Appendix K. Alternative Concepts Report

Auke Bay Corridor Study

Auke Bay Corridor Study
Conceptual Analysis
May 12, 2003

USKH, Inc.

Introduction

The purpose of this report is to document the preliminary qualitative and quantitative evaluation of each concept's compliance with the preliminary purpose and need statement. The preliminary purpose and need statement is summarized below:

Purpose

The purpose of the Auke Bay Corridor project is to improve surface transportation along the Glacier Highway corridor, between Fritz Cove Road and the Auke Bay Ferry Terminal. The improvement should provide sufficient capacity to safely handle the traffic demands for a 20-year design life.

Need

The following are the needs for the project:

- Improve the safety of identified intersections and segments:
    - The Mendenhall (Back) Loop Road and Glacier Highway intersection system has a high collision rate.
    - The Fritz Cove Road, Glacier Highway, University of Alaska Southeast (UAS) intersection system has a high number of conflicts.
    - The Auke Nu Drive to Ferry Terminal segment on Glacier Highway has a high collision rate.
    - The segment of Back Loop Road, between University Drive and the UAS entrance, has a high collision rate.
- Improve the substandard geometric design deficiencies along the existing road alignment:
    - Four horizontal curves on Glacier Highway have radii that are less than the minimum radii for both the posted and design speeds.
        - Near the National Marine Fisheries Service (NMFS) lab
        - At the intersection with Back Loop Road
        - Near the Auke Bay post office
        - At Stabler's Point
    - The curve near the NMFS lab exhibits features that could be unexpected to drivers:
        - Spiral curve
        - Substandard superelevation
        - Poor sight distance

  - Residents report Fritz Cove Road as an intersection with sight distance concerns.
  - There are potential sight distance problems at the DeHart's exit.
  - Back Loop Road and Glacier Highway intersection has a less than desirable layout due to skew angles on both the right and left turn lanes impacting the driver's ability to take full advantage of the available sight distance.
- Provide more reliable, efficient, convenient and cost effective movement throughout the corridor
- Enhance non-motorized access on, off and across the corridor:
  - There are two schools (Auke Bay Elementary School and the University of Alaska Southeast (UAS)) located in the project corridor
  - The corridor provides access to popular boating and recreation opportunities. Bicyclists and pedestrians walk and bike for recreation. Many other pedestrians in the area are marina users who walk from remote parking areas to the harbor.

USKH Inc. (USKH) developed a range of concepts to address specific project problem areas and to meet the preliminary purpose and need. Sixteen discrete segments were identified for possible improvements to the corridor. The segments either identified new alignments or proposed improvements to the existing Glacier Highway alignment. USKH and DOT&PF then held meetings with the Project Steering Committee (PSC), the Citizens Advisory Committee (CAC) and the public to solicit additional ideas. Using this wide range of ideas, we then combined the discrete segments into seven concept alternatives to address the entire project corridor. We considered construction alternatives as well as Traffic Demand Management (TDM).

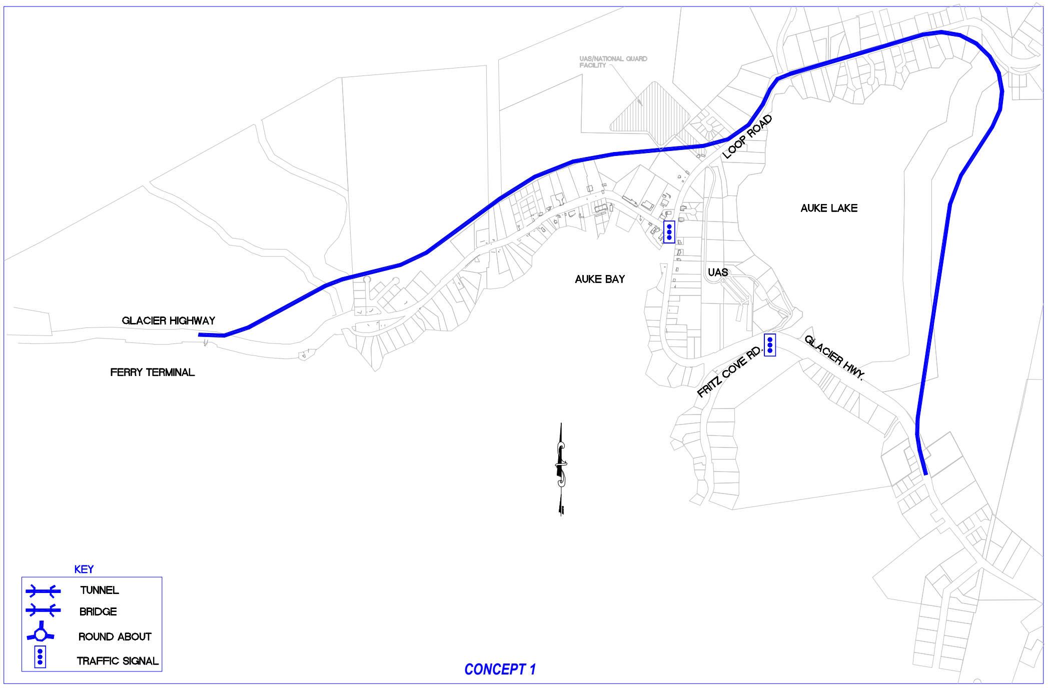
Below is a narrative discussion of each concept alternative and how it qualitatively and quantitatively meets the preliminary purpose and need statement. Appendix A has a summary matrix that qualitatively compares each concept alternative and its compliance with the purpose and need statement. There is a graphical drawing of the seven concepts in Appendix B. Appendix C shows a comparison by length and travel time for the concepts, and Appendix D contains a detailed cost estimate. Appendices E and F contain a discussion on TDM and a description of the width of the major cross section road elements.

Conceptual Evaluation

Concept 1

Concept 1's alignment begins on Glacier Highway between Engineers Cutoff Road and Auke Lake. The new alignment follows the east and north sides of Auke Lake and connects to Back Loop Road near Goat Hill. It continues along Back Loop Road to Lee Drive, then follows a new alignment north of Glacier Highway, reconnecting to Glacier Highway near the ferry terminal.

The Back Loop Road and Fritz Cove Road intersections would be upgraded with signals. The existing Glacier Highway would not receive any major geometric improvements within the corridor. The curves at the NMFS lab, Auke Bay post office, and Stabler's Point would all remain unchanged. The area between University Drive



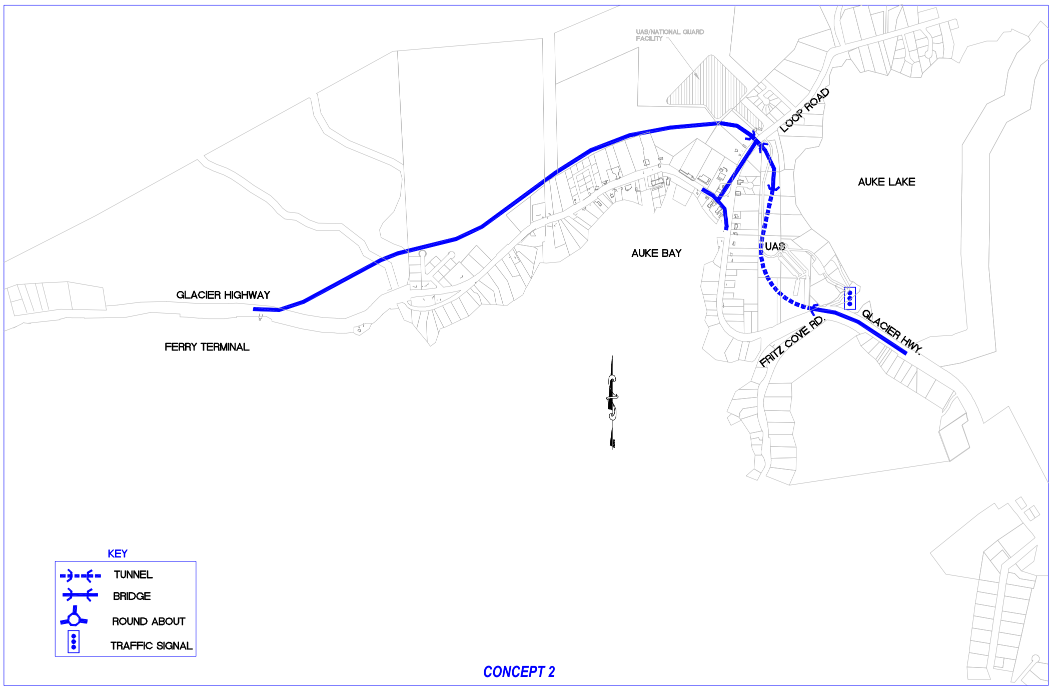
and UAS entrance on Back Loop Road would be improved to accommodate increased vehicular and pedestrian traffic. Sidewalks would be added on both sides of Glacier Highway from Fritz Cove Road to Waydelich Creek and Back Loop Road between Glacier Highway and the UAS entrance. This concept includes a pathway on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal. This concept would cost about $72 million.

- The existing geometric deficiencies at Back Loop Road and Fritz Cove Road intersections would remain. However, both intersections would be upgraded with traffic signals.
- The Auke Nu Drive to ferry terminal segment would remain unchanged.
- Access from Back Loop Road to University Drive and UAS would be improved.
- The substandard horizontal curves at the NMFS lab, Auke Bay post office, and Stabler's Point on Glacier Highway would remain unchanged.
- Sight distance conditions at the Fritz Cove Road and Back Loop Road intersections with Glacier Highway would remain the same.
- This concept upgrades pedestrian and bicycle facilities along Glacier Highway and provides facilities (shoulders) on new alignments. It also includes a pathway on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal.
- Access would be provided to undeveloped CBJ property on the east side of Auke Lake and above Auke Bay.

Concept 2

This concept diverges from Glacier Highway near the intersection with the UAS entrance and Fritz Cove Road. The new alignment would tunnel underneath the UAS campus and then daylight near the existing UAS entrance on Back Loop Road. A new intersection would be designed and constructed northeast of the existing Back Loop and

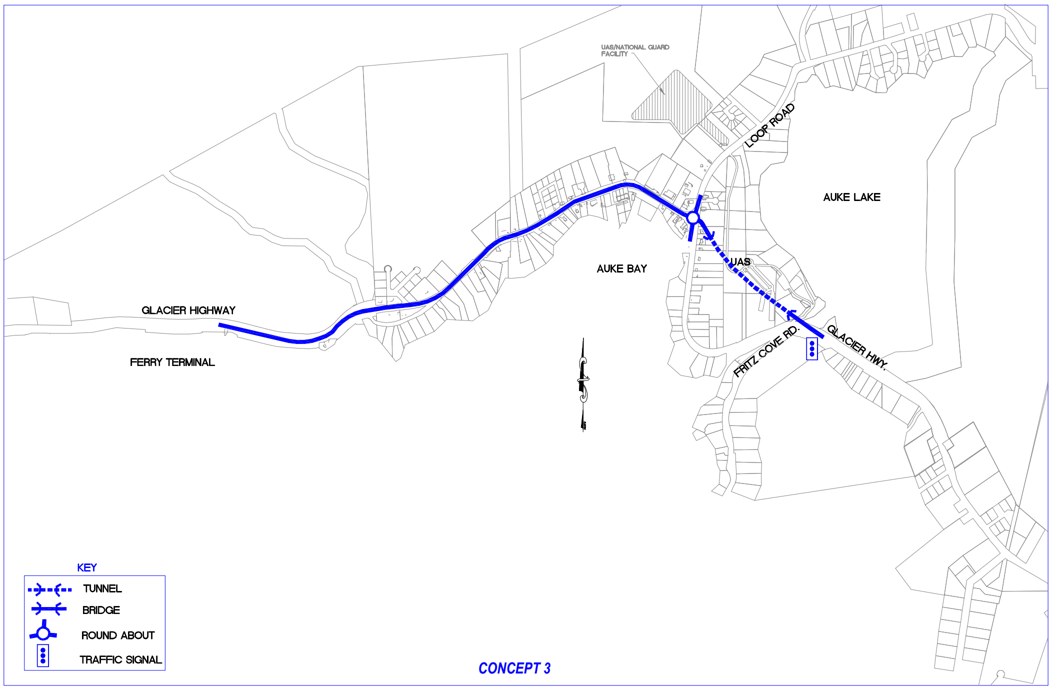
Glacier Highway intersection. Concept 2 includes an overpass at Back Loop Road and then follows the same alignment as Concept 1 to the ferry terminal.



The Fritz Cove Road intersection would be signalized. The Back Loop Road intersection with Glacier Highway could be reconfigured in conjunction with the new intersection and overpass. The existing Glacier Highway would not receive any major geometric improvements within the corridor. The curves at the NMFS lab, Auke Bay post office, and Stabler's Point would all remain unchanged. The area between University Drive and UAS entrance on Back Loop Road would be improved to accommodate increased vehicular and pedestrian traffic. Sidewalks would be added on both sides of Glacier Highway from Fritz Cove Road to Back Loop Road. This concept includes a pathway on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal. This concept would cost about $201 million.

- The existing geometric deficiencies at Fritz Cove Road intersections would remain the same. However, the intersection would be upgraded with a signal.
- The Back Loop Road intersection could be reconfigured in conjunction with the new intersection and overpass.
- The Auke Nu Drive to ferry terminal segment would remain unchanged.
- Back Loop Road between University Drive and UAS entrance would be improved.
- The substandard horizontal curves at the NMFS lab, Auke Bay post office, and Stabler's Point on Glacier Highway would remain unchanged.
- Sight distance conditions at the Fritz Cove Road intersection with Glacier Highway would remain the same.
- This concept upgrades pedestrian and bicycle facilities along Glacier Highway and provides facilities (shoulders) on new alignments. This concept also includes a pathway on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal.
- Access would be provided to undeveloped CBJ property above Auke Bay.

Concept 3

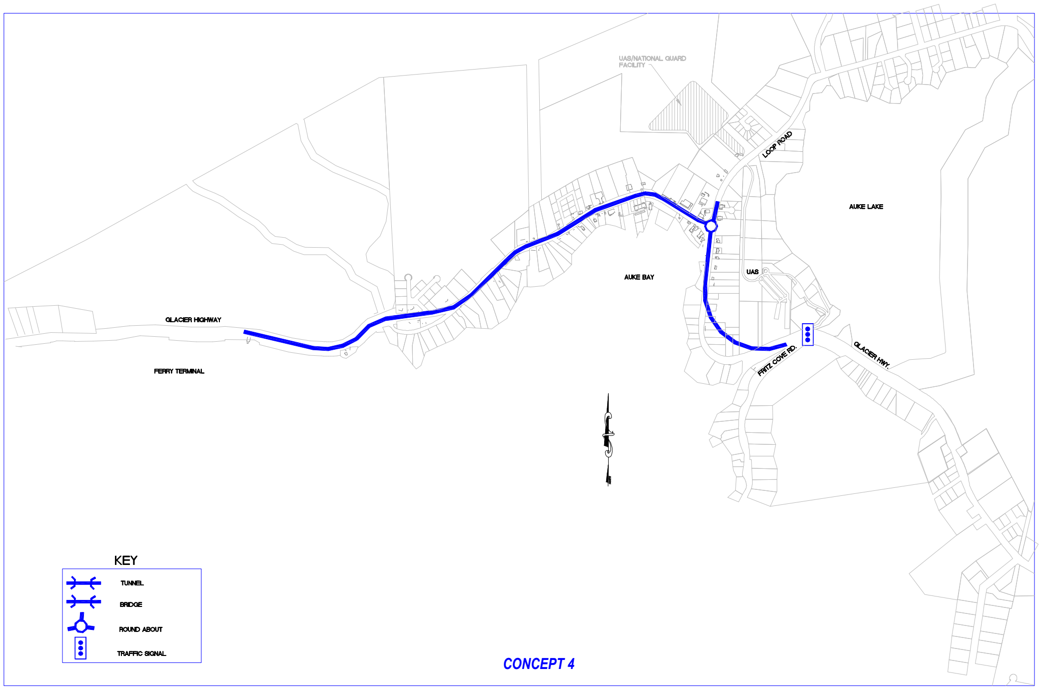


This concept also diverges from Glacier Highway near the intersection with the UAS entrance and Fritz Cove Road. Concept 3 includes tunneling beneath the UAS campus, then daylighting near the existing Back Loop Road and Glacier Highway intersection. The addition of this new leg makes this a four-way intersection. This concept then follows the existing Glacier Highway alignment to the ferry terminal.

A roundabout would be constructed at the Back Loop Road intersection and a signal would be installed at Fritz Cove Road. The segment of highway from Auke Nu to the ferry terminal would be upgraded, but the area between University Drive and the UAS entrance on Back Loop Road remains unchanged. Since the new alignment bypasses the NMFS lab curve, this section of Glacier Highway also remains unchanged. The curves at the Auke Bay post office and Stabler's Point would be upgraded to standard. Sidewalks would be added on both sides of Glacier Highway from Fritz Cove Road to Waydelich Creek and on Back Loop Road between Glacier Highway and the UAS entrance. This concept also includes a pathway on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal. This concept would cost about $126 million.

- The geometric deficiencies associated with the existing intersection at Back Loop Road would be corrected
- The geometric deficiencies associated with the existing intersections Fritz Cove Road would remain. However, the intersection would be signalized.
- The Auke Nu Drive to ferry terminal segment would be improved.
- Back Loop Road between University Drive and UAS entrance would remain unchanged, except for new sidewalks.
- The horizontal curve at the NMFS lab would remain unchanged.
- The horizontal curves at Auke Bay post office and Stabler's Point on Glacier Highway would be brought up to standards.
- Sidewalks would be added from Fritz Cove Road to Waydelich Creek and a pathway on the beach side from Waydelich Creek to the ferry terminal.

Concept 4

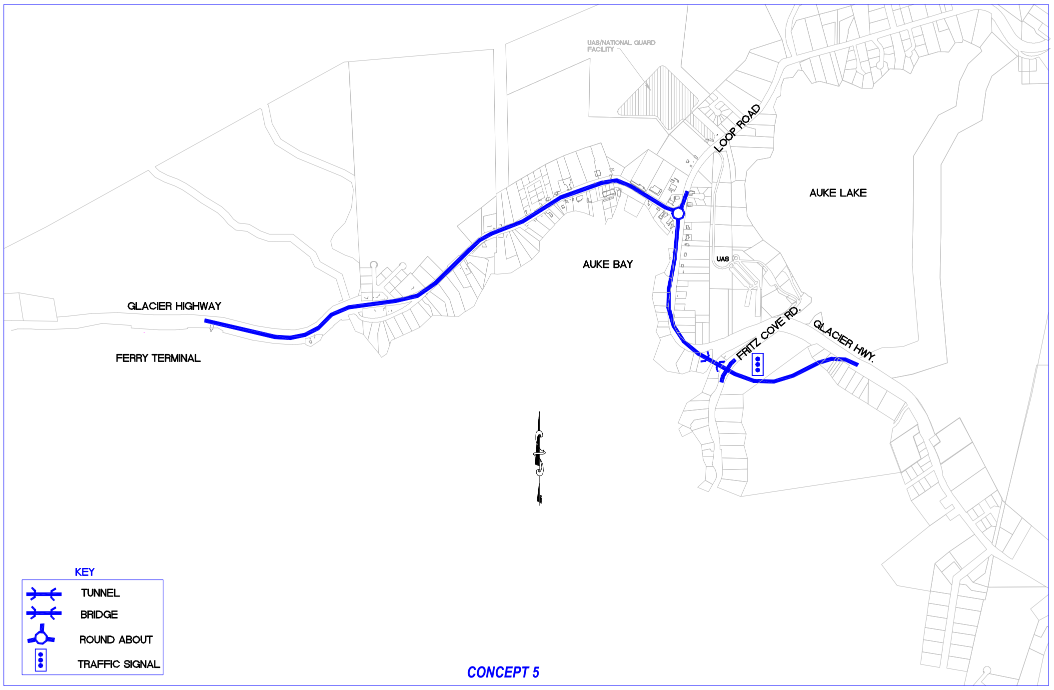


This concept realigns the existing curve near the NMFS lab to standards, but otherwise follows the existing Glacier Highway alignment through the corridor. Substandard geometry would be upgraded, requiring minor realignments in several areas. A signal would be installed at Fritz Cove Road and a roundabout constructed at the Back Loop Road intersection. The segment between University Drive and the UAS entrance on Back Loop Road remains unchanged.

Sidewalks would be added on both sides of Glacier Highway from Fritz Cove Road to Waydelich Creek and on Back Loop Road between Glacier Highway and the UAS entrance. A continuous two-way left turn lane or a combination of left-turn pockets and center medians with landscaping would be constructed between the NMFS lab and Waydelich Creek. This segment could include a streetscape with trees or plantings in the median and between the highway and sidewalks. A pathway would be added on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal. This concept would cost about $14 million.

- The geometric deficiencies associated with the existing intersections at Back Loop Road would be corrected
- The geometric deficiencies associated with the existing intersections Fritz Cove Road would be improved and a signal would be installed.
- The Auke Nu Drive to ferry terminal segment would be improved.
- Back Loop Road between University Drive and UAS entrance would remain unchanged.
- The horizontal curves at the NMFS lab, Auke Bay post office, and Stabler’s Point on Glacier Highway would be brought up to standards.
- Sight distance at Fritz Cove Road and DeHart’s would be improved.
- This concept would add sidewalks on both sides from Fritz Cove to Waydelich and a pathway on the beach side from Waydelich to the ferry terminal.

Concept 5

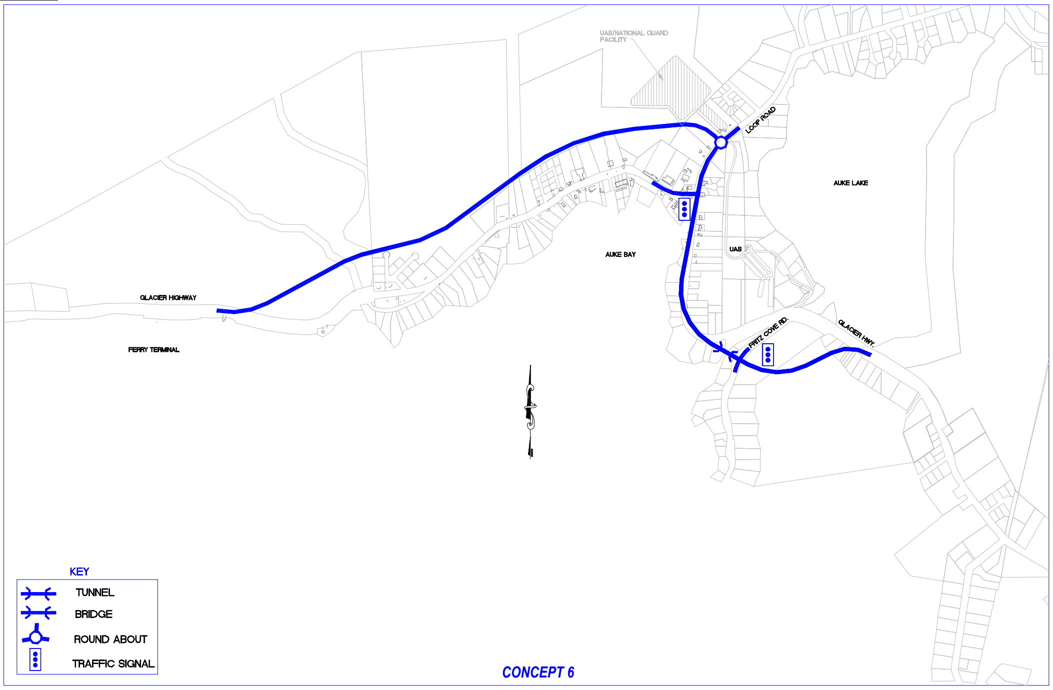


This concept departs from the Glacier Highway alignment between Pederson Hill and Fritz Cove Road, bearing south to a new crossing of Auke Creek before rejoining Glacier Highway near the NMFS lab. It results in improving the NMFS lab curve to meet standards. This concept then follows the existing Glacier Highway alignment to the ferry terminal, but upgrades the alignment to meet current standards.

A new intersection with Fritz Cove Road would be constructed south of the existing intersection, which could be abandoned or reconfigured to improve non-motorized access between the main UAS campus and the Anderson Building/NMFS lab. The Fritz Cove intersection would be signalized. This concept includes a roundabout at Back Loop Road. The segment between University Drive and the UAS entrance on Back Loop Road would remain unchanged. Typical sections and non-motorized facilities would be similar to Concept 4. This concept would cost about $30 million.

- The geometric deficiencies associated with the existing intersections at Back Loop Road would be corrected
- A new intersection with Fritz Cove Road would be constructed south of the existing intersection.
- The Auke Nu Drive to ferry terminal segment would be improved.
- Back Loop Road between University Drive and UAS entrance would remain unchanged.
- The horizontal curves at the NMFS lab, Auke Bay post office, and Stabler’s Point on Glacier Highway would be brought up to standards.
- Sight distance conditions at Fritz Cove Road and DeHart’s would be corrected.
- This concept would add sidewalks on both sides from Fritz Cove to Waydelich and a pathway on the beach side from Waydelich to the ferry terminal.

Concept 6



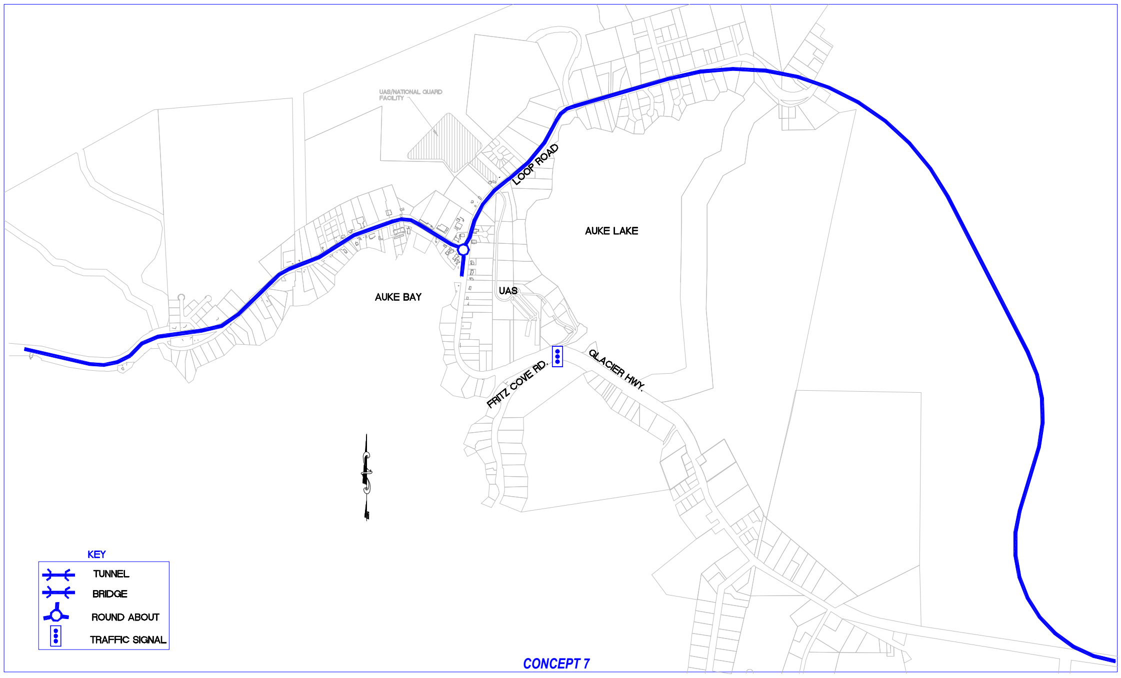
This concept follows the same alignment as Concept 5 to the Back Loop Road intersection. The alignment continues on Back Loop Road to the intersection with Concept 2 then follows the Concept 2 alignment to the ferry terminal.

The Back Loop Road and Fritz Cove Road intersections with Glacier Highway would be signalized. The existing Glacier Highway between Back Loop Road and the ferry terminal would not receive any major geometric improvements. The curves at the Auke Bay post office and Stabler's Point, and the area between University Drive and UAS entrance on Back Loop Road, would remain unchanged. Sidewalks would be added on both sides of Glacier Highway from Fritz Cove Road to Back Loop Road.. This concept also includes a pathway on the beach side of Glacier Highway from Waydelich Creek to the ferry terminal. This concept would cost about $63 million.

- The geometric deficiencies associated with the existing intersections at Back Loop Road and Fritz Cove Road would be corrected. A roundabout would be built at Back Loop Road.
- A new signalized intersection with Fritz Cove Road would be constructed south of the existing intersection.
- Back Loop Road between University Drive and UAS entrance would remain unchanged.
- The horizontal curves at the NMFS lab would be brought up to standards.
- Sight distance conditions at Fritz Cove Road and DeHart's would be corrected.
- Both the Auke Nu Drive to ferry terminal segment and Back Loop Road, between University Drive and UAS entrance, would remain unchanged.
- The horizontal curve at the NMFS lab would be brought up to standards.
- The horizontal curves at the Auke Bay post office and Stabler's Point on Glacier Highway would remain unchanged.

- This concept would add sidewalks on both sides of Glacier Highway from Fritz Cove to Waydelich Creek, a pathway on the beach side from Waydelich Creek to the ferry terminal, and shoulders on the new bypass route.
- Access would be provided to undeveloped CBJ property above Auke Bay.

<u>Concept 7</u>



Concept 7 leaves Glacier Highway between Industrial Boulevard and Sherwood Lane. It circles the east side of Pederson Hill and connects to Back Loop Road near Goat Hill. It then follows Back Loop Road to the intersection with Glacier Highway and follows the Glacier Highway alignment to the ferry terminal.

A roundabout would be constructed at the Back Loop Road intersection. The segment of highway from Fritz Cove Road to the ferry terminal would remain unchanged. This concept would cost approximately $43 million.

- The geometric deficiencies associated with the existing intersection at Back Loop Road would be corrected.
- The geometric deficiencies associated with the existing intersections Fritz Cove Road would remain, but it would be signalized.
- Deficiencies associated with the Fritz Cove Road to ferry terminal segment would remain.
- Back Loop Road between Goat Hill Road and UAS entrance would remain the same.
- The horizontal curves at the NMFS lab, Auke Bay post office, and Stabler's Point on Glacier Highway would remain unchanged.
- Sight distance conditions at Fritz Cove Road would remain unchanged.
- This concept would add shoulders for pedestrians to walk on the new bypass route around Auke Lake and behind Auke Bay.

- This concept would add sidewalks on both sides from Fritz Cove Road to Waydelich Creek and a pathway on the beach side from Waydelich Creek to the ferry terminal.
- Access would be provided to undeveloped CBJ property on the east side of Auke Lake.

TDM Alternative

Traffic Demand Management (TDM) uses strategies and tactical actions that are designed to influence people's travel behavior to reduce congestion. Primarily, they are aimed at large employers and centers of commerce. TDM is most effective when the site has a high number of employees, such as at UAS, where many commuters could vanpool or commute together toward a common destination. Surveys of TDM programs at large businesses have shown that TDM could produce a 20-50% reduction in site trips, and that a TDM program developed for a concentrated subarea or corridor have had about 2% to 18% reduction in trips. A local government agency is usually used to manage and coordinate these subarea TDM programs.

For the ABCor Study, UAS does not have an actively managed TDM program and the bus system, Capital Transit, is the only TDM measure. With very successful improvements to the bus system, such as implementation of the proposed Route 5, CBJ's Capital Transit system would provide about a 6 percent reduction in AADT at best. This reduction does not change the future need for improvements in the corridor. Therefore, the purpose and need for the Auke Bay Corridor Study would not be satisfied with an exclusive TDM alternative. See Appendix E for a further discussion on TDM.

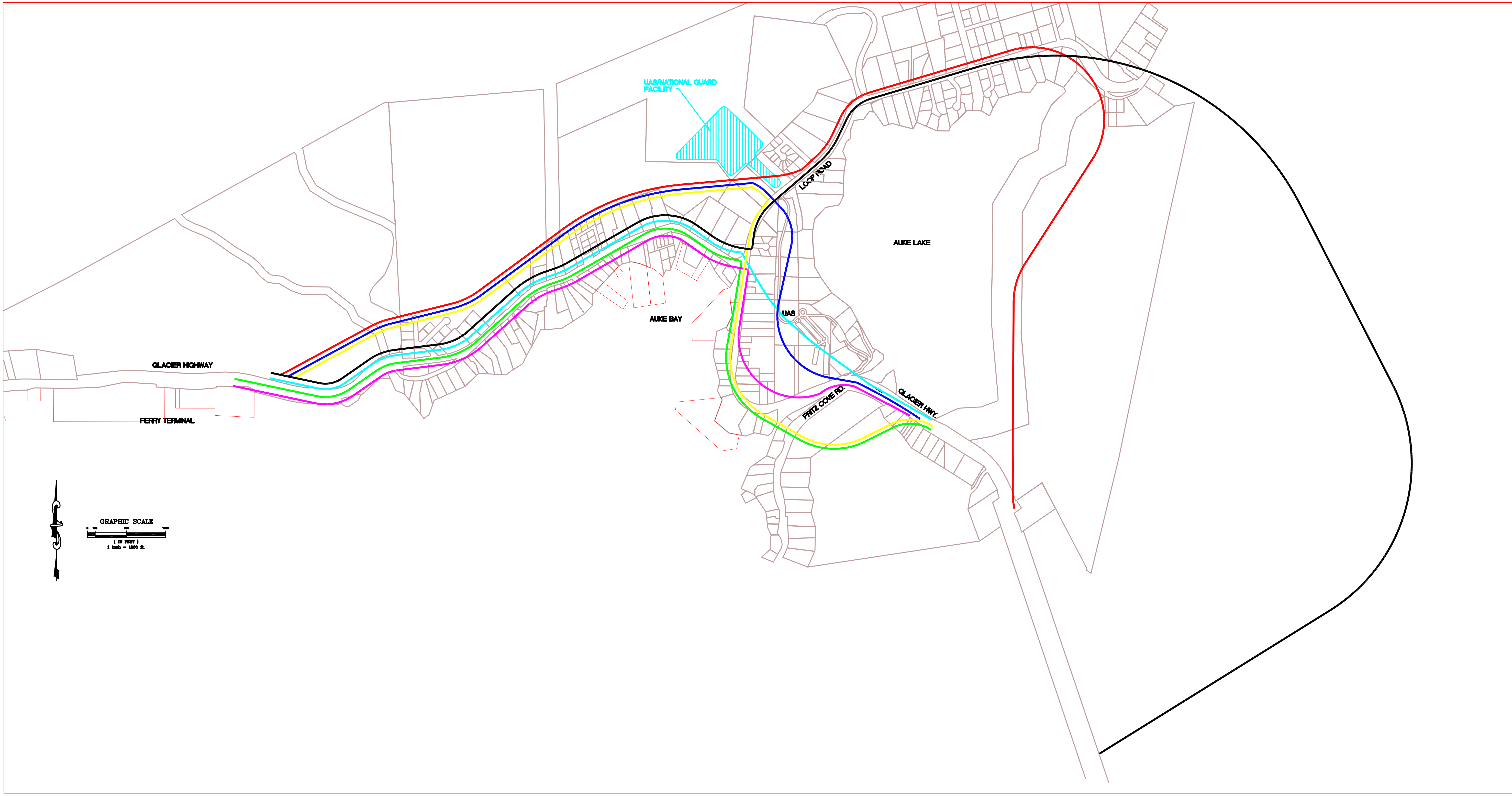
Appendix A

Concepts Evaluation Matrix

The purpose of the Auke Bay Corridor project is to improve surface transportation along the Glacier Highway corridor, between Fritz Cove Road and the Auke Bay Ferry Terminal. The improvement should provide sufficient capacity to safely handle the traffic demands for a 20-year design life.

Appendix B

Alignment Exhibit



ALIGNMENT KEY

1	RED	5	GREEN
2	BLUE	6	YELLOW
3	CYAN	7	BLACK
4	PURPLE		

Appendix C

Concepts Length and Time to Travel

Concepts Distances and Time to Travel

Concept	Total Distance (ft.)	Time	
		Seconds	Minutes
1	21538	294	**4.90**
2	17996	257	**4.28**
3	15647	243	**4.06**
4	16073	251	**4.18**
5	18127	286	**4.76**
6	20026	293	**4.88**
7	24064	356	**5.94**
Existing	14297	274	**4.56**

Appendix D

Concepts Cost Estimates

Concepts Cost Estimates

	Concept 1	Concept 2	Concept 3	Concept 4
Construction Subtotal:	$36,507,000.00	$96,303,000.00	$77,388,000.00	$8,534,000.00
Construction Coningency (10%):	$3,650,700.00	$9,630,300.00	$7,738,800.00	$853,400.00
Construction Total:	$40,157,700.00	$105,933,300.00	$85,126,800.00	$9,387,400.00
Design (10%):	$4,015,770.00	$10,593,330.00	$8,512,680.00	$938,740.00
Right of Way:	$0.00	$0.00	$0.00	$0.00
Utilities:	$0.00	$0.00	$0.00	$0.00
Construction Eng. (15%):	$6,023,655.00	$15,889,995.00	$12,769,020.00	$1,408,110.00
Project Total:	**$50,197,125.00**	**$132,416,625.00**	**$106,408,500.00**	**$11,734,250.00**

Construction Subtotal:	Concept 5	Concept 6	Concept 7
Construction Coningency (10%):	$17,851,000.00	$35,082,000.00	$16,591,000.00
Construction Total:	$1,785,100.00	$3,508,200.00	$1,659,100.00
Design (10%):	$19,636,100.00	$38,590,200.00	$18,250,100.00
Right of Way:	$1,963,610.00	$3,859,020.00	$1,825,010.00
Utilities:	$0.00	$0.00	$0.00
Construction Eng. (15%):	$0.00	$0.00	$0.00
Project Total:	$2,945,415.00	$5,788,530.00	$2,737,515.00
	$24,545,125.00	**$48,237,750.00**	**$22,812,625.00**

Appendix E

Transportation Demand Management Alternatives

Auke Bay Corridor Study
Transportation Demand Management Alternatives
March 18, 2003 (rev. April 28, 2003)

USKH, Inc. / Kinney Engineering

Introduction
This memorandum summarizes feasible transportation demand alternatives for the ABCor study.

This discussion used the following references: :

1) *A Toolbox For Alleviating Traffic Congestion and Enhancing Mobility*, Institute of Transportation Engineers, 1997.
2) *A Compendium of Articles on Transportation Demand Management*, Institute of Transportation Engineers (Various Journals and Compendium Articles through 1992)
3) *ITE Digital Library*, Institute of Transportation Engineers (Various Journals and Compendium Articles through 2000)
4) *City and Borough of Juneau Transit Development Plan and Transit Improvement Program 2002,* Draft Report, Nelson\Nygaard Consulting Associates.

Overview of Transportation Demand Management (TDM)
Transportation demand management employs strategies and tactical actions that are designed to influence people's travel behavior to reduce congestion (Reference 1), usually through a change in travel modes, by shifting travel times, or by having employees telecommute from the home (Reference 1). A successful program not only reduces vehicle miles traveled, or vehicle trips during the time of concern (during a peak travel time) but it also offers the public an attractive mobility alternative to the single occupant vehicle (SOV) trip (Reference 2, Meyer).

Some of the reasons for a TDM policy, beyond congestion reduction, are less air pollution, lower levels of stress for commuters, enhanced customer access, extended business hours (through changing work time), reduced investment in roadway capacity, and enhanced ability to recruit and retain staff (partial list from Reference 1).

One thing that becomes clear from a review of the literature is that there is no design criteria framework for TDM. Each community has its own blueprint for TDM, usually employing a set of incentives to use alternative modes or disincentives for using a vehicle. The following table, adapted from Reference 1, shows some of the strategies that might apply to the Auke Bay Corridor.

Table 1

Trip Purpose	Site Strategies (By The Employer-Market)	Subarea/Corridor Strategies (By CBJ or DOT&PF)
Work	Carpools, Vanpools, Transit, Bicycle/Walking, Alternative Work Hours, Telecommuting, Parking Policies.	Subarea Rideshare, Parking Policies, Transit Subsidies, Subarea Telecommute
Shopping Retail Entertainment	Shuttles, Transit Subsidies, Pedestrian And Bicycle Access, Urban Design, On-Line Shopping	Shuttles, Park And Ride, Transit Services
Tourist	Shuttles, Parking Policies, Transit Services	Park And Ride Lots, Parking Management, Shuttles, Transit Services, Pedestrian/Bicycle Amenities.
	At Site	**For Subarea/Corridor**
How TDM strategies could be applied	Employer Transportation Coordinators, Personnel Department, Voluntary Participation, Negotiated Traffic Mitigation, Site Design	Transportation Management Associations, Chambers Of Commerce, local government

The site strategies are generally in the hands of employers or centers of commerce. These are usually most effective when the site has a high number of employees. Both references 1, 2 (Meyer, Mierzejewski) and 3 (Dewey et. al) have presented information that employer TDM programs could produce a 20 to 50 percent reduction in site trips, and that a subarea or corridor program by CBJ area wide programs would have about 2% to 18% reduction in trips.

Current TDM Practice

We are not aware of any TDM policies by the area employers, CBJ, or DOT&PF. However, Capital Transit runs a UAS express route and routes to 3/4 to the area.

Transit is an effective TDM measure if it offers the incentive of a subsidized fare, as well as removing reducing the burden of car ownership and operational and parking costs.

According to the Transit Development Plan (Reference 4), the routes currently run one-hour headways (each direction). They have about 700 boardings per day in about 30 revenue hours per day. The plan doesn't contain data regarding boarding and alighting locations, therefore it isn't possible to ascertain how many boardings are generated by the Corridor area or UAS.

The overall ridership for Capital Transit is about 30 passengers per revenue hour in 2002.

The plan recommends that a new route, Route 5[1], be established to Auke Bay and UAS which would run on a one-half hour schedule during the day and 1 hour at night. The plan also recommends other changes, which would result in a 39% increase in service hours over current by 2008. The overall increase in ridership, though, is projected to be about 5% by the plan (for budgeting purposes). The productivity would drop from 30 passengers per revenue hour now, to about 23 or 24 passengers per revenue hour in 2008. However, the long-term hope is that passengers would be attracted to the improved service and the productivity would rise to, or exceed current levels.

If this transit development plan is adopted, the increase in service hours could make transit a more attractive alternative to the SOV trip.

TDM Potential for the Auke Bay Corridor

The purpose and need for the Auke Bay Corridor Study would not be satisfied with an exclusive TDM alternative. We have forecasted that the study year 2029 ADT volume would be on the order of 15,000 to 16,000 vehicle trips per day. The design year's level of service would be D/E between Fritz Cove Road and Auke Nu Drive. Moreover, the Back Loop Road and Fritz Cove Road intersections would operate at unacceptable levels of service.

To get a sense of the benefit of a TDM shift to transit, we could assume that the proposed Route 5 is a success and continues on a ½ hour schedule into the future. We could also assume that the route would have 30 revenue hours per day as planned in the 5-year development plan, and that the productivity would rise from 23 passengers/revenue hour projected in 2008 to 30 passengers/revenue hour in 2029. Given these assumptions, the transit system would serve 900 passenger trip ends, with a possible reduction of 900 SOV trips, or about 6 % reduction in AADT.

---

[1] Route 5 is a proposed replacement for the UAS Express and Routes 3 and 4. UAS Express follows Egan Drive and Glacier Highway on a one-hour headway and operates Mon-Fri from 8a to 5p. Route 3 is a counterclockwise flow route on Egan Drive/Mendenhall Loop Road/Glacier Highway, with service to/from the alley and downtown. Route 4 is a clockwise flow route on Mendenhall Loop Road/Glacier Highway, again with service between the valley and downtown. Headways for 3 and 4 are one hour between 7a and 7p and two hours for late night runs. The proposed Route 5 would operate on a 30-minute headway between downtown and UAS. Proposed Routes 12 and 2 will serve Mendenhall Loop Road and the valley.

There is more transit capacity in reserve, as well as other TDM measures that could be implemented to reduce vehicle miles or trips. As indicated above, the more successful programs are initiated with the large employers, but area wide TDM measures could result in 15 to 18% reductions. Overall, an aggressive, successful TDM strategy might reduce corridor volumes by about 2,900 trips, which would reduce the design year volume to about 13,000 trips per day. TDM would be driven by CBJ and local area employers, most notably UAS as the area's largest employer and with a sizable student body. This project could provide features that would encourage TDM, including pedestrian and bicycle facilities, and transit facilities.

In summary, TDM strategies cannot be relied upon to completely replace the need for new street capacity improvements. However, TDM could influence our decision on the selection of the number of lanes and the cross section of the preferred alternative, especially if there is a marginal need for a wider street section. In that case, we could decide to select the narrower street sections and count on TDM to reduce future vehicle trips.

Appendix F

Cross Section Alternatives

Auke Bay Corridor Study
Cross-Section Alternatives
March 18, 2003 (rev. April 28, 2003)

USKH, Inc. / Kinney Engineering

Introduction

This memorandum summarizes our proposed cross-section alternatives for study.

Alternative Elements Description

Travel way- Consists of 2, 3, 4, and 5 lane sections. Three and five lane sections would include a center-two-way-left-turn-lane, and would only be used in urban settings with moderate to high driveway density. The number of lanes would be determined to meet volume and capacity needs. Widths would be developed to meet AASHTO requirements. Usually lane widths are 12 feet, but they could be reduced to 11 feet in an urban area. A center two way left turn lane (CTWTL) should be slightly wider than a normal lane width but can be reduced to 10 feet wide.

Shoulders- Shoulders provide pavement structural support, additional width for safety, space for breakdown or temporary parking, commuter bicycle lanes, and drainage capacity when combined with a curb and gutter. Widths should meet rural standards. The desired shoulder width for a rural highway is 8 feet, but it could be reduced to 4 feet.

Curb and Gutter- Curb and gutter would be used to convey drainage in urban areas.

Pathway- Pedestrian and bicycle travel ways should have at least 8 feet wide with two-foot of clearance and shoulders and must be separated by a barrier curb or a 5 feet distance from the roadway.

Sidewalk- Pedestrian walkways should have a minimum width of 6 feet. These could be attached to the back of curb, or built separated from the roadway.

Appendix L. Measures of Effectiveness

Measures of Effectiveness

Table-8

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
Goal 1: To Create a Safe Corridor	1-1 Meet current design standards for vehicles, bicycles, and pedestrians		Establish Reasonable and Defensible Traffic Volume Forecasts and Design Speeds	Design Year AADT and Peak Hour Movements, Arterial Design Speeds	-
			Roadway minimum criteria values	Individual Design Criteria Values from PCM and AASHTO (Radius, Length VC, Lane and Shoulder)	-
			% of alignment elements exceed minimum (maximum) requirements	Design Criteria Values	Comparative %
			Intersection Criteria and Guidelines (PCM, AASHTO, ITE, TRB, FHWA)	Design Year 95th Queues, Bay Tapers and Lanes for Auxiliary Lanes, Roundabouts	Number of Intersections that meet Criteria and Guidelines
			Bicycle and Pedestrian Criteria and Guidelines	Individual Design Criteria Values (Radius, Length VC, Lane and Shoulder)	-

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
	1-2 Reduce the number and severity of accidents		Meet minimum criteria values for all design elements	Design Criteria Values (stated in Criteria for Objective 1-1)	-
			Provide countermeasures that would predictively reduce accident rates at intersections and segments to be equal or less than the population rate	Average Rates Per HSIP	Comparative Accident Reduction of Alternatives
			Where feasible, provide countermeasures to reduce conflicts (as measured in conflict studies) at intersections that are perceived as hazardous by the public	Reduce conflicts by 25%	Comparative Conflict Reduction of the Alternative
			Average Speed	85th Percentile Speed Less than or equal to Posted Speed	Closest Travel Speed to Anticipated Posted Speed Limit
	1-3 Accommodate future traffic volumes		Meet minimum criteria values for all design elements	Design Criteria Values (stated in Criteria for Objective 1-1)	-

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
			Select appropriate major intersection control and configurations for traffic and pedestrians	Signal Warrants per MUTCD	-
				Future Signalization per Cal Trans Warrants	-
				Roundabout warrants/guidelines per FHWA	-
				Intersection Geometrics per AASHTO, TRB, and ITE references	-
			Access compatible with land use, road function	Medians, Auxiliary Lanes, or Center Two-Way Left Turn Lane per AASHTO, TRB, and ITE Guidelines	-
			Roadway Illumination	Per AASHTO Guidelines	-
	1-4 Investigate and address roadside boat trailer parking		Identify potential off-road separate parking areas	-	Can Alternative Provide?

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
	1-5 Accommodate mixed-use activities (education, tourism, recreation, etc.)		Provide at least one parking area turnout for tourists, recreation	-	Can Alternative Provide?
			Bicycle Path and Sidewalks along network	-	% of Network served by Pathways and Sidewalks
Goal 2: To Balance Accessibility and Mobility	2-1 Improve travel efficiency for local and through traffic		Intersection Level of Service	"C" or better for Design Year	Comparative LOS for intersections
			Intersection Control Delay	-	Comparative Network delay control for each intersection (Lower is Favorable)
			Intersection Volume to Capacity Ratio	V/c < 0.85	Comparative Network v/c for each intersection (Lower is Favorable)
			Intersection Queuing Penalty (product of volume affected by queue blocks by percent of time blocked)	QP = 0	Comparative Network Queuing Penalty (Lower is Favorable)

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
			Network Average Travel Speed	-	Difference between Travel Speed and Anticipated Posted Speed Limit (The less the difference, the more favorable)
	2-2 Increase pedestrian and bicycle connectivity and mobility		Bicycle Path and Sidewalks along network	Meets current PCM and AASHTO guidelines for path and sidewalk placement	% of Network served by Pathways and Sidewalks
			Safe Crossing Points	1/4-mile spacing, and at major generators	Alternative meets or exceeds maximum spacing?
	2-3 Maintain or improve access for emergency response		Intersections	Accommodate Turning Movements	% of Intersections that accommodate EMS vehicles
			Mobility	-	Does Alternative have shoulders or CTWLTL to allow vehicles to pull over and EMS vehicles to pass?

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
	2-4 Maintain or improve access for elementary school and UAS		Roadway Improvements consistent with UAS Master Plan Change of Access	-	Alternative Consistent?
			Roadway Improvements consistent with CBJ SD Long Range Plans	Consider Access, Circulation, need for pedestrian Crossings, additional auxiliary lanes	Alternative Consistent?
Goal 3: To Develop a project that is Compatible with the Human and Natural Environment	3-1 Minimize impacts to the natural environment		Estimate CO and N0x Emission	-	Comparative emissions
			Natural areas that are disturbed	-	Area of Land disturbed by Alternative
	3-2 Minimize social and economic impacts		Right-of-way	-	Area of Land required by alternative

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
			Access	-	Number of Vehicles redirected by access reconfigurations
			Parking	Existing or CBJ standards	Parking Spaces Lost
	3-3 Actively involve the public		Consistent Communications	Public involvement Plan	Which alternative preferred by public?
	3-4 Be consistent with existing and future land use plans		Traffic Volume Forecasts consistent with CBJ zoning, future development, and future extension of JNU Access Road?	-	Are Volumes used for Alternatives consistent?
			Roadway Improvements consistent with CBJ zoning, future development, future extension of JNU Access Road?	-	Are Alternatives consistent?
	3-5 Enhance the community of Auke		Gateways	-	Does Alternative have a gateway?

Goals	Objectives		Criterion / Performance Measures	Standards (Values or Practice)	Alternative Comparison Performance Measure
	Bay.		Amenities and Beautification	-	Does the Alternative have pedestrian amenities, rest areas, scale lighting, landscaping, beautification?
Goal 4: To Develop a Project That is Feasible	4-1 To develop a project that is Financially Feasible		Project Budget	-	Is Alternative within budget?
	4-2 Develop a project that has community acceptance		Community Acceptance	-	Is Alternative accepted by Community?

Appendix M. Analysis of Alternatives 1, 2 and 3

In order to evaluate and analyze each alternative, we investigated anticipated traffic performance, delay, speeds, accidents, ROW impacts and potential environmental and socioeconomic impacts of each alternative This section contains several tables of information that summarize this information.

The following table presents the current AADT of the existing system and then predicted AADT of each alternative in the year 2029, by segment.

	Glacier Highway				**Mendenhall Loop Road**		**By-Pass**		
	Ferry Terminal to Auke Nu Drive	**Auke Nu Drive to Harbor Drive**	**Harbor Drive to Fritz Cove Road**	**Fritz Cove Road to Engineers Cut-Off Road**	**Glacier to UAS North Access**	**UAS Outbound (Alt 1&2) or to By Pass (Alt 3)**	**UAS Access**	**Mendenhall Loop Road**	**Glacier Hwy (Industrial Blvd)**
Current (2001)	4,117	5,668	7,977	12,013	2532				
2029 No-build and Alternative1	6,840	8,140	15,710	23,010	4800				
2029 Alternative 2	6,000	7,300	15,710	23,010	7,000	5,900	800		
2029 Alternative 3	6,000	3,600	10,300	12,700	3,000	4,600	3,600	4,800	9,200

The table below presents PM LOS for the design year (2029) for the intersection of each alternative.

	Alternative 1		**Alternative 2**		**Alternative 3**	
	Intersection Control	**LOS**	**Intersection Control**	**LOS**	**Intersection Control**	**LOS**
Glacier Highway-Fritz Cove Road- UAS South Entrance	Single-Lane Roundabout	A	Single-Lane Roundabout	A	*Stop Sign (New LT Lanes N&S)	NB and SB LT are F, Other movements at C or better
Glacier Highway- Mendenhall Loop Road (Reconfigured into a Tee intersection)	Single-Lane Roundabout	B	Reconfigured Tee Intersection with Signal	C	Reconfigured Tee Intersection with Stop Sign	D
Mendenhall Loop Road- UAS North Entrance-Guard/By Pass Access	Stop Sign	C/D	Single-Lane Roundabout	A	Stop Sign	C
Glacier Highway- By Pass (New formed by By-Pass West Terminus, near Ferry Terminal)			Stop Sign	B	Stop Sign	B
By Pass-Mendenhall Loop Road (New)					Signal with LT lanes	C
By Pass-UAS Access					Stop Sign	B

Glacier Highway-East By Pass-Industrial Boulevard (New formed by By Pass East Terminus)			Signal	C

The following table presents PM LOS for the design year (2029) for segment of each alternative.

Segment	Alternative 1		Alternative 2		Alternative 3	
	Lanes	**LOS**	**Lanes**	**LOS**	**Lanes**	**LOS**
Glacier Highway, Fritz Cove through Commercial Area	3-Lane	D	3-Lane / 2-Lane	E	2-lane	C
Glacier Highway, Outbound to Ferry Terminal	2-lane	C	2-lane	C	2-lane	C
Mendenhall Loop Road	2-lane	C	2-lane	C	2-lane	B
By-Pass, Alternative 2			2-lane	C		
By-Pass, Alternative 3					2-lane	C

The following table presents anticipated delay of the alternatives and the existing system during the PM peak in the year 2029.

2029 PM Traffic		
Alternative	**Delay Experienced in System (Seconds / Vehicle)**	**Cumulative Travel Time (hours) During PM Peak Hour**
Alternative 1	227	369
Alternative 2	187	339
Alternative 3	130	266
No-Build, Existing Conditions	346	441

The following table presents anticipated speed for existing conditions and the three alternatives during the PM peak in the year 2029.

	Posted Speed	2029 PM Traffic			
		No-Build, Existing Conditions	**Alternative 1**	**Alternative 2**	**Alternative 3**
Glacier Highway, Fritz Cove through Commercial Area	35 MPH (45 MPH to NOAA)	24 MPH	18 MPH	16 MPH	27 MPH
Glacier Highway, Outbound to Ferry Terminal	45 MPH	41 MPH	41 MPH	37 MPH	40 MPH
Mendenhall Loop Road	40-45 MPH	11 MPH	26 MPH	25 MPH	28 MPH
By-Pass, Alternative 2	45 MPH (estimated)			31 MPH	

By-Pass, Alternative 3	45 MPH (estimated)				37 MPH

The following table presents current and estimate annual accidents for the no-build and the three alternatives in the year 2029.

	Current	**2029 No-Build / No Action**	**2029 Alternative 1**	**2029 Alternative 2**	**2029 Alternative 3**
Estimated Annual Accidents	13	24	16	19	25
Estimated Annual Public Costs	$544,120	$ 994,808	$ 469,936	$ 615,126	$ 617,460

The table below presents potential right of way and utility impacts of each alternative.

	Alt. 1	**Alt. 2**	**Alt. 3**
Remove house	3	4	6
Remove garage	3	1	1
Major change in or remove access to structure			7
Substantial change in access grade	11	7	7
Relocate power pole	13	10	3
Remove parking spaces	13	2	2
Extend fire hydrants to back of sidewalk	X	X	
Sewer manholes located in travel lanes	X	X	
Extend large culvert at Auke Creek	X	X	

The following table presents wetland and fish stream impacts of each alternative.

Alternative 1

Wetland Fill	1.2+ acres
Auke Creek	Reroute/Replace culvert
Waydelich Creek	Extension
Bay Creek	Extension
Auke Nu Creek	Extension

Alternative 2

Wetland Fill	5.3+ acres
Auke Creek	Reroute/Replace culvert
Waydelich Creek	New Crossing
Bay Creek	New Crossing
Auke Nu Creek	New Crossing, Extension

Alternative 3

Wetland Fill	10.0+ acres
Lake Creek	New Crossing
Auke Nu Creek	New Crossing, Extension
Waydelich Creek	New Crossing
Bay Creek	New Crossing
Lake Two Creek	New Crossing
Hanna Creek	New Crossing
Wild Meadow Crossing	New Crossing

The following table presents socioeconomic considerations for each alternative.

	Alternative 1	**Alternative 2**	**Alternative 3**
Issues (+/-)	– Community Cohesion: Wider transportation corridor transects community + Pedestrians And Bicyclists: Wider shoulders, more sidewalk, separated pathway from Waydelich Creek to ferry terminal + Decrease congestion, improve access to schools, churches, emergency response – Travel Pattern: Out of direction travel for Caroline St. due to median – No direct access from DeHart's to Glacier Highway	+ Community Cohesion: Main route bypasses the community + Pedestrians And Bicyclists: Wider shoulders, more sidewalk, separated pathway from Waydelich Creek to ferry terminal + Decrease congestion, improve access to schools, churches, emergency response + DeHart's has direct access to Glacier Highway – Increased traffic volume on UAS Joint Use Facility access – Crosses Spaulding Meadows trail	+ Community Cohesion: Main route bypasses the community + DeHart's has direct access to Glacier Highway + Decrease congestion, improve access to schools, churches, emergency response – Increased traffic volume on UAS Joint Use Facility access – Crosses Spaulding Meadows trail

The following table presents cost estimate for each alternative.

	Alternative 1	**Alternative 2**	**Alternative 3**
Construction Subtotal:	$ 9,240,000	$ 10,770,000	$ 25,650,000
Construction Contingency (20%):	$ 1,850,000	$ 2,150,000	$ 5,130,000
Construction Total:	$ 11,090,000	$ 12,930,000	$ 30,780,000
Design (10%):	$ 1,110,000	$ 1,290,000	$ 3,080,000
Right of Way:	$ -	$ -	$ -
Utilities:	$ -	$ -	$ -
Construction Engineering (15%):	$ 1,660,000	$ 1,940,000	$ 4,620,000
Project Total:	**$ 13,860,000**	**$ 16,160,000**	**$ 38,480,000**

Auke Bay Corridor Study

Interim Submittal
Alternative 1
Preliminary Summary of Geometric and Intersection Elements

USKH, Inc. / Kinney Engineering

This document summarizes geometric and intersection control elements for Alternative A that will provide satisfactory operations throughout the project life. The purpose of this document is to provide USKH with the information that is needed to begin the preliminary engineering and environmental analysis work on Alternative 1. This document represents work done to date on this alternative, and although we consider it substantially complete, the elements may be revised before the final report is complete.

Level of Service

The American Association of State Highway and Transportation Officials (AASHTO) A Policy on the Geometric Design of Streets and Highways (Exhibit 2-32) recommends that urban and suburban arterial, similar to Glacier Highway, should be designed to operate at a LOS C or better. However, within the Chapter VII, Rural and Urban Arterials, AASHTO states “Heavily developed sections of metropolitan areas may necessitate the use of level of service D.”

The operational performance measures uses for this analysis are levels of service, control delay, and volume to capacity ratio. Technical Memo 3 established the upper volume to capacity ratio (v/c) value at 0.85, or 85% of capacity. This upper value represents good design practice, in that there is some reserve capacity to absorb surges in volumes or flow turbulence.

Other performance measures that were proposed in Technical Memorandum 3 included queuing penalty and average network speed. These are more meaningful when used in comparing build alternatives to one another or to the no-build alternative. This work will be done later in the final report.

Levels of Service and other measures of effectiveness are calculated differently for intersections and roadway segments. Descriptions of these performance measures are included at the end of this memo under Attachment A.

The project area between Fritz Cove Road and the Waydelich Creek is well developed and overall capacity will generally be controlled by intersection capacity. Between Waydelich

Creek and the Ferry Terminal, the roadway becomes more like an uninterrupted 2-lane highway.

Intersection Control

There are three control/geometric configuration options for intersections of this Alternative 1. These include unsignalized intersections, signalized intersections, and modern roundabouts. A fourth option, grade-separated interchanges, isn't feasible for this alternative.

Accident evaluations have determined that the existing intersection of Mendenhall Loop Road and Glacier Highway, also known as the "Wye", probably contributes to the accident issues at the intersection. As such, this intersection should be reconfigured to a standard Tee intersection.

The following table summarizes existing intersections operational performance with future volumes.

Intersection	Approach	Year	2002	2009	2019	2029
Glacier Hwy/ Fritz Cove / UAS South Entrance	eastbound left	AM	A	A	A	A
		PM	*B*	*B*	*B*	*B*
	westbound left	AM	A	A	A	A
		PM	*A*	*A*	*A*	*B*
	northbound left/through/right	AM	B	C	C	E
		PM	*E*	*F*	*F*	*F*
	southbound left	AM	C	C	C	D
		PM	*F*	*F*	*F*	*F*
Glacier Hwy/ Harbor Rd	northbound left/through	AM	A	A	A	A
		PM	*A*	*A*	*A*	*A*
	eastbound left/right	AM	B	B	B	C
		PM	*C*	*C*	*D*	*F*
Glacier Hwy/ Mendenhall Lp.	southbound-inbound (modeled as westbound left)	AM	B	B	C	C
		PM	*C*	*D*	*E*	*F*
Glacier Hwy/ Mendenhall Lp Wye	eastbound left/ through (inbound)	AM	*A*	*A*	*A*	*A*
		PM	*A*	*A*	*A*	*A*
	southbound right	AM	A	A	A	A
		PM	B	B	C	C
Mendenhall Lp/ Mendenhall Lp Wye	eastbound left	AM	A	B	B	B
		PM	*B*	*B*	*B*	*C*
Mendenhall Lp/ UAS North Entrance	westbound left	AM	A	A	A	A
		PM	*A*	*A*	*A*	*A*
	northbound left/ right	AM	A	B	B	B
		PM	*B*	*C*	*C*	*D*

Table 1- Existing Conditions, Future Traffic Volumes Levels of Service

Signalized Intersection Control

Intersection control may only be signals if one or more warrants established by the Manual of Uniform Traffic Control Devices (MUTCD) are satisfied. The warrants include:

Warrant 1- Eight-Hour Volume
Warrant 2- Four-Hour Volume
Warrant 3- Peak Hour Volume
Warrant 4- Minimum Pedestrian Volumes
Warrant 5- School Crossings
Warrant 6- Coordinated Signal System
Warrant 7- Crash Experience
Warrant 8- Roadway Network

These warrants use existing data as analysis parameters. This warrants system cannot be applied to facilities that have not been constructed, or where major traffic circulation changes will occur, as is the case in this project. We used a Cal-Trans methodology for future volumes presented in the Institute of Transportation Engineers (ITE) *Manual of Traffic Signal Design*, Second Edition, by James H. Kell and Iris J. Fullerton. The method uses future estimated average daily traffic (EADT) as the input variables and estimates whether the intersection with future EADT will meet the MUTCD signal Warrant 1, Condition A- Minimum Vehicular Volume; Condition B- Interruption Of Continuous Traffic; and the combination of warrants allowed in MUTCD procedure.

This warrant methodology was applied to the major intersections of this project. The following table summarizes the results. concluding that the Glacier Highway-Fritz Cove Road- UAS South Entrance intersection, and the reconfigured Glacier Highway-Mendenhall Loop Road intersection will meet signal warrants during the life of the project.

Intersection	A- Minimum Vehicular Volume	B- Interruption Of Continuous Traffic	C- Combination of Warrants (80% of A & B
Glacier Highway-Fritz Cove Road- UAS South Entrance	Not Satisfied During The Project Life	Satisfied by 2019 (Mid-Life)	Not Satisfied During The Project Life
Glacier Highway-Mendenhall Loop Road (Reconfigured into a Tee intersection)	Satisfied by 2009 (Construction)	Satisfied by 2019 (Mid-Life)	Satisfied by 2009 (Construction)
Mendenhall Loop Road-UAS North Entrance	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life

Table 2- Future Signal Warrants

The Glacier Highway-Fritz Cove Road- UAS South Entrance intersection meets warrants by 2019, and the reconfigured Glacier Highway- Mendenhall Loop Road intersection will meet signal warrants in 2009.

Intersection geometrics at the signals are as depicted in the following figures. Auxiliary left-turn lanes are recommended for each approach at these signals as good design practice for safety and capacity. A westbound right-turn lane is recommended at the intersection of Glacier Highway-Fritz Cove Road- UAS South Entrance Intersection because of the high number of conflicts that was observed between turning traffic and following traffic.

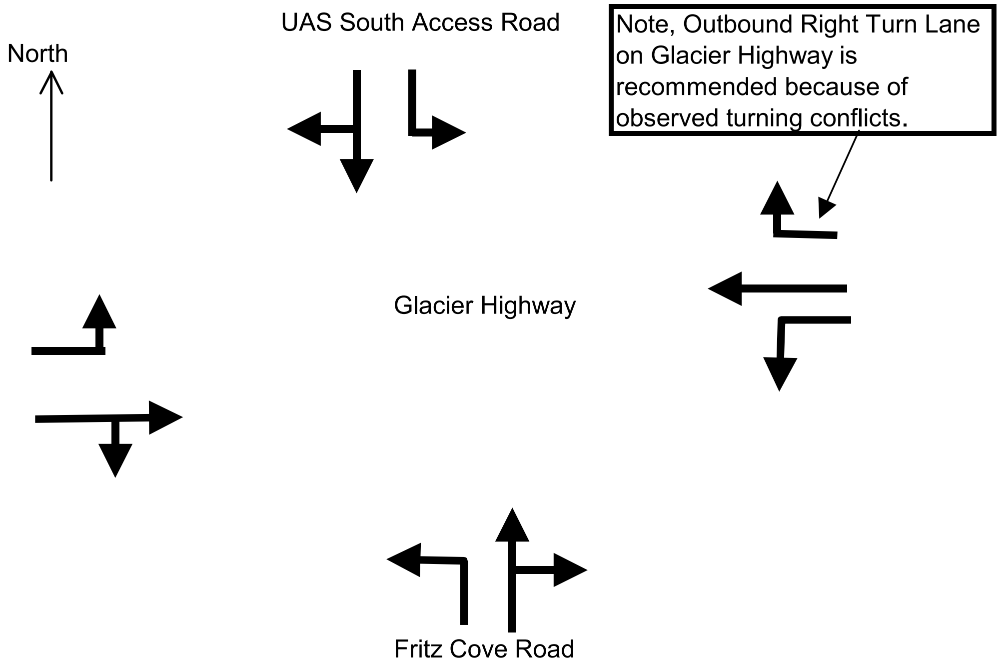


Figure 1- Glacier Highway-Fritz Cove Road- UAS South Entrance Intersection Lanes

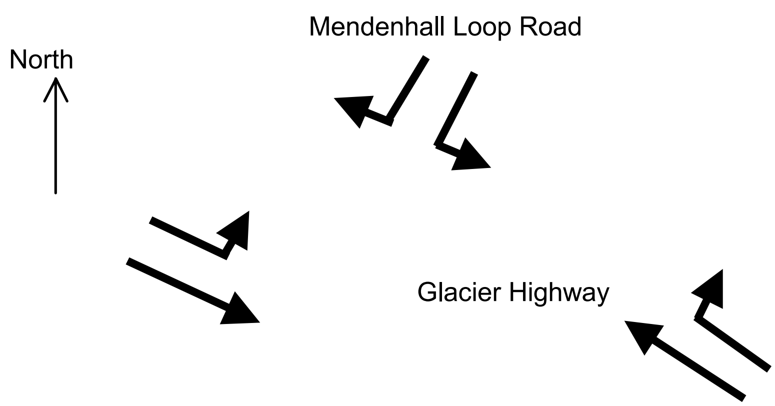


Figure 2- Glacier Highway- Mendenhall Loop Road (Reconfigured into a Tee intersection) Intersection Lanes

The following table summarizes 2029 Design Year performance measures for the intersections under signal control (lanes shown in Figures 1 and 2, 100 second cycles with optimized timing).

Intersection	2029 Morning Peak Hour			2029 Evening Peak Hour		
	Average Control Delay (sec/veh)	**v/c Ratio**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio**	**Level of Service**
Glacier Highway-Fritz Cove Road- UAS South Entrance	9	0.64	A	22	0.90	C
Glacier Highway- Mendenhall Loop Road (Reconfigured into a Tee intersection)	31	0.49	C	17	0.71	B
Mendenhall Loop Road- UAS North Entrance	Not applicable since this intersection will not meet warrants.					

Table 3- Signalized Intersection Operation Performance for Design Year, 2029

As shown in Table 3, operations will be adequate during the life of the facility. One objective, v/c ratio, is not met at the Glacier Highway-Fritz Cove Road- UAS South Entrance intersection in 2029. However, it would be for most of the project life. Figures 3 and 4 present auxiliary lane lengths for the signalized intersections. These are developed to accommodate deceleration (outside of through lane) and for storage in accordance with Table 1150-1 of the *Preconstruction Manual*. Note that highway speeds on Glacier Highway change from 45 mph to 35 mph near the Fish Lab, and that only storage is required at the Mendenhall Loop Road intersection.

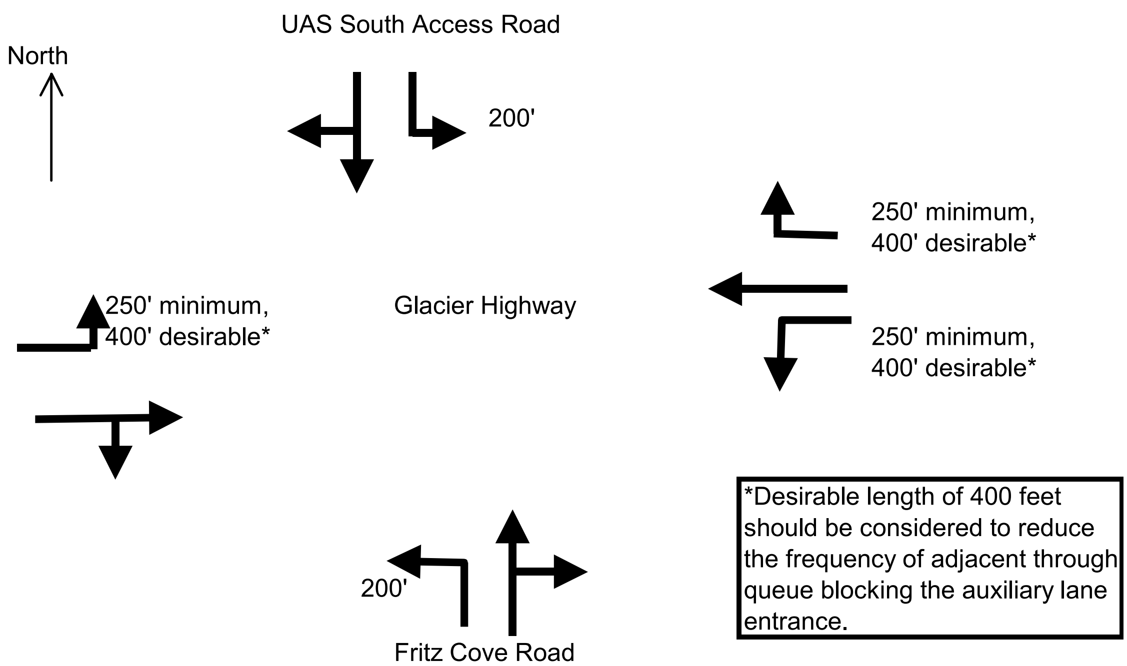


Figure 3- Auxiliary Lane Lengths Glacier Highway-Fritz Cove Road- UAS South Entrance Signalized Intersection

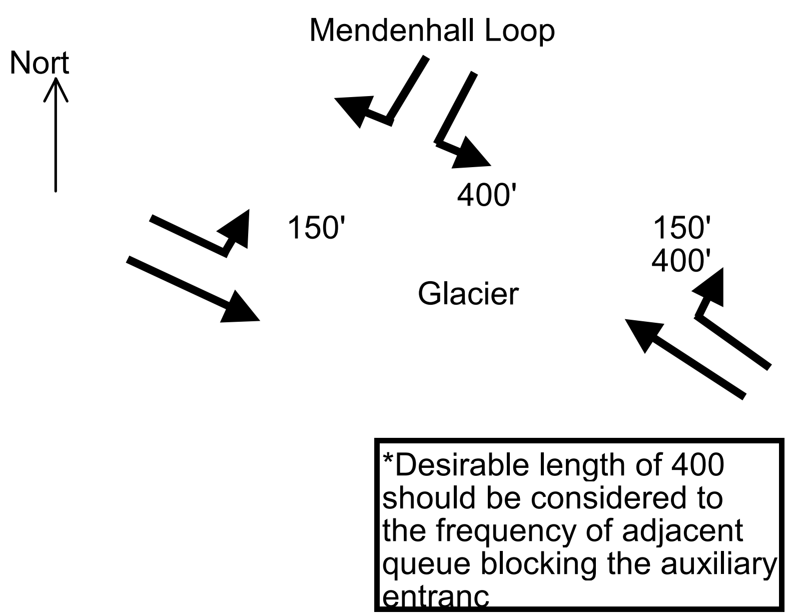


Figure 4- Auxiliary Lane Lengths Glacier Highway- Mendenhall Loop Road Signalized Intersection

Unsignalized Intersection Control

If the reconfigured Glacier Highway- Mendenhall Loop Road intersection were to operate under stop sign control, the southbound left-turns would have a poor level of service, “E”, in 2019, and would continue to decline during the project life, operating at “F” level in 2029. With stop sign control at the Glacier Highway-Fritz Cove Road- UAS South Entrance intersection, the northbound and southbound left-turn movements would operate at a level of service “F” immediately upon opening in 2009. The poor levels of service also confirm that signals or roundabouts will be required at these intersections in the future.

The Mendenhall Loop Road- UAS North Entrance intersection will not warrant signalization in the future and will continue to operate under sign control or as a modern roundabout. We find that a left-turn lane on the southwest bound approach of Mendenhall Loop Road is recommended according to AASHTO Table 9-75. This table is further developed into a graphical presentation available in NCHRP Report 457 *Engineering Study Guide for Evaluating Intersections Improvements*, Bonneson and Fontaine.

Figure 5 presents the recommend lanes for the Mendenhall Loop Road- UAS North Entrance intersection.

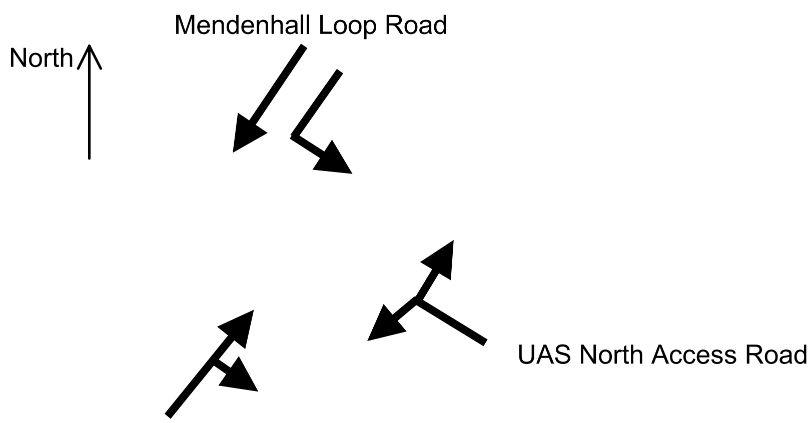


Figure 5- Mendenhall Loop Road- UAS North Entrance Intersection Lanes, Stop Control

Table 4 summarizes Design Year (2029) performance measures for this intersection.

Glacier Highway-Mendenhall Loop Road Intersection Movements	**2029 Morning Peak Hour**			**2029 Evening Peak Hour**		
	Average Control Delay (sec/veh)	**v/c Ratio**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio**	**Level of Service**
Southwest Bound Left Turn	8	0.05	A	9	0.07	A
Northwest Bound (UAS) Left/Right	12	0.04	B	26	0.59	D (note that threshold for C is 25 seconds)

Table 4- Glacier Highway- Mendenhall Loop Road Intersection Unsignalized Intersection Performance Measures

The southwest bound left-turn lane should be 250 feet to accommodate deceleration (outside of through lane) and for storage in accordance with Table 1150-1 of the *Preconstruction Manual*. Mendenhall Loop Road speed is 45 mph.

Modern Roundabouts

In NCHRP 457, there is a summary table to determine if a roundabout would be suitable for a location (NCHRP 457 Table 2-12 based on FHWA RD-00-067 Roundabouts: An Informational Guide). We apply these seven questions to major intersections of the project.

Question	Glacier Highway-Fritz Cove Road-UAS South Entrance	Glacier Highway-Mendenhall Loop Road	Mendenhall Loop Road-UAS North Entrance
1) Will operation as an uncontrolled or two-way-stop-controlled intersection yield unacceptable delay?	Yes	Yes	No
2) Is the daily entering volume less than the maximum service volume for a roundabout? (*Use Figure 2-3 of NCHRP 457*)	Yes, 1-lane on each approach is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.
3) Is the subject junction located outside of the coordinated signal network?	Yes	Yes	Yes
4) Is the ratio of major-road to minor-road volume less than 5?	Yes, about 5:1	Yes, 4:1	Yes, 4:1
5) Is the entering drivers view free of sight obstructions?	Yes, can be designed	Yes, can be designed	Yes, can be designed
6) Will the subject junction infrequently be used by large or oversized trucks?	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic
7) Will the subject junction infrequently be used by pedestrians and bicyclists?	Yes	No, Expect Moderate Use by Bikes and Pedestrians	No, Expect High Frequency Use by Bikes and Pedestrians

Table 5- Roundabout Suitability Questions

As NCHRP 457 points out, the more frequently that these questions in Table 4 are answered with “Yes”, then the more likely that this intersection would work as a roundabout. Given our answers, we conclude that these intersections are candidates for roundabouts.

There are other advantages to roundabouts, as well as providing good levels of service. FHWA demonstrates a reduction in both crash rates and injuries when intersections are converted to roundabouts. Overall, accident rate reduction is achieved, in part, by the reduction of conflict points from 32 at a standard four-legged intersection, to 8 with a roundabout. Another part of accident reduction for roundabouts is that they by nature reduce approach speeds on all legs, which in turn allow vehicles more reaction time. Accident severity is reduced as well. Roundabouts reduce the relative velocity of vehicles involved in a crash in two ways. The first is an overall speed reduction and the second is that the collision types are dramatically changed. Angle and head-on accidents, both with high relative velocities are almost eliminated from the roundabout crash patterns. Instead, the roundabout reconfigures these high-severity conflicts into merge conflicts, which at shallow angles and low speeds have a very low relative velocity.

Recent roundabouts on minor arterial and collector roads within the Municipality of Anchorage have used an inscribed diameter of about 140 feet with 20-foot circulation lanes to accommodate WB-50 (tractor-trailer rig) turning path widths. Figure 6 and Table 6 present roundabout geometric elements. It should be noted that 3-leg roundabouts are acceptable and would be used at the Mendenhall Loop Road and Glacier Highway intersection and the UAS North Access intersection.

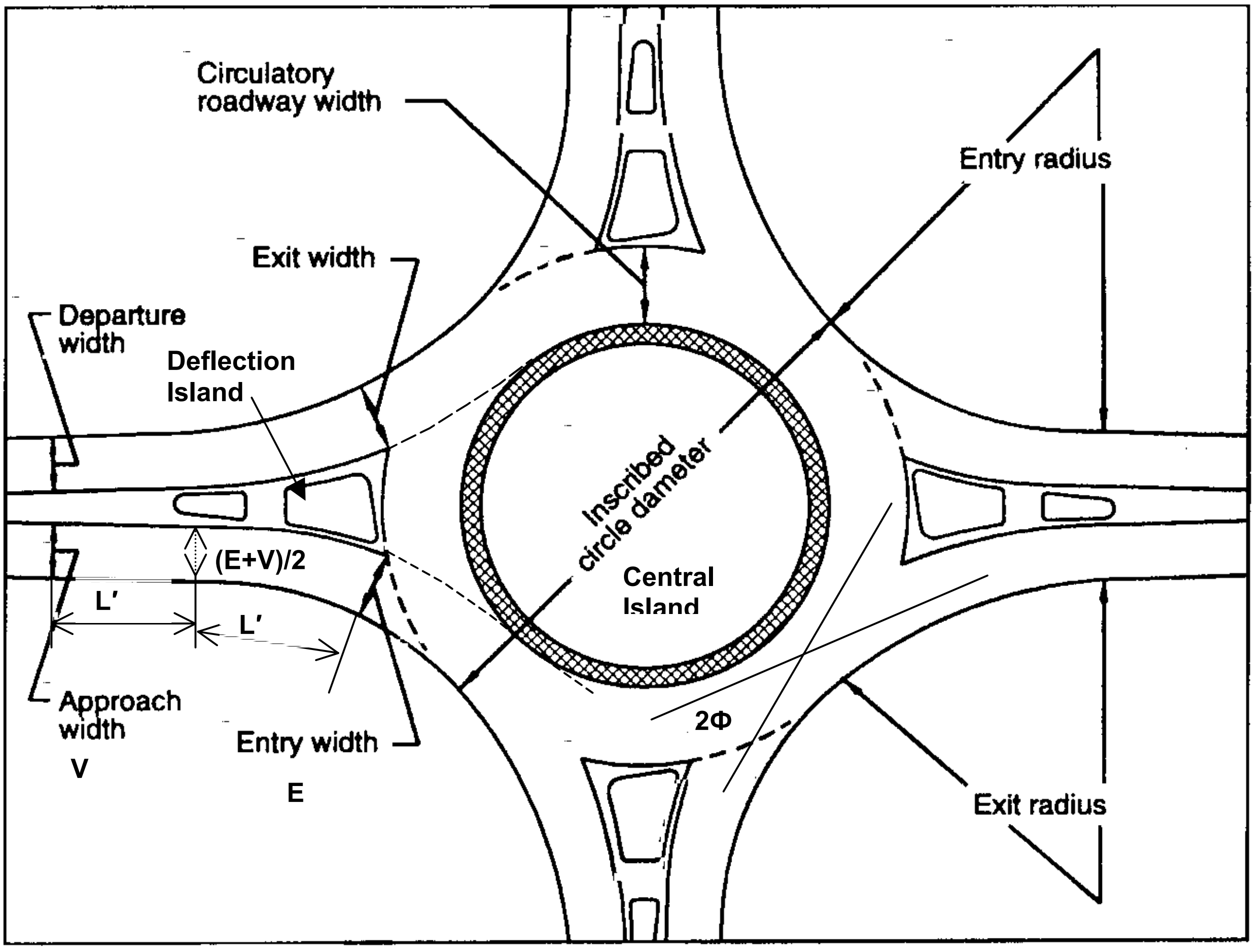


Figure 6- Roundabout Geometric Elements

Table 6 has value ranges for these geometric elements. Sources include FHWA RD-00-067 *Roundabouts: An Informational Guide* and *Interactive Roundabout Design Software and Manual*, Rodel Software Ltd and Staffordshire County Council.

Element	Value	Source, Comments
Inscribed Circle Diameter	140 feet single lane	FHWA with local experience. Will be adequate for WB-50 design vehicles.
Central Island Diameter	Approximately 100 feet (single lane circulation lane), with an outer ring that accommodates occasional truck-trailer combinations larger than WB-50.	Inscribed Circle Diameter- Circulatory Road Width, divided by 2.
Approach Width, **V**	Lane Width (assumed 12 feet)	FHWA, Rodel
Entry Width, **E**	14 to 16 feet for single lane	FHWA
L′	Minimum 16 feet (Rodel), 40 feet recommended minimum (FHWA)	Use 40 feet. (derived from FHWA's recommendation of an 80-foot flare taper in urban areas.)
Φ	25 to 35 degrees	Rodel
Entry Radius, Single Lane	>30 feet, <100 feet	Rodel, FHWA
Exit Radius, Single Lane	>50 feet (FHWA)	Rodel recommend that the exit radius be determined as transition from circulatory road width, through the deflection island, and to the departure width. Radius should be selected to that taper is 15 or 20 to 1.
Circulatory Road Width	1 to 1.2 x **E,** use 20 feet minimum for single lane	Rodel, FHWA
Deflection Island (splitter island), Exit Width	Defined by tangential extensions to the Central Island	FHWA and Rodel. FWHA recommends a minimum of 5-foot pedestrian refuge be located at about 20 feet from the yield line.

Table 6- Typical Design Values for Roundabout Geometric Elements, Auke Bay Corridor Intersections

These values will be confirmed during detail design.

Table 7 presents the performance measures for the project intersection under a modern roundabout configuration.

Intersection	2029 Morning Peak Hour			2029 Evening Peak Hour		
	Average Control Delay (sec/veh)	**v/c Ratio (intersection average**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio (intersection average)**	**Level of Service**
Glacier Highway- Fritz Cove Road- UAS South Entrance	2	0.36	A	5	0.71	A
Glacier Highway- Mendenhall Loop Road	8	0.30	A	16	0.77	B
Mendenhall Loop Road- UAS North Entrance	3	0.13	A	4	0.30	A

Table 7- Roundabout Performance Measures

Intersection Summary

Table 8 summarizes the work in this section.

Intersection	Unsignalized Operations	Signalized Operations	140-foot Roundabout	Recommendation
Glacier Highway-Fritz Cove Road-UAS South Entrance	Unsatisfactory-Fails in 2009	Meets warrants by 2019, good operations since it operates at LOS C or better over the project life.	Good operations, LOS A over the entire life.	Roundabout provides superior operations.
Glacier Highway-Mendenhall Loop Road	Unsatisfactory-LOS E in 2019, F in 2029	Meets warrants by 2009, good operations since it operates at LOS C or better over the project life.	Good operations, LOS B or better over the entire life.	Roundabout provides superior operations.
Mendenhall Loop Road-UAS North Entrance	Satisfactory-LOS D, almost C in 2029	Signals will not be warranted.	Good operations, LOS A over the entire life.	Although roundabout will provide better operations, the high pedestrian traffic volume may make this unfeasible. Consider leaving as unsignalized intersection.

Table 8- Intersection Evaluation Summary

Roadway Typical Section

Fritz Cove Road to Waydelich Creek

This segment of the roadway is urban in appearance and function.

Two through lanes (one inbound and outbound) will be adequate for the intersections as discussed above, and will be all required for the segments between intersections. Because of the relatively high traffic volume through the corridor, the typical section should provide left-turn lanes at all cross streets and at significant generators for the segments between

Fritz Cove Road and Waydelich Creek. This is best accomplished with a three-lane section that has a center two way left turn lane (CTWLTL). For the section of roadway between Fritz Cove Road and Mendenhall Loop Road, the lower density of driveway and cross streets would allow a raised median that is opened with a turn bay at each of the cross-street or driveways.

Operations for the segment of the roadway between Fritz Cove Road and Waydelich Creek are best modeled with interrupted flow capacity techniques. For two lanes and adequate left turn provisions at the minor cross streets and driveways (either CTWLTL or median openings and left turn lanes), two through lanes will operate well through the design year. Several simulation runs of the proposed alternative network (with signals) show that speeds (including stopped delay at signals) in this segment had results between 19 to 23 mph. This would represent a LOS of C/D, using the arterial criteria discussed in Attachment A. Roundabouts would likely increase the segment LOS speed well above the LOS C threshold. Even so, as stated above, LOS of D is acceptable for the design year in an urban setting.

Waydelich Creek to the Ferry Terminal

Even thought this short segment of the road, approximately 0.9 miles, is functionally classified as an urban arterial, it is rural in character and function. As such, HCM2000 two-lane highway methods may be used. The following table summarizes Design Year, evening operations with a two-lane highway section.

Begin	**Waydelich Creek**
End	**Ferry Terminal**
Length	**0.9 miles**
ADT	6,840
DHV	750
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	50%
Free Flow (85th reading)	56 mph
Average of Mean Speed S_{FM}	51 mph
Percent Time Following	66%
Volume/Capacity Ratio	0.29
Average Travel Speed	46 mph
Levels of Service	C

Table 9-2029 Waydelich Creek to Ferry Terminal Segment Performance Measures

Segment Evaluation Summary

Two-through lanes will function adequately throughout the project life. The following table summarizes the geometric elements required for each segment.

	2-lane	3-lane (CTWLTL)	Curb and Gutter	Shoulders	Sidewalk	Pathway
Fritz Cove Road to Waydelich Ck (Urban)	-	11 or 12 – foot through lanes, 12 to 14-foot CTWLTL	x	Optional, 5 feet desirable for bikes	x	x
Waydelich Ck to Ferry Terminal (Rural)	12-foot lanes	-	-	8 feet	x	x

Table 10- Segment Geometric Elements

Attachment A
Level of Service Discussion

We use capacity analysis to determine operational performance. The capacity analysis was performed in accordance with the procedures outlined in Transportation Research Board Highway Capacity Manual 2000 (HCM) for interrupted flow facilities, using Synchro/SimTraffic, Version 5, distributed by Trafficware. In an urban area, the capacity of a system is constrained by the capacity of the system's intersections and uninterrupted capacity methods generally do not apply.

Capacity analysis for a facility yields operational performance that is defined as level of service (LOS). For signalized intersections, LOS relates to the control delay of a vehicle. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. The HCM methodology calculates LOS for each movement and for the intersection as a whole.

The following narrative from Chapter 9 of the 1997 HCM defines LOS for signalized intersections. (Note that this definition has not changed with the 2000 edition of HCM)

> LOS A describes operations with very low control delay, up to 10 seconds per vehicle. This level of service occurs when progression is extremely favorable and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.
>
> LOS B describes operations with control delay greater than 10 and up to 20 seconds per vehicle. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of average delay.
>
> LOS C describes operations with control delay greater than 20 and up to 35 seconds per vehicle. These higher delays may result from fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.
>
> LOS D describes operations with control delay greater than 35 and up to 55 seconds per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
>
> LOS E describes operations with control delay greater than 55 and up to 80 seconds per vehicle. This level is considered by many agencies to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent occurrences.

LOS F describes operations with control delay in excess of 80 seconds per vehicle. This level, considered unacceptable to most drivers, often occurs with over saturation, that is, when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.0 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing factors to such delay l

Capacity analysis for a facility yields operational performance that is defined as level of service (LOS). For signalized and unsignalized intersections, LOS relates to the control delay of a vehicle. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.

The methodology for unsignalized intersections only computes LOS for the minor movements of the intersection, which include the minor street approaches under sign control, or major movements that must yield to oncoming traffic, such as left-turning traffic. Unsignalized LOS is defined as follows (HCM Exhibit 17-2):

LOS A: ≤10 seconds of control delay per vehicle
LOS B: >10 and ≤15 seconds of control delay per vehicle
LOS C: >15 and ≤25 seconds of control delay per vehicle
LOS D: >25 and ≤35 seconds of control delay per vehicle
LOS E: >35 and ≤50 seconds of control delay per vehicle
LOS F: >50 seconds of control delay per vehicle

Between Waydelich Creek and Ferry Terminal, the roadway adopts a rural highway character in appearance and in function and fits HCM's two-lane highway model very well. The methods for this analysis are found in Chapters 12 and 20 in the HCM. HCM provides two levels of service (LOS) descriptions for two lane highways according to its class. We determined that Glacier fits the Class II description since it is a users expect moderate speed, arterial, with a significant access function. The LOS for two-lane, Class II highways is defined as follows (from Exhibit 20-4 of the HCM).

LOS A: ≤40 Percent Time Following
LOS B: >40 and ≤55 Percent Time Following
LOS C: >55 and ≤70 Percent Time Following
LOS D: >70 and ≤85 Percent Time Following
LOS E: >85 Percent Time Following

HCM's arterial evaluation method gives LOS based upon travel speed. The Fritz Cove Road to Waydelich Creek segment most closely represents the HCM's Suburban Principal Arterial functional category (HCM Exhibits 10-3 and 10-4). This is classified as a Class II (Average Free-Flow Speed of 40 miles per hour) and Exhibit 15-2 provides the following LOS assignment based upon average travel speed.

LOS A: >35 mph
LOS B: >28-35 mph
LOS C: >22-28 mph
LOS D: >17-22 mph
LOS E: >13-17 mph
LOS F: ≤13 mph

Auke Bay Corridor Study

Interim Submittal
Alternative 2
Preliminary Summary of Geometric and Intersection Elements

USKH, Inc. / Kinney Engineering

This document summarizes geometric and intersection control elements for Alternative 2 that will provide satisfactory operations throughout the project life. The purpose of this document is to provide USKH with the information that is needed to begin the preliminary engineering and environmental analysis work on Alternative 2. This document represents work done to date on this alternative, and although we consider it substantially complete, the elements may be revised before the final report is complete.

Alternative 2 Average Annual Daily Traffic (AADT)

Table 1 presents Alternative 2 Design Year volume information. The Design Hour Volume is estimated to be 11%.

Glacier Highway *From* *To*				**Mendenhall Loop Road** *From* *To*		**By-Pass** *From* *To*
Auke Bay Ferry Terminal	*Auke Nu Drive*	*Harbor Drive/ Auke Bay Float Road*	*Fritz Cove Road*	*Glacier Highway*	*UAS*	*Mendenhall Loop Road*
Auke Nu Drive	*Harbor Drive/ Auke Bay Float Road*	*Fritz Cove Road*	*Engineers Cut-Off Road*	*UAS North Entrance and By Pass*	*End of Project*	*Ferry Terminal*
6,000	7,300	15,710	23,010	7,000	5,900	800

Table 1- Design Year Volumes

Level of Service

The American Association of State Highway and Transportation Officials (AASHTO) A Policy on the Geometric Design of Streets and Highways (Exhibit 2-32) recommends that urban and suburban arterial, similar to Glacier Highway, should be designed to operate at a LOS C or better. However, within the Chapter VII, Rural and Urban Arterials, AASHTO states "Heavily developed sections of metropolitan areas may necessitate the use of level of service D."

The operational performance measures uses for this analysis are levels of service, control delay, and volume to capacity ratio. Technical Memo 3 established the upper volume to capacity ratio (v/c) value at 0.85, or 85% of capacity. This upper value represents good design practice, in that there is some reserve capacity to absorb surges in volumes or flow turbulence.

Other performance measures that were proposed in Technical Memorandum 3 included queuing penalty and average network speed. These are more meaningful when used in comparing build alternatives to one another or to the no-build alternative. This work will be done later in the final report.

Levels of Service and other measures of effectiveness are calculated differently for intersections and roadway segments. Descriptions of these performance measures are included at the end of this memo under Attachment A.

The project area between Fritz Cove Road and the Waydelich Creek is well developed and overall capacity will generally be controlled by intersection capacity. Between Waydelich Creek and the Ferry Terminal, the roadway becomes more like an uninterrupted 2-lane highway.

Intersection Control

There are three control/geometric configuration options for intersections of this Alternative 2. These include unsignalized intersections, signalized intersections, and modern roundabouts. A fourth option, grade-separated interchanges, isn't feasible for this alternative, primarily because intersection volumes are not high enough to justify the expense and impacts of interchanges.

Accident evaluations have determined that the existing intersection of Mendenhall Loop Road and Glacier Highway, also known as the "Wye", probably contributes to the accident issues at the intersection. As such, this intersection should be reconfigured to a standard Tee intersection.

The following table summarizes existing intersections operational performance with future volumes.

Intersection	Approach	Year	2002	2009	2019	2029
Glacier Hwy/ Fritz Cove / UAS South Entrance	eastbound left	AM	A	A	A	A
		PM	*B*	*B*	*B*	*B*
	westbound left	AM	A	A	A	A
		PM	*A*	*A*	*A*	*B*
	northbound left/through/right	AM	B	C	C	E
		PM	*E*	*F*	*F*	*F*
	southbound left	AM	C	C	C	D
		PM	*F*	*F*	*F*	*F*
Glacier Hwy/ Harbor Rd	northbound left/through	AM	A	A	A	A
		PM	*A*	*A*	*A*	*A*
	eastbound left/right	AM	B	B	B	C
		PM	*C*	*C*	*D*	*F*
Glacier Hwy/ Mendenhall Lp.	southbound-inbound (modeled as westbound left)	AM	B	B	C	C
		PM	*C*	*D*	*E*	*F*
Glacier Hwy/ Mendenhall Lp Wye	eastbound left/ through (inbound)	AM	*A*	*A*	*A*	*A*
		PM	*A*	*A*	*A*	*A*
	southbound right	AM	A	A	A	A
		PM	B	B	C	C
Mendenhall Lp/ Mendenhall Lp Wye	eastbound left	AM	A	B	B	B
		PM	*B*	*B*	*B*	*C*
Mendenhall Lp/ UAS North Entrance	westbound left	AM	A	A	A	A
		PM	*A*	*A*	*A*	*A*
	northbound left/ right	AM	A	B	B	B
		PM	*B*	*C*	*C*	*D*

Table 2- Existing Conditions, Future Traffic Volumes Levels of Service

<u>Signalized Intersection Control</u>

Intersection control may only be signals if one or more warrants established by the Manual of Uniform Traffic Control Devices (MUTCD) are satisfied. The warrants include:

Warrant 1- Eight-Hour Volume
Warrant 2- Four-Hour Volume
Warrant 3- Peak Hour Volume
Warrant 4- Minimum Pedestrian Volumes

Warrant 5- School Crossings
Warrant 6- Coordinated Signal System
Warrant 7- Crash Experience
Warrant 8- Roadway Network

These warrants use existing data as analysis parameters. This warrants system cannot be applied to facilities that have not been constructed, or where major traffic circulation changes will occur, as is the case in this project. We used a Cal-Trans methodology for future volumes presented in the Institute of Transportation Engineers (ITE) *Manual of Traffic Signal Design*, Second Edition, by James H. Kell and Iris J. Fullerton. The method uses future estimated average daily traffic (EADT) as the input variables and estimates whether the intersection with future EADT will meet the MUTCD signal Warrant 1, Condition A- Minimum Vehicular Volume; Condition B- Interruption Of Continuous Traffic; and the combination of warrants allowed in MUTCD procedure.

This warrant methodology was applied to the major intersections of this project. The following table summarizes the results. concluding that the Glacier Highway-Fritz Cove Road- UAS South Entrance intersection, and the reconfigured Glacier Highway-Mendenhall Loop Road intersection will meet signal warrants during the life of the project.

Intersection	**A- Minimum Vehicular Volume**	**B- Interruption Of Continuous Traffic**	**C- Combination of Warrants (80% of A & B**
Glacier Highway-Fritz Cove Road- UAS South Entrance	Not Satisfied During The Project Life	Satisfied by 2019 (Mid-Life)	Not Satisfied During The Project Life
Glacier Highway-Mendenhall Loop Road (Reconfigured into a Tee intersection)	Satisfied by 2009 (Construction)	Satisfied by 2009 (Construction)	Satisfied by 2009 (Construction)
Mendenhall Loop Road-UAS North Entrance-By Pass	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Satisfied by 2029 (Design Year)
Glacier Highway- By Pass (New formed by By-Pass Terminus)	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life

Table 3- Future Signal Warrants

The Glacier Highway-Fritz Cove Road- UAS South Entrance intersection meets warrants by 2019, and the reconfigured Glacier Highway- Mendenhall Loop Road intersection will meet signal warrants in 2009. The Mendenhall Loop Road-UAS North Entrance- By Pass intersection satisfies a warrant in the Design Year, but will not be signalized with this project. The new intersection formed by the By Pass and Glacier Highway would not meet warrants.

Intersection geometrics at the signals are as depicted in the following figures. Auxiliary left-turn lanes are recommended for each approach at these signals as good design practice for safety and capacity. A westbound right-turn lane is recommended at the intersection of Glacier Highway-Fritz Cove Road- UAS South Entrance Intersection because of the high number of conflicts that was observed between turning traffic and following traffic.

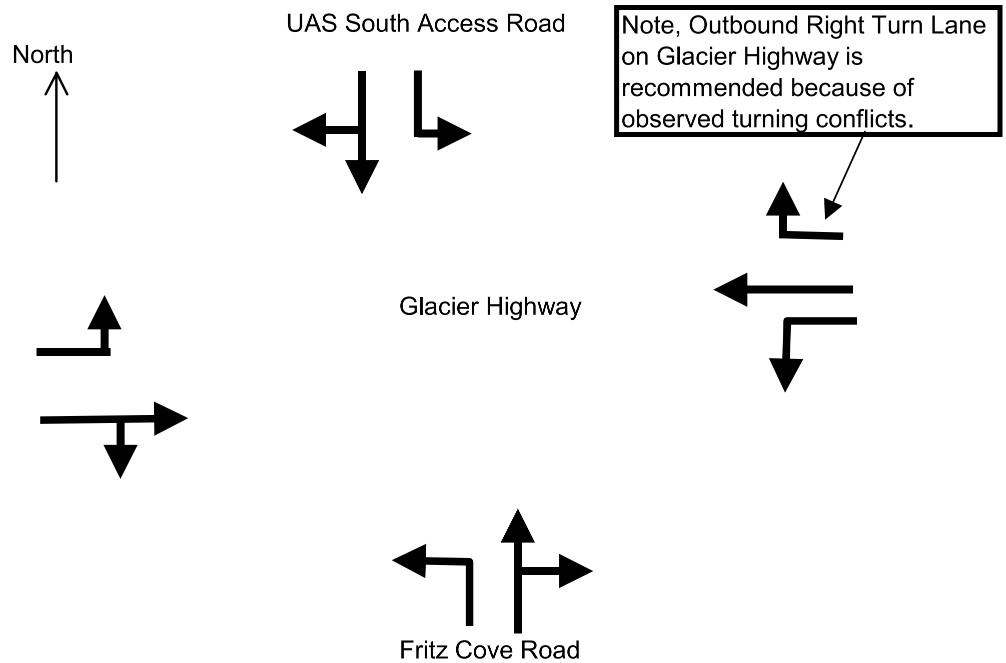


Figure 1- Glacier Highway-Fritz Cove Road- UAS South Entrance Intersection Lanes

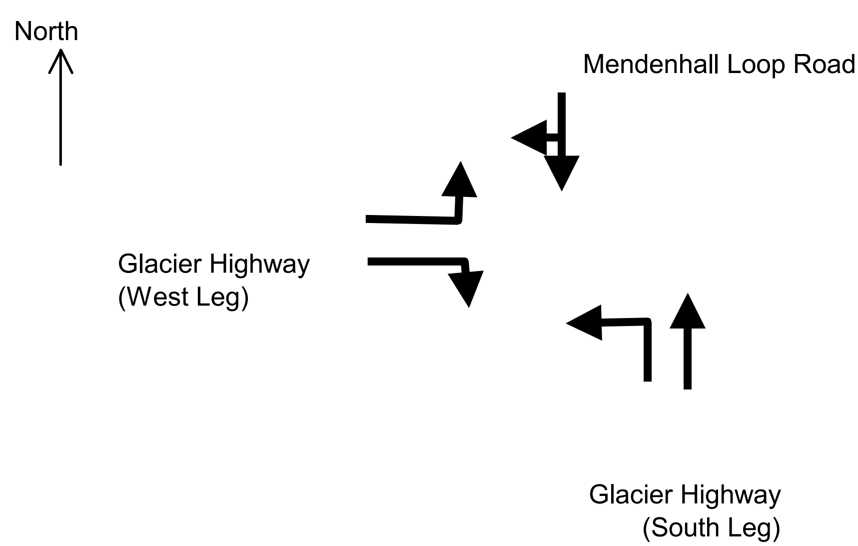


Figure 2- Glacier Highway- Mendenhall Loop Road (Reconfigured into a Tee intersection) Intersection Lanes

The following table summarizes 2029 Design Year performance measures for the intersections under signal control (lanes shown in Figures 1 and 2, optimized timing for 120 second cycle in the evening and 95 second cycle in the morning).

Intersection	**2029 Morning Peak Hour**			**2029 Evening Peak Hour**		
	Average Control Delay (sec/veh)	**v/c Ratio**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio**	**Level of Service**
Glacier Highway-Fritz Cove Road- UAS South Entrance	10	0.53	A	30	0.94	C
Glacier Highway- Mendenhall Loop Road (Reconfigured into a Tee intersection)	19	0.50	B	26	0.81	C
Mendenhall Loop Road- UAS North Entrance- By Pass	Not applicable since this intersection does not meet warrants until the end of the design life.					
By Pass- Glacier Highway	Not applicable since this intersection does not meet warrants					

Table 4- Signalized Intersection Operation Performance for Design Year, 2029

As shown in Table 3, operations will be adequate during the life of the facility. One objective, v/c ratio, is not met at the Glacier Highway-Fritz Cove Road- UAS South Entrance intersection in 2029. However, it would be for most of the project life. Figures 3 and 4 present auxiliary lane lengths for the signalized intersections. These are developed to accommodate deceleration (outside of through lane) and for storage in accordance with Table 1150-1 of the *Preconstruction Manual*. Note that highway speeds on Glacier Highway change from 45 mph to 35 mph near the Fish Lab, and that only storage is required at the Mendenhall Loop Road intersection.

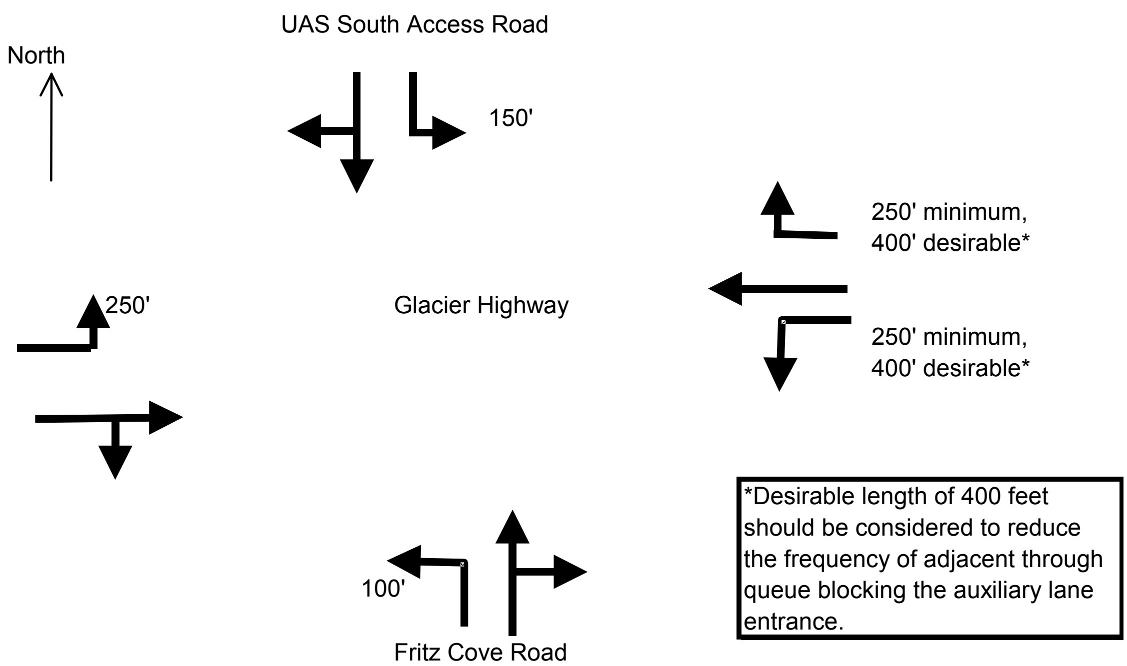


Figure 3- Auxiliary Lane Lengths Glacier Highway-Fritz Cove Road- UAS South Entrance Signalized Intersection

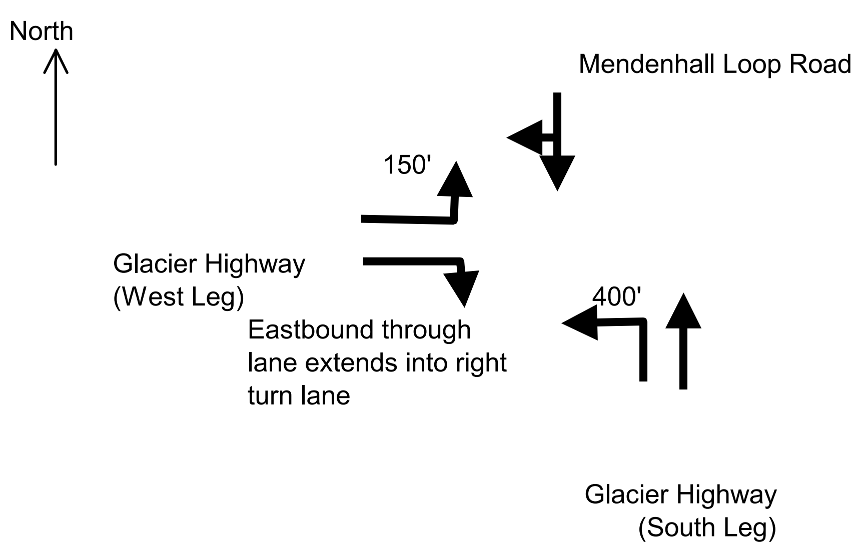


Figure 4- Auxiliary Lane Lengths Glacier Highway- Mendenhall Loop Road Signalized Intersection

Unsignalized Intersection Control

The Mendenhall Loop Road- UAS North Entrance intersection will not warrant signalization in the future and will continue to operate under sign control or as a modern roundabout. We find that a left-turn lane on the northwest and southwest bound approaches of Mendenhall Loop Road is recommended according to AASHTO Table 9-75. This table is further developed into a graphical presentation available in NCHRP Report 457 *Engineering Study Guide for Evaluating Intersections Improvements*, Bonneson and Fontaine. A left-turn lane for the UAS North Entrance approach is recommended to increase capacity.

The volumes on Mendenhall Loop Road are larger than the By-Pass or UAS approach volumes, and therefore the By-Pass and UAS approaches will be controlled by stop signs.

Figure 5 presents the recommend lanes configurations and auxiliary lane lengths for the Mendenhall Loop Road- UAS North Entrance- By Pass intersection. Deceleration lengths for the Mendenhall left-turn auxiliary lanes are calculation for the 40 mph posted speeds.

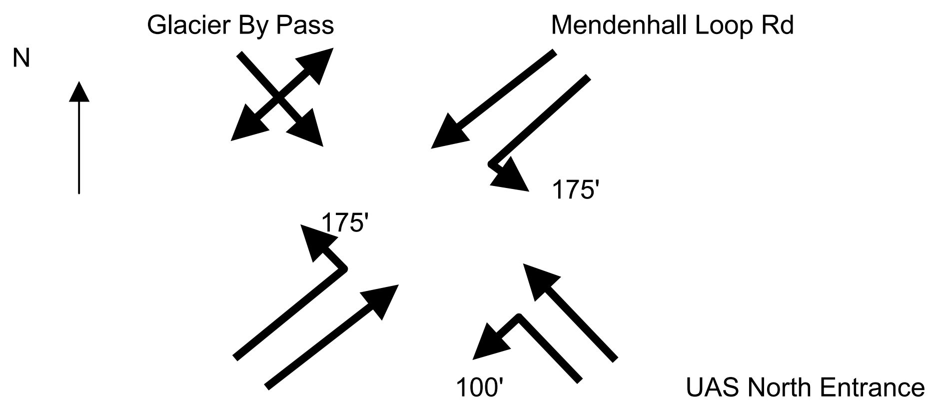


Figure 5- Mendenhall Loop Road- UAS North Entrance – By Pass Intersection Lanes, Stop Control

Table 5 summarizes Design Year (2029) performance measures for this intersection.

Glacier Highway-Mendenhall Loop Road Intersection Movements	2029 Morning Peak Hour			2029 Evening Peak Hour		
	Average Control Delay (sec/veh)	v/c Ratio	Level of Service	Average Control Delay (sec/veh)	v/c Ratio	Level of Service
Southwest Bound Left Turn	8	0.04	A	8	0.02	A
Northeast Bound Left Turn	8	0.02	A	9	0.08	A
Northwest Bound (UAS) Left Turn Lane	16	0.03	C	44	0.64	E
Northwest Bound (UAS) Right/Through Lane	9	0.01	A	14	0.18	B
Southeast Bound (By-Pass) Left/Through/Right Lane	10	0.12	B	16	0.11	C

Table 5- Glacier Highway- Mendenhall Loop Road Intersection Unsignalized Intersection Performance Measures

The By Pass- Glacier Highway intersection should have the following lane configurations and lengths (based upon a 50 mph design speed). We recommend a left-turn lane for the southwest bound approach, even though not justified by the volume methodology cited above.

The following figure presents recommended lane configurations and lengths for the intersection. Deceleration lengths for the Mendenhall left-turn auxiliary lanes are calculation for a 50 mph By Pass design speed.

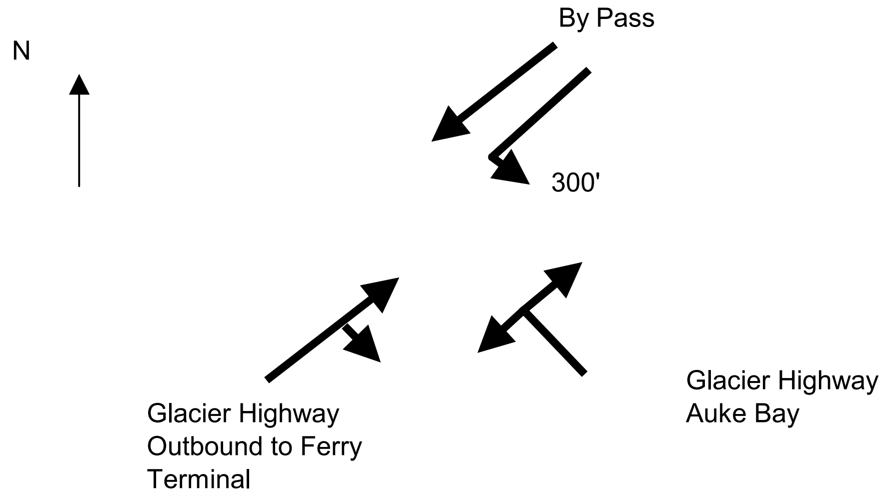


Figure 6- By Pass and Glacier Highway Intersection Lanes

The northwest bound approach (Glacier Highway Auk Bay Side) is assumed to be under stop control. The northwest right and left turn lanes will have a level of service of "B", with v/c ratio of 0.44, and an average delay of 12 seconds per vehicle.

Modern Roundabouts

In NCHRP 457, there is a summary table to determine if a roundabout would be suitable for a location (*NCHRP 457* Table 2-12 based on *FHWA RD-00-067 Roundabouts*: An Informational Guide). We apply these seven questions to major intersections of the project.

Question	Glacier Highway-Fritz Cove Road-UAS South Entrance	Glacier Highway-Mendenhall Loop Road	Mendenhall Loop Road-UAS North Entrance	By-Pass-Glacier Highway
1) Will operation as an uncontrolled or two-way-stop-controlled intersection yield unacceptable delay?	Yes	Yes	Yes	No
2) Is the daily entering volume less than the maximum service volume for a roundabout? (*Use Figure 2-3 of NCHRP 457*)	Yes, with qualifications, 1-lane on each approach and in the roundabout is probably less that maximum service volume. 2-lanes will work.	Yes, 1-lane on each approach and in the roundabout is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.
3) Is the subject junction located outside of the coordinated signal network?	Yes	Yes	Yes	Yes
4) Is the ratio of major-road to minor-road volume less than 5?	No, between 5:1 and 10:1	Yes, 4:1	Yes, about 4:1	No, between 5:1 and 10:1
5) Is the entering drivers view free of sight obstructions?	Yes, can be designed	Yes, can be designed	Yes, can be designed	Yes, can be designed
6) Will the subject junction infrequently be used by large or oversized trucks?	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic
7) Will the subject junction infrequently be used by pedestrians and bicyclists?	Yes	No, Expect Moderate Use by Bikes and Pedestrians	No, Expect High Frequency Use by Bikes and Pedestrians	Yes

Table 6- Roundabout Suitability Questions

As NCHRP 457 points out, the more frequently that these questions in Table 4 are answered with "Yes", then the more likely that this intersection would work as a roundabout. We would discard the Bypass and Glacier Highway as a roundabout since there are two "No" answers, and since the intersection will function well as an unsignalized intersection. In addition, we would like to encourage mobility at this location, which is better facilitated with the "tee" intersection.

There are other advantages to roundabouts, as well as providing good levels of service. FHWA demonstrates a reduction in both crash rates and injuries when intersections are converted to roundabouts. Overall, accident rate reduction is achieved, in part, by the reduction of conflict points from 32 at a standard four-legged intersection, to 8 with a roundabout. Another part of accident reduction for roundabouts is that they by nature reduce approach speeds on all legs, which in turn allow vehicles more reaction time. Accident severity is reduced as well. Roundabouts reduce the relative velocity of vehicles involved in a crash in two ways. The first is an overall speed reduction and the second is that the collision types are dramatically changed. Angle and head-on accidents, both with high relative velocities are almost eliminated from the roundabout crash patterns. Instead, the roundabout reconfigures these high-severity conflicts into merge conflicts, which at shallow angles and low speeds have a very low relative velocity.

Recent roundabouts on minor arterial and collector roads within the Municipality of Anchorage have used an inscribed diameter of about 140 feet with 20-foot circulation lanes to accommodate WB-50 (tractor-trailer rig) turning path widths. Figure 7 and Table 7 present roundabout geometric elements. It should be noted that 3-leg roundabouts are acceptable and would be used at the Mendenhall Loop Road and Glacier Highway intersection and the UAS North Access intersection.

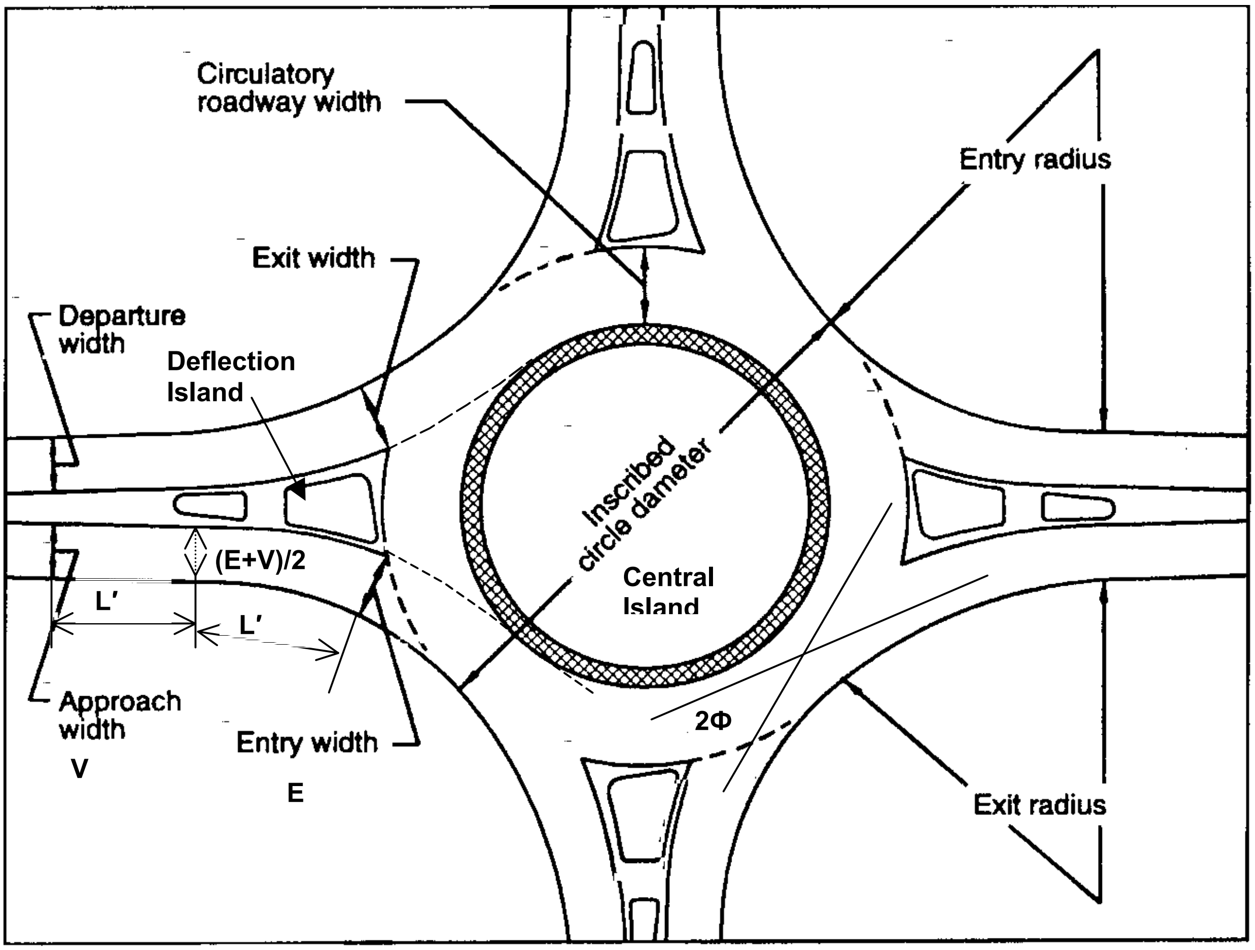


Figure 7- Roundabout Geometric Elements

Table 7 has value ranges for these geometric elements. Sources include FHWA RD-00-067 *Roundabouts: An Informational Guide* and *Interactive Roundabout Design Software and Manual*, Rodel Software Ltd and Staffordshire County Council.

Element	Value	Source, Comments
Inscribed Circle Diameter	140 feet single lane	FHWA with local experience. Will be adequate for WB-50 design vehicles.
Central Island Diameter	Approximately 100 feet (single lane circulation lane), with an outer ring that accommodates occasional truck-trailer combinations larger than WB-50.	Inscribed Circle Diameter- Circulatory Road Width, divided by 2.
Approach Width, **V**	Lane Width (assumed 12 feet)	FHWA, Rodel
Entry Width, **E**	14 to 16 feet for single lane	FHWA
L′	Minimum 16 feet (Rodel), 40 feet recommended minimum (FHWA)	Use 40 feet. (derived from FHWA's recommendation of an 80-foot flare taper in urban areas.)
Φ	25 to 35 degrees	Rodel
Entry Radius, Single Lane	>30 feet, <100 feet	Rodel, FHWA
Exit Radius, Single Lane	>50 feet (FHWA)	Rodel recommend that the exit radius be determined as transition from circulatory road width, through the deflection island, and to the departure width. Radius should be selected to that taper is 15 or 20 to 1.
Circulatory Road Width	1 to 1.2 x **E,** use 20 feet minimum for single lane	Rodel, FHWA
Deflection Island (splitter island), Exit Width	Defined by tangential extensions to the Central Island	FHWA and Rodel. FWHA recommends a minimum of 5-foot pedestrian refuge be located at about 20 feet from the yield line.

Table 7- Typical Design Values for Roundabout Geometric Elements, Auke Bay Corridor Intersections

These values will be confirmed during detail design.

Table 8 presents the performance measures for the project intersection under a modern roundabout configuration.

Intersection	2029 Morning Peak Hour			2029 Evening Peak Hour		
	Average Control Delay (sec/veh)	**v/c Ratio (intersection average**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio (intersection average)**	**Level of Service**
Glacier Highway- Fritz Cove Road- UAS South Entrance	2	0.30	A	5	0.71	A
Glacier Highway- Mendenhall Loop Road	6	0.25	A	9	0.57	A
Mendenhall Loop Road- UAS North Entrance- By Pass	4	0.14	A	5	0.25	A
By Pass-Glacier Highway	Not recommended, but would function at a high level of service.					

Table 8- Roundabout Performance Measures

Intersection Summary

Table 9 summarizes the work in this section.

Intersection	Unsignalized Operations	Signalized Operations	140-foot Roundabout	Recommendation
Glacier Highway-Fritz Cove Road-UAS South Entrance	Unsatisfactory-Fails in 2009	Meets warrants by 2019, good operations since it operates at LOS C or better over the project life.	Good operations, LOS A over the entire life.	Roundabout provides superior operations.
Glacier Highway-Mendenhall Loop Road	Unsatisfactory	Meets warrants by 2009, good operations since it operates at LOS C or better over the project life.	Good operations, LOS A or better over the entire life.	Roundabout provides superior operations.
Mendenhall Loop Road-UAS North Entrance	Unsatisfactory-LOS E for NW bound LT in 2029	Signals will not be warranted.	Good operations, LOS A over the entire life.	Consider Roundabout because of poor operations of Stop Controlled intersection. This will require pedestrian accommodations.
By Pass and Glacier Highway	Satisfactory, LOS B or better	Signals will not be warranted.	Not recommended, but operations would be good.	Unsignalized Operations, Stop Control on the Glacier Highway approach.

Table 9- Intersection Evaluation Summary

Roadway Typical Section

Glacier Highway- Fritz Cove Road to Waydelich Creek

This segment of the roadway is urban in appearance and function.

Two through lanes (one inbound and outbound) will be adequate for the intersections as discussed above, and will be all required for the segments between intersections. Because of the relatively high traffic volume through the corridor, the typical section should provide left-turn lanes at all cross streets and at significant generators for the segments between Fritz Cove Road and Waydelich Creek. This is best accomplished with a three-lane section that has a center two way left turn lane (CTWLTL). For the section of roadway between Fritz Cove Road and Mendenhall Loop Road, the lower density of driveway and cross streets would allow a raised median that is opened with a turn bay at each of the cross-street or driveways.

Operations for the segment of the roadway between Fritz Cove Road and Waydelich Creek are best modeled with interrupted flow capacity techniques. For two lanes and adequate left turn provisions at the minor cross streets and driveways (either CTWLTL or median openings and left turn lanes), two through lanes will operate well through the design year.

Glacier Highway - Waydelich Creek to the Ferry Terminal

Even thought this short segment of the road, approximately 0.9 miles, is functionally classified as an urban arterial, it is rural in character and function. As such, HCM2000 two-lane highway methods may be used. The following table summarizes Design Year, evening operations with a two-lane highway section.

Begin	**Waydelich Creek**
End	**Ferry Terminal**
Length	**0.9 miles**
Two-lane Highway Class (see discussion under Attachment A)	II
ADT	6,000
DHV	650
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	50%
Free Flow (85th reading)	56 mph
Average of Mean Speed S_{FM}	51 mph
Percent Time Following	62%
Volume/Capacity Ratio	0.25
Average Travel Speed	47 mph
Levels of Service	C

Table 10-2029 Glacier Highway Waydelich Creek to Ferry Terminal Segment Performance Measures

<u>By-Pass, Mendenhall Loop Road to Glacier Highway near Ferry Terminal</u>

The following table summarizes design year operations of the By Pass segment.

Begin	**Mendenhall Loop Road**
End	**Glacier Highway**
Length	**1.2 miles**
Two-lane Highway Class (see discussion under Attachment A)	I
ADT	800
DHV	90
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	50%
Estimated Base Free Flow Speed	50 mph
Percent Time Following	30%
Volume/Capacity Ratio	0.25
Average Travel Speed	47 mph
Levels of Service	C (Speed Constrained)

Table 11- 2029 By Pass Segment Performance Measures

<u>Mendenhall Loop Road</u>

Mendenhall Loop Road between Glacier Highway and the UAS North Entrance-By Pass intersection is dominated by the intersection operations. As such, this relatively short segment lane configuration is determined by intersection needs. Both intersections on the termini of this segment will operate well with one through lane approaches (exclusive of auxiliary left-turn lanes). Therefore, this segment may have one lane in each direction. We don't expect significant landside development, which would create a mid-block left-turn demand. As such, a CTWLTL is not needed.

The segment of Mendenhall Loop Road beyond the UAS North Entrance-By Pass intersection functions a Class II rural two-lane highway. The 2029 performance is summarized in the following table.

Begin	UAS North Entrance-By Pass
End	**-**
Length	**-**
Two-lane Highway Class (see discussion under Attachment A)	II
ADT	5900
DHV	650
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	50%
Estimated Base Free Flow Speed	45 mph
Percent Time Following	62%
Volume/Capacity Ratio	0.25
Average Travel Speed	37 mph
Levels of Service	C

Segment Evaluation Summary

Two-through lanes will function adequately throughout the project life. The following table summarizes the geometric elements required for each segment.

	2-lane	3-lane (CTWLTL)	Curb and Gutter	Shoulders	Sidewalk	Pathway
Fritz Cove Road to Waydelich Ck (Urban)	-	11 or 12 – foot through lanes, 12 to 14-foot CTWLTL	x	Optional, 5 feet desirable for bikes	x	x
Waydelich Ck to Ferry Terminal (Rural)	12-foot lanes	-	-	8 feet	x	x
By Pass	12-foot lanes	-	-	8 feet		
Mendenhall Loop Road	12-foot lanes	-	-	8 feet	x	x

Table 12- Segment Geometric Elements

Attachment A
Level of Service Discussion

We use capacity analysis to determine operational performance. The capacity analysis was performed in accordance with the procedures outlined in Transportation Research Board Highway Capacity Manual 2000 (HCM) for interrupted flow facilities, using Synchro/SimTraffic, Version 5, distributed by Trafficware. In an urban area, the capacity of a system is constrained by the capacity of the system's intersections and uninterrupted capacity methods generally do not apply.

Capacity analysis for a facility yields operational performance that is defined as level of service (LOS). For signalized intersections, LOS relates to the control delay of a vehicle. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. The HCM methodology calculates LOS for each movement and for the intersection as a whole.

The following narrative from Chapter 9 of the 1997 HCM defines LOS for signalized intersections. (Note that this definition has not changed with the 2000 edition of HCM)

> LOS A describes operations with very low control delay, up to 10 seconds per vehicle. This level of service occurs when progression is extremely favorable and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.
>
> LOS B describes operations with control delay greater than 10 and up to 20 seconds per vehicle. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of average delay.
>
> LOS C describes operations with control delay greater than 20 and up to 35 seconds per vehicle. These higher delays may result from fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.
>
> LOS D describes operations with control delay greater than 35 and up to 55 seconds per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
>
> LOS E describes operations with control delay greater than 55 and up to 80 seconds per vehicle. This level is considered by many agencies to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent occurrences.

LOS F describes operations with control delay in excess of 80 seconds per vehicle. This level, considered unacceptable to most drivers, often occurs with over saturation, that is, when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.0 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing factors to such delay l

Capacity analysis for a facility yields operational performance that is defined as level of service (LOS). For signalized and unsignalized intersections, LOS relates to the control delay of a vehicle. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.

The methodology for unsignalized intersections only computes LOS for the minor movements of the intersection, which include the minor street approaches under sign control, or major movements that must yield to oncoming traffic, such as left-turning traffic. Unsignalized LOS is defined as follows (HCM Exhibit 17-2):

LOS A: ≤10 seconds of control delay per vehicle
LOS B: >10 and ≤15 seconds of control delay per vehicle
LOS C: >15 and ≤25 seconds of control delay per vehicle
LOS D: >25 and ≤35 seconds of control delay per vehicle
LOS E: >35 and ≤50 seconds of control delay per vehicle
LOS F: >50 seconds of control delay per vehicle

The Glacier Highway between Waydelich Creek and Ferry Terminal, and Mendenhall Loop Road are rural highways in appearance and in function and fits HCM's two-lane highway model very well. The methods for this analysis are found in Chapters 12 and 20 in the HCM. HCM provides two levels of service (LOS) descriptions for two lane highways according to its class. We determined that Glacier fits the Class II description since it is a users expect moderate speed, arterial, with a significant access function. The LOS for two-lane, Class II highways is defined as follows (from Exhibit 20-4 of the HCM).

<u>Class II</u>
LOS A: ≤40 Percent Time Following
LOS B: >40 and ≤55 Percent Time Following
LOS C: >55 and ≤70 Percent Time Following
LOS D: >70 and ≤85 Percent Time Following
LOS E: >85 Percent Time Following

The By Pass will also be a rural two-lane highway in appearance and function and should be under the Class I Performance measures, since it's only function is mobility. It's performance measures are as follows (from Exhibit 20-2 of the HCM)..

<u>Class I</u>
LOS A: ≤35 Percent Time Following, > 55 mph average travel speed
LOS B: >35 and ≤50 Percent Time Following, 50 to 55 mph average travel speed

LOS C: >50 and ≤65 Percent Time Following, 45 to 50 mph average travel speed
LOS D: >65 and ≤80 Percent Time Following, 40 to 45 mph average travel speed
LOS E: >80 Percent Time Following, ≤ 40 mph.

HCM's urban arterial evaluation method gives LOS based upon travel speed. The Fritz Cove Road to Waydelich Creek segment most closely represents the HCM's Suburban Principal Arterial functional category (HCM Exhibits 10-3 and 10-4). This is classified as a Class II (Average Free-Flow Speed of 40 miles per hour) and Exhibit 15-2 provides the following LOS assignment based upon average travel speed.

LOS A: >35 mph
LOS B: >28-35 mph
LOS C: >22-28 mph
LOS D: >17-22 mph
LOS E: >13-17 mph
LOS F: ≤13 mph

Auke Bay Corridor Study

Interim Submittal
Alternative 3
Preliminary Summary of Geometric and Intersection Elements

USKH, Inc. / Kinney Engineering / Northland Systems Engineering

This document summarizes geometric and intersection control elements for Alternative 3 that will provide satisfactory operations throughout the project life. The purpose of this document is to provide USKH with the information that is needed to begin the preliminary engineering and environmental analysis work on Alternative 3. This document represents work done to date on this alternative, and although we consider it substantially complete, the elements may be revised before the final report is complete.

Alternative 3 Description

Alternative 3 is a corridor route that intersects Glacier Highway east of Engineer's Cutoff, proceeds north around the east side of Auke Lake, crosses Mendenhall Loop Road, and proceeds west to intersect the Glacier Highway between Auke Nu Drive and the Ferry Terminal. The intent of this corridor is to remove through traffic from the development along Glacier Highway in the Auke Bay area, thereby increasing overall travel efficiency. We included in our analysis an access road between the bypass and the UAS driveway on Mendenhall Loop Road, called UAS/Guard Drive. This link makes the bypass more attractive to potential users by providing intermediate access to mid-corridor generators.

Alternative 3 Average Annual Daily Traffic (AADT)

Table 1 presents Alternative 3 Design Year volume information. The Design Hour Volume is estimated to be 11%.

Glacier Highway *From* *To*				**Mendenhall Loop Road** *From* *To*		**By-Pass** *From* *To*		
Auke Bay Ferry Terminal	***Auke Nu Drive***	***Harbor Drive/ Auke Bay Float Road***	***Fritz Cove Road***	***Glacier Highway***	***UAS***	***Ferry Terminal***	***UAS Access***	***Mendenhall Loop Road***
Auke Nu Drive	***Harbor Drive/ Auke Bay Float Road***	***Fritz Cove Road***	***Engineers Cut-Off Road***	***UAS North Entrance and By Pass***	***By Pass***	***UAS Access***	***Mendenhall Loop Road***	***Glacier Hwy***
6,000	3,600	10,300	12,700	3,000	4,600	3,600	4,800	9,200

Table 1- Design Year Volumes

Level of Service

The American Association of State Highway and Transportation Officials (AASHTO) A Policy on the Geometric Design of Streets and Highways (Exhibit 2-32) recommends that urban and suburban arterial, similar to Glacier Highway, should be designed to operate at a LOS C or better. However, within the Chapter VII, Rural and Urban Arterials, AASHTO states “Heavily developed sections of metropolitan areas may necessitate the use of level of service D.”

The operational performance measures uses for this analysis are levels of service, control delay, and volume to capacity ratio. Technical Memo 3 established the upper volume to capacity ratio (v/c) value at 0.85, or 85% of capacity. This upper value represents good design practice, in that there is some reserve capacity to absorb surges in volumes or flow turbulence.

Other performance measures that were proposed in Technical Memorandum 3 included queuing penalty and average network speed. These are more meaningful when used in comparing build alternatives to one another or to the no-build alternative. This work will be done later in the final report.

Levels of Service and other measures of effectiveness are calculated differently for intersections and roadway segments. Descriptions of these performance measures are included at the end of this memo under Attachment A.

The project area between Fritz Cove Road and the Waydelich Creek is well developed and overall capacity will generally be controlled by intersection capacity. Between Waydelich Creek and the Ferry Terminal, the roadway becomes more like an uninterrupted 2-lane highway.

Intersection Control

There are three control/geometric configuration options for intersections of this Alternative 3. These include unsignalized intersections, signalized intersections, and modern roundabouts. A fourth option, grade-separated interchanges, isn't feasible for this alternative, primarily because intersection volumes are not high enough to justify the expense and impacts of interchanges.

Accident evaluations have determined that the existing intersection of Mendenhall Loop Road and Glacier Highway, also known as the "Wye", probably contributes to the accident issues at the intersection. As such, this intersection should be reconfigured to a standard Tee intersection.

The following table summarizes existing intersections operational performance with future volumes.

Intersection	Approach	Year	2002	2009	2019	2029
Glacier Hwy/ Fritz Cove / UAS South Entrance	eastbound left	AM	A	A	A	A
		PM	*B*	*B*	*B*	*B*
	westbound left	AM	A	A	A	A
		PM	*A*	*A*	*A*	*B*
	northbound left/through/right	AM	B	C	C	E
		PM	*E*	*F*	*F*	*F*
	southbound left	AM	C	C	C	D
		PM	*F*	*F*	*F*	*F*
Glacier Hwy/ Harbor Rd	northbound left/through	AM	A	A	A	A
		PM	*A*	*A*	*A*	*A*
	eastbound left/right	AM	B	B	B	C
		PM	*C*	*C*	*D*	*F*
Glacier Hwy/ Mendenhall Lp.	southbound-inbound (modeled as westbound left)	AM	B	B	C	C
		PM	*C*	*D*	*E*	*F*
Glacier Hwy/ Mendenhall Lp Wye	eastbound left/ through (inbound)	AM	*A*	*A*	*A*	*A*
		PM	*A*	*A*	*A*	*A*
	southbound right	AM	A	A	A	A
		PM	B	B	C	C
Mendenhall Lp/ Mendenhall Lp Wye	eastbound left	AM	A	B	B	B
		PM	*B*	*B*	*B*	*C*
Mendenhall Lp/ UAS North Entrance	westbound left	AM	A	A	A	A
		PM	*A*	*A*	*A*	*A*
	northbound left/ right	AM	A	B	B	B
		PM	*B*	*C*	*C*	*D*

Table 2- Existing Conditions, Future Traffic Volumes Levels of Service

Signalized Intersection Control

Intersection control may only be signals if one or more warrants established by the Manual of Uniform Traffic Control Devices (MUTCD) are satisfied. The warrants include:

Warrant 1- Eight-Hour Volume
Warrant 2- Four-Hour Volume
Warrant 3- Peak Hour Volume
Warrant 4- Minimum Pedestrian Volumes
Warrant 5- School Crossings
Warrant 6- Coordinated Signal System
Warrant 7- Crash Experience
Warrant 8- Roadway Network

These warrants use existing data as analysis parameters. This warrants system cannot be applied to facilities that have not been constructed, or where major traffic circulation changes will occur, as is the case in this project. We used a Cal-Trans methodology for future volumes presented in the Institute of Transportation Engineers (ITE) *Manual of Traffic Signal Design*, Second Edition, by James H. Kell and Iris J. Fullerton. The method uses future estimated average daily traffic (EADT) as the input variables and estimates whether the intersection with future EADT will meet the MUTCD signal Warrant 1, Condition A- Minimum Vehicular Volume; Condition B- Interruption Of Continuous Traffic; and the combination of warrants allowed in MUTCD procedure.

This warrant methodology was applied to the major intersections of this project. The following table summarizes the results, concluding that the Glacier Highway-By Pass intersection (east side, opposite Industrial Boulevard), and the new By Pass- Mendenhall Loop Road intersection will meet signal warrants during the life of the project.

Intersection	**A- Minimum Vehicular Volume**	**B- Interruption Of Continuous Traffic**	**C- Combination of Warrants (80% of A & B**
Glacier Highway-Fritz Cove Road- UAS South Entrance	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life
Glacier Highway-Mendenhall Loop Road (Reconfigured into a Tee intersection)	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life
Mendenhall Loop Road-UAS North Entrance-By Pass Access	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life
Glacier Highway- By Pass (New formed by By-Pass West Terminus, near Ferry Terminal)	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life
By Pass-Mendenhall Loop Road (New)	Satisfied by 2019 (Midlife)	Not Satisfied During The Project Life	Satisfied by 2029 (Design Year)
By Pass-UAS Access	Not Satisfied During The Project Life	Not Satisfied During The Project Life	Not Satisfied During The Project Life
Glacier Highway-East By Pass-Industrial Boulevard (New formed by By Pass East Terminus)	Satisfied by 2009 (Construction)	Satisfied by 2009 (Construction)	Satisfied by 2009 (Construction)

Table 3- Future Signal Warrants

The new intersection formed by the By Pass and Glacier Highway east of Engineer's Cutoff meets warrants by 2009. The new intersection of the By Pass with Mendenhall Loop Road meets one signal warrant by 2019, and another by 2029. None of the other intersections in this alternative meet a signal warrant by the design year 2029.

Intersection geometrics at the signals are as depicted in the following figures. Auxiliary left-turn lanes are recommended for each approach at these signals as good design practice for safety and capacity. A westbound right-turn lane is recommended at the intersection of Glacier Highway-By Pass Intersection because of the high volume of right turning traffic.

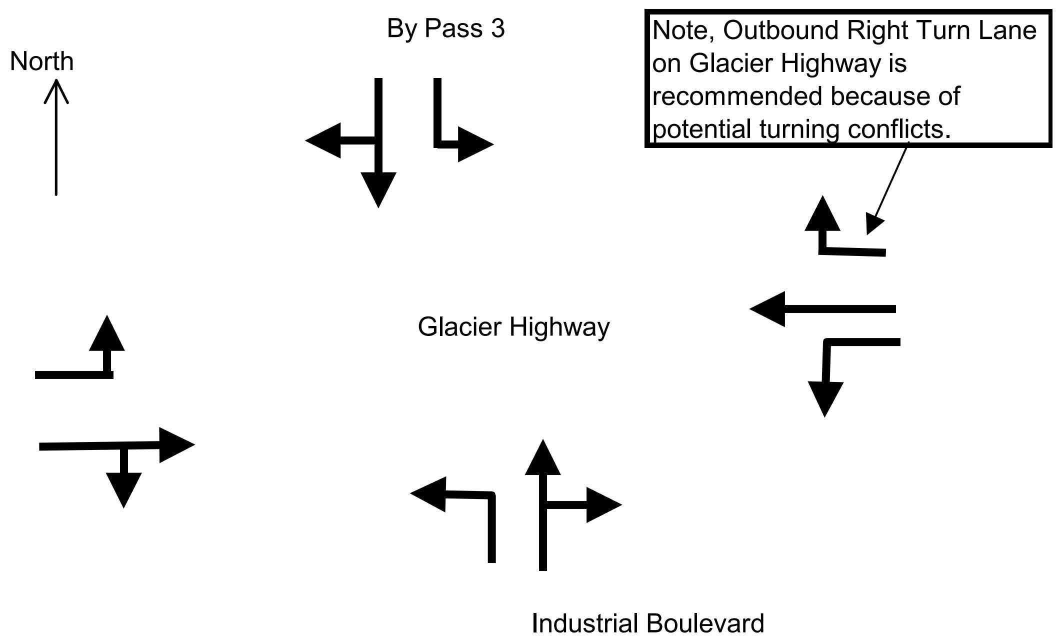


Figure 1- Glacier Highway-East By Pass Intersection Lanes

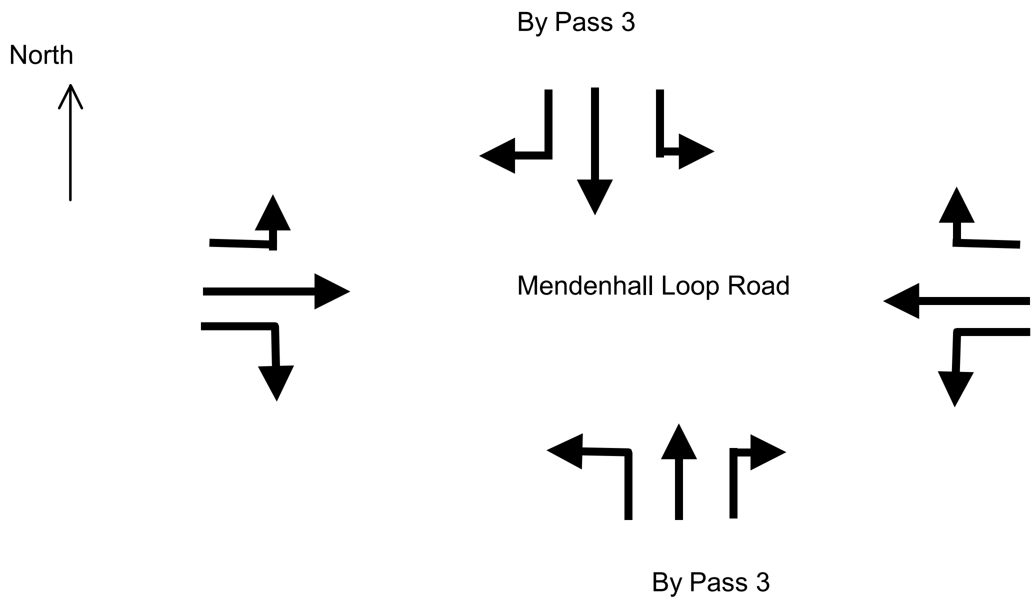


Figure 2- By Pass - Mendenhall Loop Road Intersection Lanes

The following table summarizes 2029 Design Year performance measures for the intersections under signal control (lanes shown in Figures 1 and 2, optimized timing for 90 second cycle in the evening and 65 second cycle in the morning).

Intersection	2029 Morning Peak Hour			2029 Evening Peak Hour		
	Average Control Delay (sec/veh)	v/c Ratio	Level of Service	Average Control Delay (sec/veh)	v/c Ratio	Level of Service
Glacier Highway-By Pass East-Industrial Boulevard	23	0.61	C	30	0.90	C
By Pass- Mendenhall Loop Road	19	0.36	B	22	0.50	C

Table 4- Signalized Intersection Operation Performance for Design Year, 2029

As shown in Table 4, operations will be adequate during the life of the facility. One objective, v/c ratio, is not met at the Glacier Highway-East By Pass intersection in 2029. However, it would be for most of the project life. Figures 3 and 4 present auxiliary lane lengths for the signalized intersections. These are developed to accommodate deceleration (outside of through lane) and for storage in accordance with Table 1150-1 of the *Preconstruction Manual*. For these intersections, Table 1150-1 recommends both storage and deceleration for auxiliary lanes. Deceleration lengths were computed based upon Glacier Highway and Mendenhall Loop posted speeds of 45 mph, and upon the anticipated design speed of 50 mph for the By-Pass.

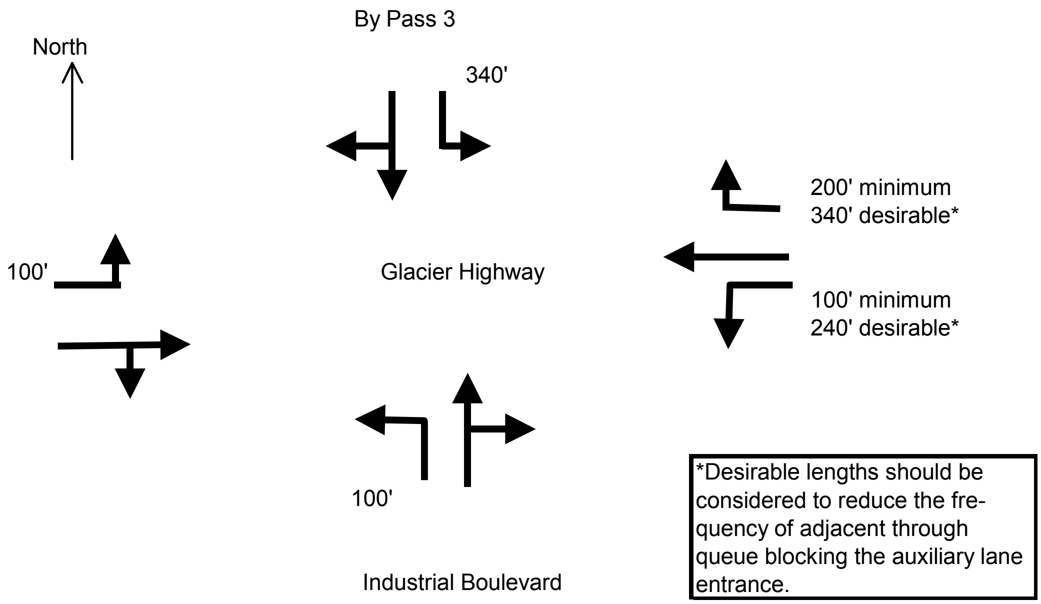


Figure 3- Auxiliary Lane Lengths Glacier Highway-East By Pass-Industrial Boulevard Intersection

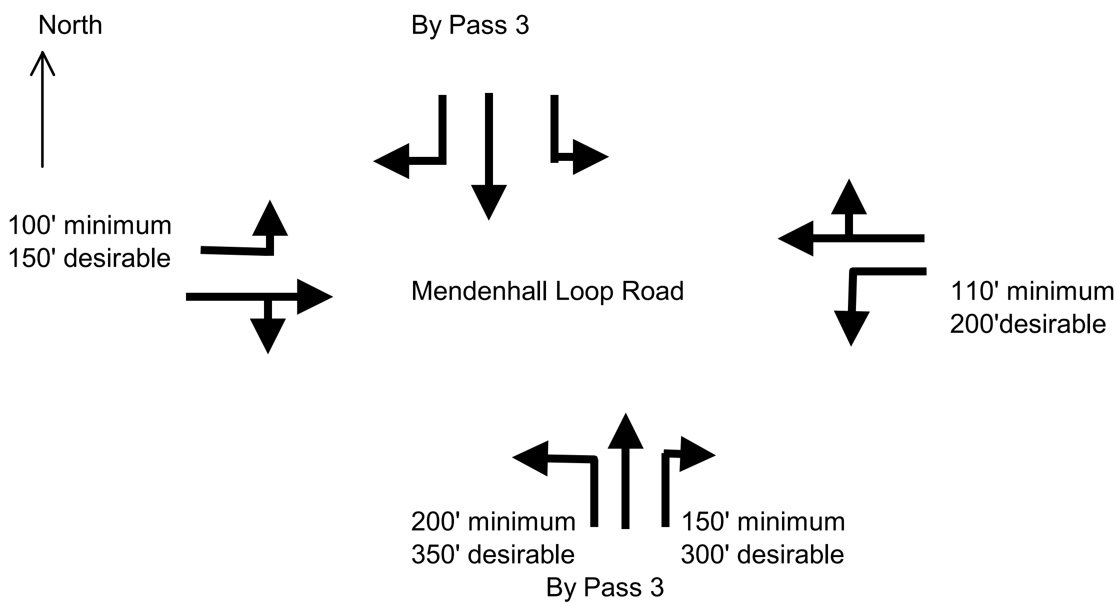


Figure 4- Auxiliary Lane Lengths By Pass- Mendenhall Loop Road Signalized Intersection

Unsignalized Intersection Control

The Mendenhall Loop Road- UAS North Entrance intersection will not warrant signalization in the future and will continue to operate under sign control or as a modern roundabout. We find that single lane approaches on all approaches are recommended according to AASHTO Table 9-75. This table is further developed into a graphical presentation available in NCHRP Report 457 *Engineering Study Guide for Evaluating Intersections Improvements*, Bonneson and Fontaine (which was used in this analysis). A left-turn lane for the UAS North Entrance approach is recommended to increase capacity and facilitate use of this driveway and the main entrance to the campus.

The volumes on Mendenhall Loop Road are larger than the UAS/Guard Access or UAS Driveway approach volumes, and therefore the UAS/Guard Access and UAS Driveway approaches will be controlled by stop signs.

Figure 5 presents the recommend lanes configurations and auxiliary lane lengths for the Mendenhall Loop Road- UAS North Entrance- UAS/Guard Access intersection. Deceleration lengths for the Mendenhall left-turn auxiliary lanes are calculated for the 40 mph posted speeds.

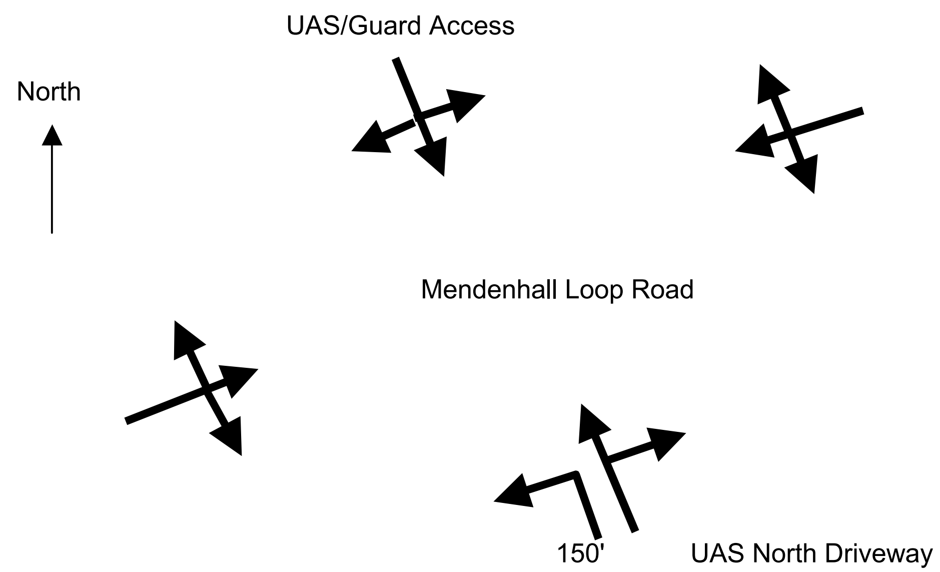


Figure 5- Mendenhall Loop Road- UAS North Entrance – By Pass Intersection Lanes, Stop Control

Table 5 summarizes Design Year (2029) performance measures for this intersection.

Mendenhall Loop Road-UAS Driveway Intersection Movements	**2029 Morning Peak Hour**			**2029 Evening Peak Hour**		
	Average Control Delay (sec/veh)	**v/c Ratio**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio**	**Level of Service**
Southwest Bound Left/Through/Right Lane	2	0.03	A	4	0.11	A
Northeast Bound Left/Through/Right	1	0.01	A	1	0.02	A
Northwest Bound (UAS) Left Turn Lane	13	0.01	B	21	0.13	C
Northwest Bound (UAS) Right/Through Lane	2	0.02	A	20	0.46	C
Southeast Bound (By-Pass) Left/Through/Right Lane	13	0.16	B	20	0.32	C

Table 5- UAS/Guard Access-UAS Driveway- Mendenhall Loop Road Intersection Unsignalized Intersection Performance Measures

The West By Pass- Glacier Highway (Ferry Terminal) intersection should have the following lane configurations and lengths (based upon a 50 mph design speed). We recommend a left-turn lane for the southwest bound approach, even though not justified by the volume methodology cited above.

The following figure presents recommended lane configurations and lengths for the intersection. Deceleration lengths for the Bypass left-turn auxiliary lanes are calculated for a 50 mph By Pass design speed.

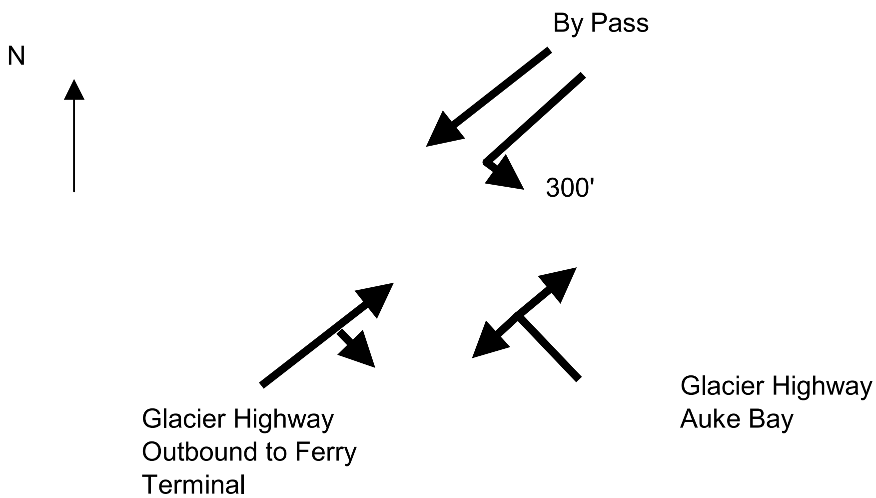


Figure 6- West By Pass and Glacier Highway Intersection Lanes

The northwest bound approach (Glacier Highway Auk Bay Side) is assumed to be under stop control. The northwest right and left turn lanes will have a level of service of “B”, with v/c ratio of 0.11, and an average delay of 12 seconds per vehicle.

Figure 7 presents the lane configuration and auxiliary lane lengths for the intersection of Glacier Highway and Mendenhall Loop Road. In this alternative, the Wye is converted to a Tee intersection and the southbound approach is stop controlled, as the higher volumes are on the Glacier Highway approaches. The southbound approach will have a level of service of “B”, with v/c ratio of 0.24, and an average delay of 14 seconds per vehicle in the Design Year 2029.

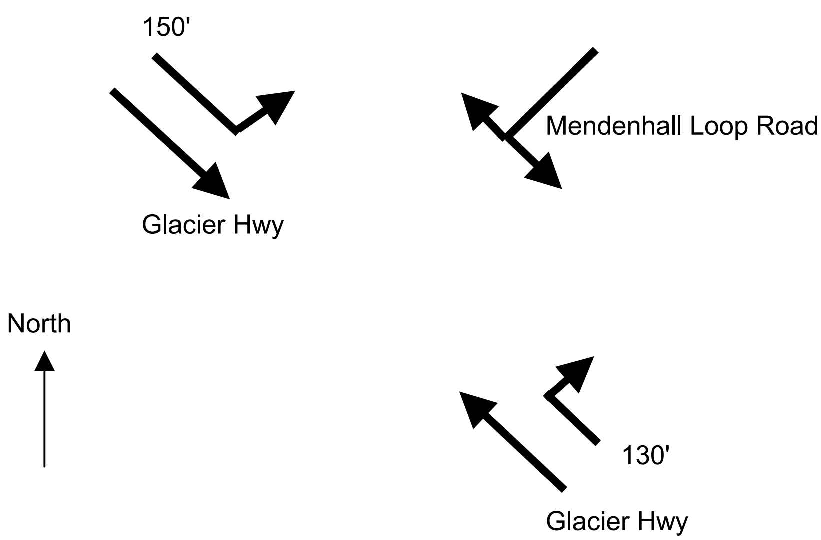


Figure 7- Glacier Highway and Mendenhall Loop Road Intersection Lanes

The intersection of By Pass 3 and UAS/Guard Access is unique to this alternative. It has the same configuration as the intersection of Glacier Highway and the By Pass at the Ferry Terminal end of the project. Figure 8 presents the configuration and auxiliary lane lengths for this intersection. This intersection will have a level of service "B", with v/c ratio of 0.15, and an average delay of 10 seconds per vehicle.

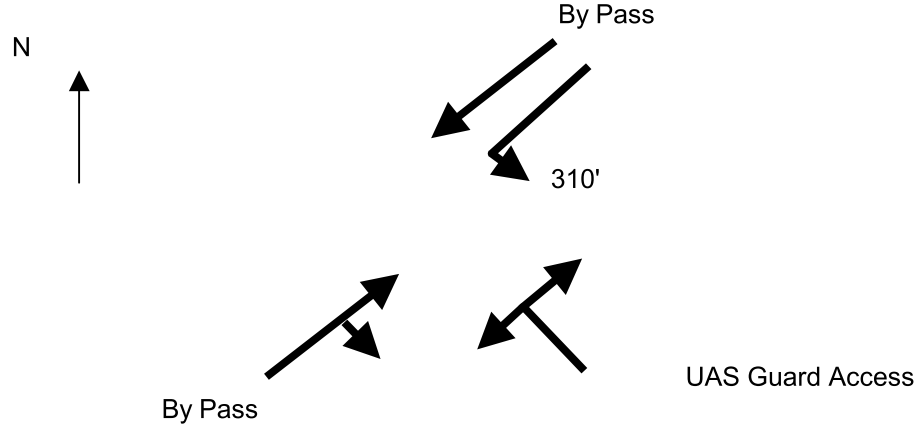


Figure 8- By Pass and UAS/Guard Access Intersection Lanes

The intersection of Glacier Highway and Fritz Cove Road does not meet signal warrants in Alternative 3. Figure 9 presents the lane configuration and auxiliary lane lengths for this intersection. We have recommended a southbound left turn lane because it is almost warranted, and it reduces the approach delay, although the approach still has level of service "F" in the design year (2029) evening peak hour.

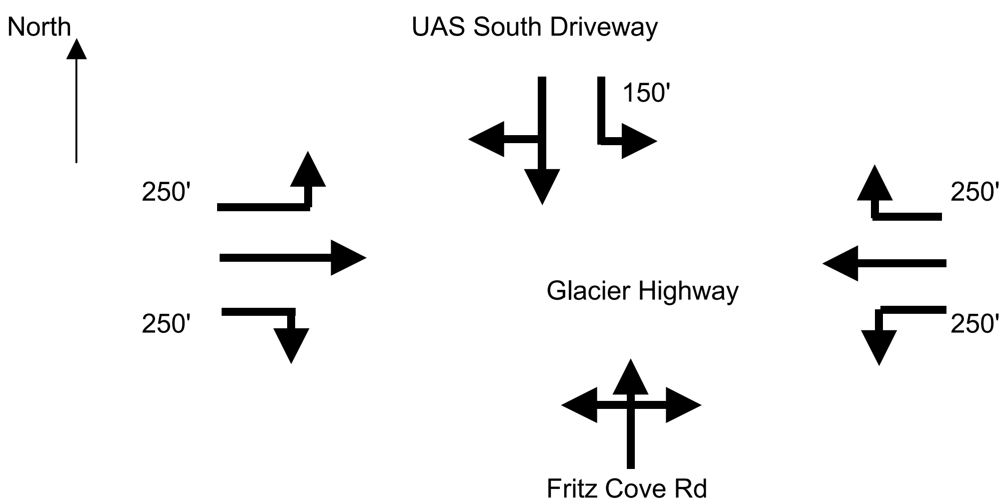


Figure 9- Glacier Highway and Fritz Cove Road Intersection Lanes

Table 6 summarizes Design Year (2029) performance measures for this intersection.

Glacier Highway-Fritz Cove Road Intersection Movements	**2029 Morning Peak Hour**			**2029 Evening Peak Hour**		
	Average Control Delay (sec/veh)	**v/c ratio**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c ratio**	**Level of Service**
Eastbound Left Turn	8	0.01	A	10	0.03	A
Westbound Left Turn	8	0.01	A	9	0.11	A
Northbound Left/Through/Right	13	0.21	B	55	0.65	F
Southbound Left Turn	16	0.05	C	226	1.10	F
Southbound Through/Right	10	0.01	A	21	0.12	C

Table 6-Glacier Highway-Fritz Cove Road Intersection Unsignalized Intersection Performance Measures

<u>Modern Roundabouts</u>

In NCHRP 457, there is a summary table to determine if a roundabout would be suitable for a location (*NCHRP 457* Table 2-12 based on *FHWA RD-00-067 Roundabouts*: *An Informational Guide*). We apply these seven questions to major intersections of the project.

Question	Glacier Highway-Fritz Cove Road-UAS South Entrance	Glacier Highway-Mendenhall Loop Road	Mendenhall Loop Road-UAS North Entrance	West By Pass-Glacier Highway	Glacier Hwy-East By-Pass-Industrial Blvd	Mendenhall Loop Road-By Pass
1) Will operation as an uncontrolled or two-way-stop-controlled intersection yield unacceptable delay?	Yes	No	No	No	Yes (Signal Warranted)	Yes (Signal Warranted)
2) Is the daily entering volume less than the maximum service volume for a roundabout? (*Use Figure 2-3 of NCHRP 457*)	Yes, 1-lane on each approach and in the roundabout is less that maximum service volume	Yes, 1-lane on each approach and in the roundabout is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.	Yes, 2-lane on each approach is less that maximum service volume.	Yes, 1-lane on each approach is less that maximum service volume.
3) Is the subject junction located outside of the coordinated signal network?	Yes	Yes	Yes	Yes	Yes	Yes
4) Is the ratio of major-road to minor-road volume less than 5?	Yes, about 3:1 to 4:1	Yes, 3:1	Yes, about 1:1 to 3:1	Yes, 2:1	Yes , 1.5:1	Yes 1:1 to 1.5:1
5) Is the entering drivers view free of sight obstructions?	Yes, can be designed	Yes, can be designed	Yes, can be designed	Yes, can be designed	Yes, can be designed	Yes, can be designed
6) Will the subject junction infrequently be used by large or oversized trucks?	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic	Yes, 4% Truck Traffic
7) Will the subject junction infrequently be used by pedestrians and bicyclists?	Yes	No, Expect Moderate Use by Bikes and Pedestrians	No, Expect High Frequency Use by Bikes and Pedestrians	Yes	Yes	Yes

Table 7- Roundabout Suitability Questions

As NCHRP 457 points out, the more frequently that these questions in Table 7 are answered with “Yes”, then the more likely that this intersection would work as a roundabout. Based upon the table, Glacier Highway- Mendenhall Loop Road, Mendenhall Loop Road- UAS North Entrance, and West By Pass- Glacier Highway intersections are not strong candidates for roundabouts, and all of them will operate well under sign control.

The intersection of Glacier Highway-Fritz Cove Road- UAS South Entrance is a good roundabout candidate as it will also serve to moderate speeds through the existing corridor. In addition, the By Pass intersections with Glacier Highway and Mendenhall Loop Road appear to be good candidates as well from the results of the table. However, a roundabout requires all traffic decelerate from 50 mph to 10 to 15 mph all of the time. With signals, there is a good probability that approaching vehicles will maintain speed through the intersection, thus encouraging By Pass use. We conclude that the only suitable intersection for a roundabout will be the Glacier Highway-Fritz Cove Road- UAS South Entrance Intersection.

There are other advantages to roundabouts, as well as providing good levels of service. FHWA demonstrates a reduction in both crash rates and injuries when intersections are converted to roundabouts. Overall, accident rate reduction is achieved, in part, by the reduction of conflict points from 32 at a standard four-legged intersection, to 8 with a roundabout. Another part of accident reduction for roundabouts is that they by nature reduce approach speeds on all legs, which in turn allow vehicles more reaction time. Accident severity is reduced as well. Roundabouts reduce the relative velocity of vehicles involved in a crash in two ways. The first is an overall speed reduction and the second is that the collision types are dramatically changed. Angle and head-on accidents, both with high relative velocities are almost eliminated from the roundabout crash patterns. Instead, the roundabout reconfigures these high-severity conflicts into merge conflicts, which at shallow angles and low speeds have a very low relative velocity.

Recent roundabouts on minor arterial and collector roads within the Municipality of Anchorage have used an inscribed diameter of about 140 feet with 20-foot circulation lanes to accommodate WB-50 (tractor-trailer rig) turning path widths. Figure 10 and Table 8 present roundabout geometric elements. It should be noted that 3-leg roundabouts are acceptable and would be used at the Mendenhall Loop Road and Glacier Highway intersection and the UAS North Access intersection.

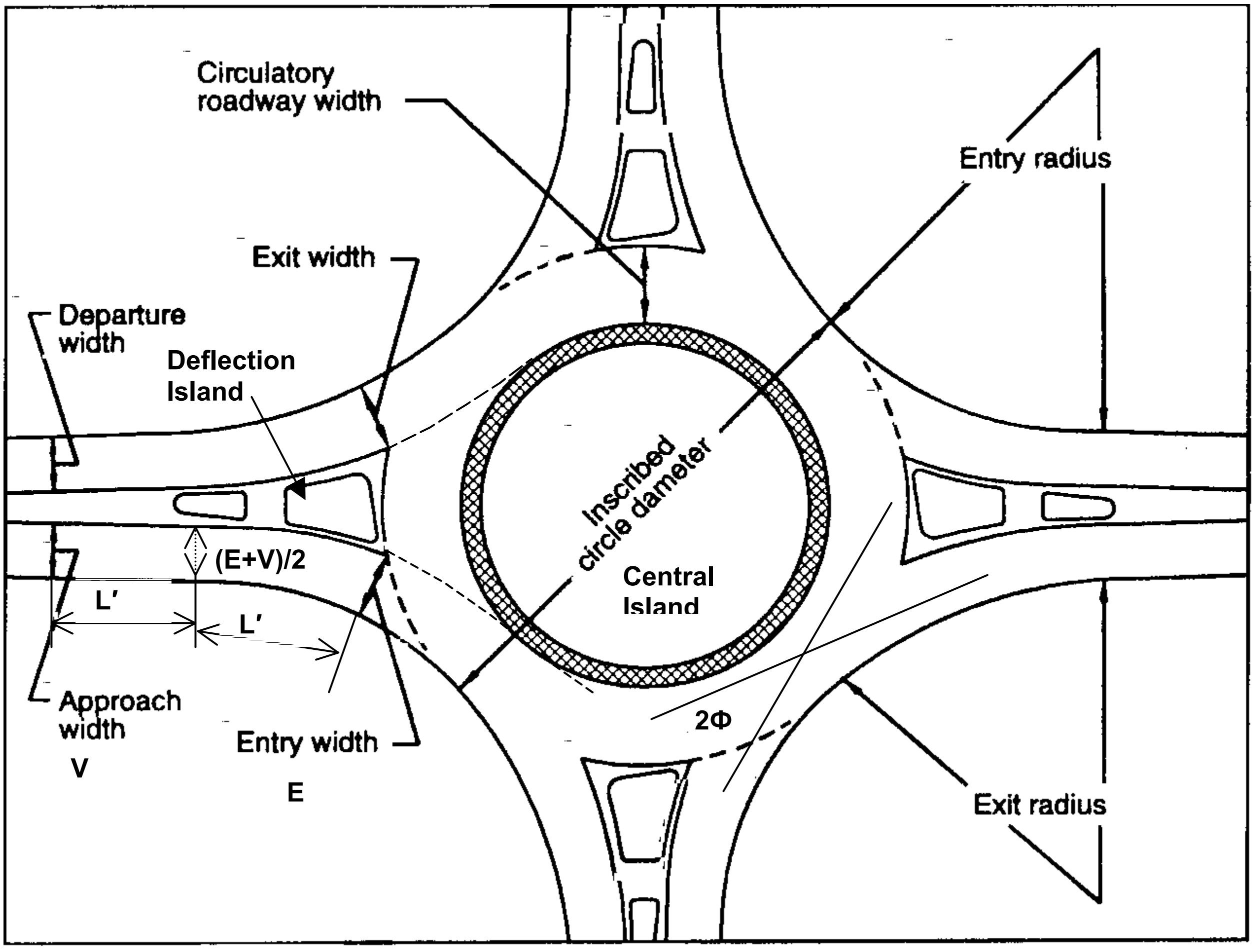


Figure 10- Roundabout Geometric Elements

Table 8 has value ranges for these geometric elements. Sources include FHWA RD-00-067 *Roundabouts: An Informational Guide* and *Interactive Roundabout Design Software and Manual*, Rodel Software Ltd and Staffordshire County Council.

Element	Value	Source, Comments
Inscribed Circle Diameter	140 feet single lane	FHWA with local experience. Will be adequate for WB-50 design vehicles.
Central Island Diameter	Approximately 100 feet (single lane circulation lane), with an outer ring that accommodates occasional truck-trailer combinations larger than WB-50.	Inscribed Circle Diameter- Circulatory Road Width, divided by 2.
Approach Width, **V**	Lane Width (assumed 12 feet)	FHWA, Rodel
Entry Width, **E**	14 to 16 feet for single lane	FHWA
L′	Minimum 16 feet (Rodel), 40 feet recommended minimum (FHWA)	Use 40 feet. (derived from FHWA's recommendation of an 80-foot flare taper in urban areas.)
Φ	25 to 35 degrees	Rodel
Entry Radius, Single Lane	>30 feet, <100 feet	Rodel, FHWA
Exit Radius, Single Lane	>50 feet (FHWA)	Rodel recommend that the exit radius be determined as transition from circulatory road width, through the deflection island, and to the departure width. Radius should be selected to that taper is 15 or 20 to 1.
Circulatory Road Width	1 to 1.2 x **E,** use 20 feet minimum for single lane	Rodel, FHWA
Deflection Island (splitter island), Exit Width	Defined by tangential extensions to the Central Island	FHWA and Rodel. FWHA recommends a minimum of 5-foot pedestrian refuge be located at about 20 feet from the yield line.

Table 8- Typical Design Values for Roundabout Geometric Elements, Auke Bay Corridor Intersections

These values will be confirmed during detail design.

Table 9 presents the performance measures for the project intersection under a modern roundabout configuration.

Intersection	2029 Morning Peak Hour			2029 Evening Peak Hour		
	Average Control Delay (sec/veh)	**v/c Ratio (intersection average**	**Level of Service**	**Average Control Delay (sec/veh)**	**v/c Ratio (intersection average)**	**Level of Service**
Glacier Highway-Fritz Cove Road-UAS South Entrance	3	0.15	A	3	0.40	A

Table 9- Roundabout Performance Measures

Intersection Summary

Table 10 summarizes the work in this section.

Intersection	Unsignalized Operations	Signalized Operations	140-foot Roundabout	Recommendation
Glacier Highway-Fritz Cove Road-UAS South Entrance	Unsatisfactory-Minor street approaches fail in 2029	Signals will not be warranted	Good operations, LOS A over the entire life.	Roundabout provides superior operations.
Glacier Highway-Mendenhall Loop Road	Satisfactory, LOS B or better.	Signals will not be warranted.	Not recommended or evaluated, but operations would be good.	Unsignalized Stop Control.
Mendenhall Loop Road-UAS North Entrance	Satisfactory, LOS C or better	Signals will not be warranted.	Not recommended or evaluated, but operations would be good.	Unsignalized Stop Control.
West By Pass and Glacier Highway	Satisfactory, LOS B or better	Signals will not be warranted.	Not recommended or evaluated, but operations would be good.	Unsignalized Operations, Stop Control on the Glacier Highway approach.
Mendenhall Loop Road and By Pass	Unsatisfactory, minor street left turns operate at LOS F in 2029.	Meets warrants by 2019, operates at LOS C or better	Not recommended or evaluated.	Signalized Intersection
East By Pass and Glacier Highway	Unsatisfactory, minor street left turns operate at LOS F in 2029.	Meets warrants by 2009, operates at LOS C or better.	Not recommended or evaluated.	Signalized Intersection
By Pass and UAS/Guard Access	Satisfactory. LOS B or better	Signals will not be warranted.	Not recommended or evaluated, but operations would be good.	Unsignalized Stop Control.

Table 10- Intersection Evaluation Summary

Roadway Typical Section

Glacier Highway- Fritz Cove Road to Waydelich Creek

Other than intersection modifications, no other improvements are planned for the existing Glacier Highway with Alternative 3.

By-Pass, East Intersection with Glacier Highway at Industrial Boulevard to West Intersection with Glacier Highway near Ferry Terminal

The following tables summarize design year operations of the By Pass segments.

Begin	**East Glacier Highway**
End	**Mendenhall Loop Road**
Length	**1.5 miles**
Two-lane Highway Class (see discussion under Attachment A)	I
ADT	9000
DHV	990
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	10%
Estimated Base Free Flow Speed	50 mph
Percent Time Following	68%
Volume/Capacity Ratio	0.35
Average Travel Speed	41 mph
Levels of Service	D (Speed Constrained)

Table 11-2029 By Pass Segment between East Intersection with Glacier Highway and Mendenhall Loop Road Performance Measures

Begin	**Mendenhall Loop Road**
End	**West Glacier Highway**
Length	**2.2 miles**
Two-lane Highway Class (see discussion under Attachment A)	I
ADT	4800
DHV	530
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	50%
Estimated Base Free Flow Speed	50 mph
Percent Time Following	59%
Volume/Capacity Ratio	0.20
Average Travel Speed	42 mph
Levels of Service	D (speed constrained)

Table 12-2029 By Pass Segment between Mendenhall Loop Road and West Glacier Highway Intersection Performance Measures

The Mendenhall Loop Road to West Glacier Highway Intersection would benefit in an increase of design speed from 50 to 55 mph. Using 55 mph as speed would produce LOS C in the design year.

Mendenhall Loop Road

Mendenhall Loop Road between Glacier Highway and the UAS North Entrance-By Pass intersection is dominated by the intersection operations. As such, this relatively short segment lane configuration is determined by intersection needs. Both intersections on the termini of this segment will operate well with one through lane approaches (exclusive of auxiliary left-turn lanes). Therefore, this segment may have one lane in each direction. We don’t expect significant landside development, which would create a mid-block left-turn demand. As such, a CTWLTL is not needed.

The segment of Mendenhall Loop Road beyond the UAS North Entrance-By Pass intersection functions a Class II rural two-lane highway. The 2029 performance is summarized in the following table.

Begin	**UAS North Entrance-By Pass**
End	**-**
Length	**-**
Two-lane Highway Class (see discussion under Attachment A)	II
ADT	4600
DHV	500
PHF	0.90
Computed DHV Factor	11%
Directional Distribution Percent	70/30
Percent Recreational Vehicles	N/A
Percent Commercial Trucks	4%
Lane Width	12 feet
Paved Shoulder	8 feet
Terrain	Rolling
Estimated No-Passing Zones	50%
Estimated Base Free Flow Speed	45 mph
Percent Time Following	58%
Volume/Capacity Ratio	0.19
Average Travel Speed	35mph
Levels of Service	C

Table 13- Mendenhall Loop Road UAS Outbound

<u>Segment Evaluation Summary</u>

Two-through lanes will function adequately throughout the project life. The following table summarizes the geometric elements required for each segment.

	2-lane	3-lane (CTWLTL)	Curb and Gutter	Shoulders	Sidewalk	Pathway
Fritz Cove Road to Waydelich Ck (Urban)	-	11 or 12 – foot through lanes, 12 to 14-foot CTWLTL	x	Optional, 5 feet desirable for bikes	x	x
Waydelich Ck to Ferry Terminal (Rural)	12-foot lanes	-	-	8 feet	x	x
By Pass, East Glacier Hwy to Mendenhall Loop Road	12-foot lanes	-	-	8 feet		
By Pass, Mendenhall Loop Road to West Glacier Hwy	12-foot lanes	-	-	8 feet		
Mendenhall Loop Road	12-foot lanes	-	-	8 feet	x	x

Table 14- Segment Geometric Elements

Attachment A
Level of Service Discussion

We use capacity analysis to determine operational performance. The capacity analysis was performed in accordance with the procedures outlined in Transportation Research Board Highway Capacity Manual 2000 (HCM) for interrupted flow facilities, using Synchro/SimTraffic, Version 5, distributed by Trafficware. In an urban area, the capacity of a system is constrained by the capacity of the system's intersections and uninterrupted capacity methods generally do not apply.

Capacity analysis for a facility yields operational performance that is defined as level of service (LOS). For signalized intersections, LOS relates to the control delay of a vehicle. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. The HCM methodology calculates LOS for each movement and for the intersection as a whole.

The following narrative from Chapter 9 of the 1997 HCM defines LOS for signalized intersections. (Note that this definition has not changed with the 2000 edition of HCM)

> LOS A describes operations with very low control delay, up to 10 seconds per vehicle. This level of service occurs when progression is extremely favorable and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.
>
> LOS B describes operations with control delay greater than 10 and up to 20 seconds per vehicle. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of average delay.
>
> LOS C describes operations with control delay greater than 20 and up to 35 seconds per vehicle. These higher delays may result from fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.
>
> LOS D describes operations with control delay greater than 35 and up to 55 seconds per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.
>
> LOS E describes operations with control delay greater than 55 and up to 80 seconds per vehicle. This level is considered by many agencies to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent occurrences.

LOS F describes operations with control delay in excess of 80 seconds per vehicle. This level, considered unacceptable to most drivers, often occurs with over saturation, that is, when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.0 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing factors to such delay l

Capacity analysis for a facility yields operational performance that is defined as level of service (LOS). For signalized and unsignalized intersections, LOS relates to the control delay of a vehicle. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay.

The methodology for unsignalized intersections only computes LOS for the minor movements of the intersection, which include the minor street approaches under sign control, or major movements that must yield to oncoming traffic, such as left-turning traffic. Unsignalized LOS is defined as follows (HCM Exhibit 17-2):

LOS A: ≤10 seconds of control delay per vehicle
LOS B: >10 and ≤15 seconds of control delay per vehicle
LOS C: >15 and ≤25 seconds of control delay per vehicle
LOS D: >25 and ≤35 seconds of control delay per vehicle
LOS E: >35 and ≤50 seconds of control delay per vehicle
LOS F: >50 seconds of control delay per vehicle

The Glacier Highway between Waydelich Creek and Ferry Terminal, and Mendenhall Loop Road are rural highways in appearance and in function and fits HCM's two-lane highway model very well. The methods for this analysis are found in Chapters 12 and 20 in the HCM. HCM provides two levels of service (LOS) descriptions for two lane highways according to its class. We determined that Glacier fits the Class II description since it is a users expect moderate speed, arterial, with a significant access function. The LOS for two-lane, Class II highways is defined as follows (from Exhibit 20-4 of the HCM).

<u>Class II</u>
LOS A: ≤40 Percent Time Following
LOS B: >40 and ≤55 Percent Time Following
LOS C: >55 and ≤70 Percent Time Following
LOS D: >70 and ≤85 Percent Time Following
LOS E: >85 Percent Time Following

The By Pass will also be a rural two-lane highway in appearance and function and should be under the Class I Performance measures, since it's only function is mobility. It's performance measures are as follows (from Exhibit 20-2 of the HCM)..

<u>Class I</u>
LOS A: ≤35 Percent Time Following, > 55 mph average travel speed
LOS B: >35 and ≤50 Percent Time Following, 50 to 55 mph average travel speed

LOS C: >50 and ≤65 Percent Time Following, 45 to 50 mph average travel speed
LOS D: >65 and ≤80 Percent Time Following, 40 to 45 mph average travel speed
LOS E: >80 Percent Time Following, ≤ 40 mph.

HCM's urban arterial evaluation method gives LOS based upon travel speed. The Fritz Cove Road to Waydelich Creek segment most closely represents the HCM's Suburban Principal Arterial functional category (HCM Exhibits 10-3 and 10-4). This is classified as a Class II (Average Free-Flow Speed of 40 miles per hour) and Exhibit 15-2 provides the following LOS assignment based upon average travel speed.

LOS A: >35 mph
LOS B: >28-35 mph
LOS C: >22-28 mph
LOS D: >17-22 mph
LOS E: >13-17 mph
LOS F: ≤13 mph