appropriate intersection treatment.