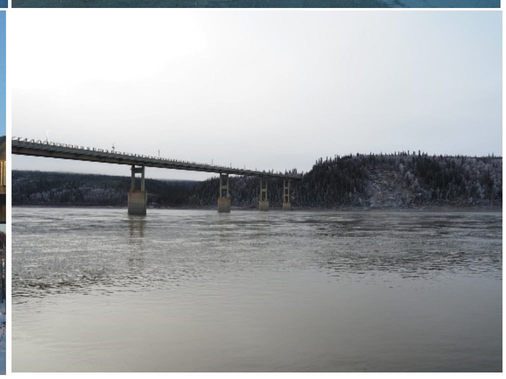
Yukon River Reconnaissance Study

Existing Conditions and Initial Needs Assessment Report



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The environmental review, consultation, and other actions required by applicable Federal environmental laws for this project are being, or have been, carried out by DOT&PF pursuant to 23 U.S.C. 327 and a Memorandum of Understanding dated November 3, 2017 and executed by FHWA and DOT&PF.

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EXECUTIVE SUMMARY

The Alaska Department of Transportation and Public Facilities (DOT&PF) initiated the Yukon River Reconnaissance Study in 2015 to determine and evaluate potential alternative Yukon River crossing locations for the Dalton Highway.

The reconnaissance study was prompted largely as a response to two events: a slope failure that occurred in the vicinity of the existing Yukon River bridge in 2012 and legislative action passed by the Alaska State Senate in 2014 requiring DOT&PF to evaluate the design and construction of a new, separate bridge across the Yukon River that would accommodate the State's proposed gas pipeline project.

This *Existing Conditions and Initial Needs Assessment* is the first component of the reconnaissance study and includes an assessment of factors that would drive a decision for a future project. The uses and value of the bridge and highway were identified primarily through a literature review and the distribution of questionnaires to stakeholder groups, tourism-related businesses, oil industry support, area residents, Native allotment holders, and tribal organizations. Pertinent area land use management plans, transportation plans, and development plans were also mined for potential needs in the corridor tied to use of the Yukon River Bridge.

The main topics investigated in this document include:

- Historical, current, and future use of the Yukon River Bridge and highway corridor;
- Future development plans in the corridor;
- Existing transportation plans in the vicinity;
- Existing and future conditions of the bridge;
- Traffic safety considerations;
- Existing and future maintenance and operation needs of the bridge;
- Bridge failure scenarios;
- Emergency access alternatives;
- Socioeconomic and environmental considerations; and
- Likely life-cycle cost analysis scenarios.

This document concludes with a summary of the conditions and needs identified in this initial effort and assigns a "scale of need" based on how soon the item might warrant action and the severity of consequences of not addressing the need. This information is intended to help inform decision makers of the scale of the need, which may influence the level of effort, timing, and composition of future work.

A draft of this report was made available for public and agency review on the project website (http://www.dot.alaska.gov/nreg/yukonriverrecon/) beginning in mid-January 2018 and extending through February 15, 2018. DOT&PF solicited comments on the report by sending emails to stakeholders and to those who had participated in the questionnaire outreach efforts early on. DOT&PF received very few comments, resulting in only minor revisions to the report.

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Acronyms

AADT	average annual daily traffic
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ADF&G	Alaska Department of Fish and Game
AGDC	Alaska Gasline Development Corporation
AIDEA	Alaska Industrial Development and Export Authority
AKLNG	Alaska liquefied natural gas
ANCSA	Alaska Native Claims Settlement Act
ARCO	Atlanta Richfield Company
AS	Alaska Statute
ASAP	Alaska Stand Alone Pipeline
ASD	Allowable Stress Design
ASRP	Alaska State Rail Plan
BLM	Bureau of Land Management
DHW	Design High Water
DNR	Alaska Department of Natural Resources
DOT&PF	Alaska Department of Transportation and Public Facilities
EIS	Environmental Impact Statement
EJ	Environmental Justice
F	Fahrenheit
FEED	Front-End Engineering and Design
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
ft-lbs	foot-pounds
FY	fiscal year
IATP	Interior Alaska Transportation Plan
IEP	Interior Energy Project
LCCA	Life-Cycle Cost Analysis
LNG	Liquefied Natural Gas
LOS	Level of Service
LRFD	Load and Resistance Factor Design

LRTP	Alaska Statewide Long-Range Transportation Plan
MASH	Manual for Assessing Safety Hardware
MP	milepost
mph	miles per hour
NWATP	Northwest Alaska Transportation Plan
NBI	National Bridge Inventory
NCHRP	National Cooperative Highway Research Program
NEPA	National Environmental Policy Act
NHS	National Highway System
NPR-A	National Petroleum Reserve-Alaska
NRHP	National Register of Historic Places
NSB	North Slope Borough
NWI	National Wetlands Inventory
OMB	Federal Office of Management and Budget
PSF	pounds per square foot
Q50	2 percent chance of flood exceedence in 100 years
Q500	0.02 percent chance of flood exceedence in 100 years
RMP	Resource Management Plan
SB	Senate Bill
TAPS	Trans-Alaska Pipeline System
TNW	Traditional Navigable Waters
TSA	Transportation Security Administration
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey

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1 INTRODUCTION

1.1 Study Overview

The Yukon River Reconnaissance Study (Study) was initiated in July 2015 to determine and evaluate potential alternative Yukon River crossing locations for the James W. Dalton Highway, and included an assessment of the existing Yukon River Bridge crossing. The Study was initiated in response to a slope failure in the vicinity of the existing bridge in 2012 and legislative action related to the gas pipeline project in 2014.

In the fall of 2012, a landslide occurred between approximately 375 and 575 feet west of the existing bridge[1], prompting the Alyeska Pipeline Service Company (Alyeska) and the Alaska Department of Transportation and Public Facilities (DOT&PF) response and analysis to determine if the existing highway bridge was at risk.

Alaska State Senate Bill (SB) 138, signed in late 2014, required DOT&PF to evaluate the design and construction of a new, separate bridge across the Yukon River that would accommodate both vehicular traffic and infrastructure related to the Alaska liquefied natural gas (AKLNG) or the Alaska Stand Alone Pipeline (ASAP) projects. The DOT&PF Bridge Section developed a preliminary alternatives memo[2] to satisfy the initial requirements of SB 138 (see Appendix A).

The first step of the Study is a needs assessment to identify the future needs and existing conditions that would drive a decision for a future project. The preliminary alternatives memo to the DOT&PF Commissioner, developed by DOT&PF Bridge Design, identified three potential crossing locations, all of which would require a construction investment of more than $150 million for just the bridge (not including any roadway realignment necessary or design and environmental effort; see Appendix B). As the AKLNG project advanced from the passing of SB 138, installation of the gas pipeline on a highway structure was determined infeasible due to cost and safety concerns. These factors led the Study team to pursue this needs assessment as a critical first step in determining the "why" for a project that would cost in excess of $150 million, as well as providing information for decision makers as to when such an investment would make sense.

The needs assessment identifies ways in which the project area is used; pertinent planning that identifies areas and opportunities for growth; risks associated with the current bridge structure; social, economic, and environmental concerns for the area; and the suite of potential improvements for further evaluation based on the needs identified.

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[1] Koehler, R.D., R.D. Reger, K.R. Sicard, and E.R. Spangler. 2013. *Yukon River Bridge Landslide: Preliminary Geologic and Geotechnical Evaluation.* Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2013-6.

[2] Alaska Department of Transportation and Public Facilities (DOT&PF). 2014. Yukon River 2nd Crossing Preliminary bridge design memorandum from DOT&PF Chief Bridge Engineer Richard Pratt to DOT&PF Commissioner Pat Kemp. May 30, 2014.

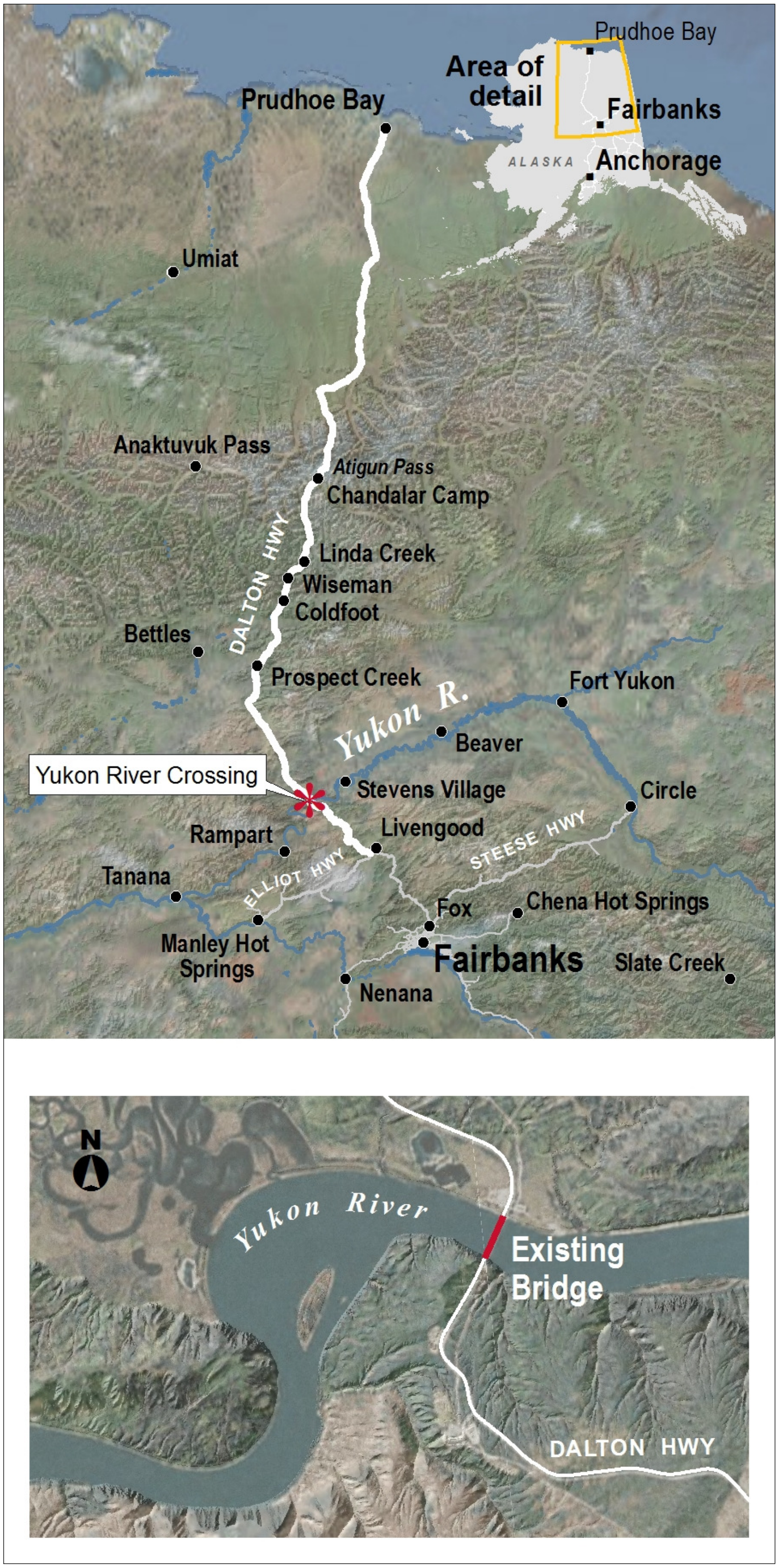
1.2 Study Setting

The Dalton Highway crosses the Yukon River at highway milepost (MP) 56, 84 miles north of Fairbanks and 360 miles south of Prudhoe Bay (Figure 1-1 and Figure 1-2). Providing access is the primary need for the Dalton Highway corridor and Yukon River Bridge. While potential crossing locations are generally focused in the vicinity of the existing crossing, a thorough understanding of the Dalton Highway corridor is necessary to understand the needs associated with the bridge. This Study includes needs associated with the Dalton Highway corridor as it pertains to the Yukon River Bridge, although the study area for potential crossing locations is in the general vicinity of the existing bridge, with consideration of locations either several miles upstream or downstream. This aligns with what DOT&PF identified as part of their 2014 second bridge crossing memorandum; DOT&PF performed a location analysis and identified a potential bridge crossing location approximately 7 miles downstream of the existing bridge, in addition to two other crossing options located approximately 3 miles upstream. Other potential crossing locations of the Yukon River, such as those near Tanana, have historically been considered[3]; however, this Study looks at only the general vicinity of the existing crossing. Locating a potential bridge crossing hundreds of miles from the existing crossing location would necessitate additional, costly accompanying road infrastructure to connect a new bridge to the existing roadway and not address connectivity for the Dalton Highway.

Figure 1-1. Project Vicinity

[3] Alaska Department of Highways. Unknown date. Yukon River Bridge Report: A Report on the Location and Design of a Highway Bridge and of a Ferry Service across the Yukon River near Tanana. Prepared by Department of Highways Chief Bridge Engineer H.H. Fickel.

Figure 1-2. Study Area



1.3 Study Methods and Content

The uses and value of the Yukon River Bridge and Dalton Highway were identified through a literature review and questionnaires distributed to stakeholder groups, tourism-related businesses, oil industry support, area residents, Native allotment holders, and tribal organizations. Pertinent area land use management plans, transportation plans, and development plans were also mined for potential needs in the corridor tied to use of the Yukon River Bridge.

For each chapter, an initial list of questions was developed to guide the existing conditions and needs assessment effort. This Study includes details on the data collection effort and a synopsis of the returned questionnaire surveys. Completed questionnaires are included in Appendix C.

The contents of this Study are as follows.

- **Section 1** ***(Introduction)*** provides the Study overview, setting, and contents.
- **Section 2** (***Background)*** provides historic background information on the Dalton Highway and Yukon River Bridge and an overview of current operations and maintenance activity; an overview of the use, function, and modal connections of the highway and bridge; an overview of development activities, opportunities, and plans that may use the highway and/or bridge; an overview of key stakeholders; a summary of existing transportation plans and how they relate to the highway and bridge; and a summary of legislative requirements pertaining to a future bridge project.
- **Section 3** ***(Existing Condition and Life Expectancy of the Yukon River Bridge)*** identifies the existing and future conditions of the Yukon River Bridge.
- **Section 4** ***(Traffic Safety)*** discusses current and projected safety concerns.
- **Section 5** ***(Maintenance and Operations)*** summarizes maintenance and rehabilitation on the Yukon River Bridge to date as well as future maintenance needs and associated projected costs for the bridge.
- **Section 6** ***(Bridge Failure Scenarios, Consequences, and Alternatives in Event of Failure)*** identifies the consequences of bridge failure, vulnerabilities, threats and hazards, and emergency alternatives in the event a failure occurs.
- **Section 7** ***(Economic, Environmental, and Social Considerations)*** identifies and summarizes social, cultural, economic, and environmental considerations in regard to the project.
- **Section 8** ***(Life-Cycle Cost Analysis)*** provides the life-cycle cost analysis for the existing Yukon River Bridge.
- **Section 9** ***(Conclusions and Recommendations)*** provides summaries of the Study, identified issues and needs, and life-cycle cost options as well as recommendations.

2 BACKGROUND

This chapter presents a collection of background information related to the Dalton Highway and Yukon River Bridge, including history, use, relevant development plans, relationship with affected stakeholders and users, relevant transportation plans, and legislative intent pertaining to a future bridge project.

Section Highlights

History

- The original basis for constructing the Dalton Highway and Yukon River Bridge crossing in the mid-1970s was for North Slope oil field development.
- Original plans considered crossing the Yukon River with ferry service and ice roads, with an oil pipeline bored under the river. However, the State preferred a bridge crossing.
- State and industry partnership resulted in construction of a bridge structure that supports both truck traffic and the 48-inch oil pipeline (Trans-Alaska Pipeline System [TAPS]). The bridge was designed to support two 4-foot pipelines.
- The Trans-Alaska Pipeline Authorization Act was signed by President Richard Nixon on November 16, 1973, authorizing the construction of the pipeline.
- Opened in 1975, the bridge has required continuous maintenance, which includes replacing the entire timber deck approximately every 15 years.

2.1 Highway and Bridge Infrastructure History

The Dalton Highway, originally known as the "Haul Road," and the Yukon River Bridge were built in the early to mid-1970s to support the development of the Prudhoe Bay oil fields on Alaska's North Slope.

2.1.1 Oil Discovery and Infrastructure Development

Oil was discovered in Prudhoe Bay in 1967, and the scope of reserves was confirmed the following year by the Atlanta Richfield Company (ARCO) and Humble Oil and Refining Company (now ExxonMobil). The oil field discovery resulted in development of the 800-mile-long, 48-inch-diameter oil pipeline (Trans-Alaska Pipeline or TAPS) that connects Prudhoe Bay with Valdez, located on Prince William Sound, with the oil being transported to the Lower 48 via tankers from Valdez. The Dalton Highway was built to provide construction and year-round surface access to the oil fields. The Alyeska was formed through a partnership of several oil companies to design and construct the Haul Road and pipeline, and ultimately to operate and maintain the system.[4] The State of Alaska and Alyeska entered into an agreement for construction of the Haul Road on June 11, 1971.[5]

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[4] Alyeska Pipeline Service Company. 1971. Project Description of the Trans-Alaska Pipeline System.
[5] Haul Road Construction Agreement, 1971.

When the highway opened in 1974, traffic beyond the Yukon River was limited to vehicular traffic related to pipeline construction and oil field development.[6] At that time, the State had considered several alternatives pertaining to use of the road. These alternatives included seasonal industrial use (primarily petroleum-related), year-round industrial use, and three combinations of year-round industrial use with variations in seasonality and the degree of public access; the State initially chose to allow seasonal (summer) public access as far north as the Yukon River Bridge.[7] Until 1981, the Dalton Highway beyond the Yukon River was open only to industry vehicular support of the North Slope oil fields development and operations. The State had determined that the road was for oil industry and also mine development-related traffic only after debating whether the road should be a "public highway" or a "development road."[8]

In 1981, the Dalton Highway was opened to the public (with a permit) to Disaster Creek at MP 211 (155 miles north of the Yukon River crossing). An estimated 25 vehicles traveled it during the first week it was open to the public.[9] In 1994, during then Governor Hickel's second term in office, the entire length of the Dalton Highway to Deadhorse was opened to the public (without permits).

2.1.2 Dalton Highway Design and Construction

The 414-mile-long Dalton Highway was constructed by Alyeska in two sections: from the Elliott Highway (at MP 73 of the Elliott Highway, 84 miles north of Fairbanks) to the Yukon River crossing, and from the Yukon River crossing to Deadhorse (Prudhoe Bay and the Beaufort Sea). The Elliott Highway to the Yukon River crossing section was constructed from August 1969 to July 1970. The Yukon River crossing to Prudhoe Bay section was constructed from April to September 1974. Alyeska oversaw the construction of the highway and built it to secondary road design standards used during that period as agreed to in coordination with the Alaska Department of Highways.[10] As part of the agreement between the State and Alyeska, ownership and maintenance of the road reverted back to the State in 1977.[11]

2.1.3 Yukon River Bridge Design and Construction

As a result of the discovery of oil on the North Slope in 1967, a bridge over the Yukon River was proposed in 1970 to cross the 2,000-foot-wide channel of the Yukon River for the pipeline, as well as to provide vehicular access to the North Slope.[12] The original plan was to have a ferry service and ice roads, with the pipeline bored under the river due to the cost and engineering challenges of crossing the Yukon. The State preferred a bridge crossing and agreed to design and build the structure to support Alyeska's pipeline.

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[6] Turner, Wallace. 1982. "Use of Haul Road By All Traffic Stirs Alaska Dispute." *The New York Times*. June 10, 1982. http://www.nytimes.com/1981/06/10/us/use-of-haul-road-by-all-traffic-stirs-alaska-dispute.html

[7] ERE SYSTEMS, LTD. 1984. Barrow Arch Transportation Systems Impact Analysis *Social and Economic Studies Program Alaska OCS Region*. Prepared for Minerals Management Service Alaska Outer Continental Shelf Region. Technical Report 104. December 1984. https://www.boem.gov/BOEM-Newsroom/Library/Publications/1984/84_TR104.aspx.

[8] State of Alaska, Department of Law. 1976. Letter to Dr. Robert LeResche, Director of Division of Policy Development & Planning, Office of the Governor, from State of Alaska Attorney General regarding North Slope Haul Road. September 7, 1976.

[9] Turner, Wallace. 1982. "Use of Haul Road By All Traffic Stirs Alaska Dispute." *The New York Times*.

[10] Mead & Hunt and CRC. 2014. Alaska Roads Historic Overview. Prepared for DOT&PF. June 10, 1982. http://www.dot.state.ak.us/stwddes/desenviron/assets/pdf/resources/roads_historic_overview.pdf

[11] Mead & Hunt and CRC. 2014. Alaska Roads Historic Overview. Prepared for DOT&PF.

[12] Federal Highway Administration (FHWA). 2006. Determination of Eligibility Yukon River Bridge (#271) Rehabilitation Project, DP-NH-065-2(12)/60431. December 12, 2006.

A joint financing agreement was reached in 1971 between the Alaska Department of Highways and Alyeska. Under the agreement, the State would design and build a bridge structure to support both truck traffic and the 48-inch oil pipeline crossing the Yukon River, with Alyeska responsible for the cost attributable to the portion required for the pipeline.[13]

The State began final design of the bridge in June 1971 and had completed most of the design work by September 1971. Much of 1972 and 1973 were used to secure government approval for the project, which became known as TAPS. This nearly 2-year period was also used to solicit and resolve comments on the bridge design from the private and public organizations involved with the project. President Richard Nixon signed the Trans-Alaska Pipeline Authorization Act into law on November 16, 1973, which authorized the construction of the pipeline.[14]

Bridge construction began in 1974, and the bridge was built from both sides of the river, meeting in the middle. Figure 2-1 depicts the bridge construction effort. Four cofferdams were constructed in the river from which the piers for the bridge were built.[15] Manson-Osberg-Ghemm constructed the bridge,[16] which cost about $30 million to build.[17] The bridge was opened to traffic in October 1975. In summer 1976, the TAPS pipeline was installed on the bridge, and the first oil began flowing south to Valdez in 1977.

Figure 2-1. Yukon River Bridge Construction, 1974-1975

Images from DOT&PF.

2.1.4 Post-construction

The Yukon River Bridge is 2,295 feet long and 30 feet wide and is the longest highway bridge in Alaska. (The Yukon River Bridge was the longest bridge overall in the State until the 3,300-foot-long rail bridge over the Tanana River opened in 2014.[18]) In 1982, the Alaska State Legislature renamed the

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[13] Agreement for Construction of Yukon River Bridge, 1971.
[14] FHWA. 2006. Determination of Eligibility Yukon River Bridge (#271) Rehabilitation Project, DP-NH-065-2(12)/60431. December 12, 2006.
[15] Cohen, Stan. 1988. The Great Alaska Pipeline: A Pictorial History.
[16] Brown, Jerry, and R.A. Kreig. 1983. Guidebook to permafrost and related features along the Elliott and Dalton Highways, Fox to Prudhoe Bay, Alaska: Alaska Division of Geological & Geophysical Surveys Guidebook 4.
[17] FHWA. 2006. Determination of Eligibility Yukon River Bridge (#271) Rehabilitation Project, DP-NH-065-2(12)/60431. December 12, 2006.
[18] Alaska Railroad Corporation. 2014. Community Ties Newsletter. Tanana River Bridge, Levee Wrap Up. https://www.alaskarailroad.com/sites/default/files/akrr_pdfs/2014_2Q_Community_Ties.pdf, accessed October 20, 2016.

structure the "E.L. Patton Bridge" in honor of Alyeska's president during the project's development and construction.

2.1.5 Operations and Maintenance

Since the original bridge construction and opening in 1975, several rehabilitation and retrofit projects have been completed on the Yukon River Bridge. The timber running planks, which serve as a sacrificial wearing surface, are replaced, on average, every 6 to 7 years, and the entire timber deck requires replacement approximately every 15 years. Deck alternatives that would require less maintenance have been investigated; however, no cost-effective or otherwise suitable alternatives to the timber system have been identified. A non-timber deck would pose challenges due to the way the bridge was originally designed and constructed. For example, the steel structure, combined with the large temperature variations in northern Alaska, requires a decking system that is highly flexible to accommodate thermal deformation. The decking must also be lightweight due to dead load limitations of the structure and extremely durable due to the large-vehicle traffic and wear from tire chains in the winter. Refer to Section 3.1 for additional information about existing bridge conditions.

The importance of the operation of the Dalton Highway was demonstrated when a segment of the roadway north of the Yukon River was closed due to flooding, further described later in the chapter. As a result of these flooding events, Governor Walker made two separate disaster declarations. Figure 2-2 shows how the backlog of trucks began to move again after the Dalton Highway opened up. Refer to Section 5 for additional information about highway conditions and operations and maintenance.

Figure 2-2. Dalton Highway: Transportation Lifeline to and from the North Slope

Source: DOT&PF. April 14, 2015, Commissioner's Office Press Release.

Section Highlights

Use

- The primary use of the Yukon River Bridge and Dalton Highway is to support oil field development and operations.
- Other uses of the bridge and highway include activities related to and support for mining, tourism, research, and other public or commercial uses such as recreation, hunting, fishing, and access to adjacent lands.
- The highway was initially limited to commercial or industrial traffic. The highway fully opened to the public in 1994, amidst stakeholder concerns related to public safety and strain on environmental resources adjacent to the highway corridor.
- In 2016, the annual average daily traffic (AADT) volume at the bridge was 267 vehicles per day. The traffic volume has decreased slightly since 2012 when the AADT volume was 305 vehicles per day (which is the highest AADT within the past 15 years).
- Forecasted AADT for 2030 is 300 (low) to 340 (moderate) for the Dalton Highway corridor.
- Truck traffic represents a significant portion of the total traffic volume along the Dalton Highway and at the Yukon River. Over the past decade, trucks comprise nearly 70% of the traffic at the bridge. Between 2014 and 2016, the share of truck traffic decreased slightly.
- Improved roadway conditions, increased presence of the highway in the media, and targeted tourism marketing efforts has resulted in increased visitors to the Dalton Highway corridor and the bridge.
- In addition to the typical summer traffic volume spike, traffic volumes at the bridge increase substantially in March due to increased winter tourism and visitors. Between 2010 and 2015, the number of visitors in March increased by nearly 50%.
- Despite the increase in visitors, public and emergency services are still limited along the highway.
- The highway corridor crosses several federal, State, municipal, and private areas, which complicates determination of who is responsible for providing security, search and rescue, motorist aid, and emergency response.
- The bridge and highway provide a critical link to the State's oil and gas field operations.
    - The oil and gas industry currently funds the majority of the State's operating budget: 92 percent of the State's unrestricted revenue in FY 2013.
    - The State's crude oil production represented approximately 6 percent of the total U.S. production in 2016.
    - The State's crude oil production represented approximately 0.6 percent of total global production in 2015.

2.2 Use

The primary use of the bridge and highway is associated with oil field operations and development and, to a lesser degree, mining. Tourism and other public use activities and interest have grown recently. Other uses include recreation, hunting, fishing, and access to adjacent lands.

Before the highway and pipeline were built, decision makers were aware of the additional issues that would inevitably result if the roadway was opened to the public (e.g., the need for fish and wildlife management, increased recreation to areas once considered remote wilderness). In 1995, after the highway was opened to the public, then-Governor Knowles committed to addressing "the specific concerns of local governments and Alaska residents near the road corridor to ensure that there will be adequate planning of land uses, provision for public safety, and protection of fish and wildlife and other natural resources in the corridor. We can maximize economic development opportunities for Alaskans while minimizing impact on residents of nearby communities, other Alaska users, and wildlife. The 400 mile long Dalton Highway is one of the most unique transportation corridors in the nation; traversing areas of unparalleled and, to most of the public, unseen beauty."[19] A decade earlier, in 1982, the Bureau of Land Management (BLM) prepared a Recreation Activity Plan for the Dalton Highway and Utility Corridor that reiterates this sentiment, citing both the State of Alaska and BLM as being "committed to making this [corridor's] scenic splendor available to the public."[20]

Better maintenance of the roadway and increased marketing efforts by the Fairbanks tourism industry have also contributed to increased use along the corridor. Reality television shows and social media depicting the Dalton Highway as the last great American road trip have also inspired a growing interest that attracts travelers to the highway.

2.2.1 History of Use and Access

The Dalton Highway was constructed between 1969 and 1974 by private developers for the primary purpose of TAPS pipeline construction and maintenance and providing ongoing access to Alaska's North Slope. Before the bridge was built, the Yukon River was a challenge for the movement of goods and equipment; trucks and supplies were transported across the river by hovercraft in summer or driven across the ice in winter.[21] This occurred until the bridge opened in fall 1975.

The highway has remained the lifeline for supporting TAPS and Alaska's North Slope, providing the only year-round road access. Keeping the Dalton Highway open is crucial to maintaining oil and gas field operations. The role of the oil and gas industry in Alaska's economy is vital, as it both historically and currently funds the majority of the State's operating budget—92 percent[22] of Alaska's unrestricted revenue in fiscal year (FY) 2013—as well as providing more than 100,000 jobs in Alaska, representing nearly one-third of all wage and salary jobs in the state.[23] Keeping the North Slope oil fields operating is important on a national scale to reduce the country's dependence on foreign sources of oil, as identified by Congress in the Trans-Alaska Pipeline Authorization Act of 1973.[24] Furthermore, Alaska's crude oil production represented approximately 6 percent of the country's total production in 2016, in addition to accounting for approximately 0.6 percent of total global production in 2015.[25]

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[19] Office of the Governor. 1995. State Bill 93 memorandum from Governor Tony Knowles to DNR Commissioner John Shively. June 5, 1995. Accessed in the Dalton Highway Maser Plan appendices: http://dnr.alaska.gov/mlw/planning/mgtplans/dalton_highway/pdf/dalton_hwy_appendices.pdf.

[20] U.S. Department of the Interior, Bureau of Land Management (BLM). 2002. Renewal of the Federal Grant for the Trans-Alaska Pipeline System Right-of-Way Final Environmental Impact Statement. November 2002.

[21] Alaska Department of Natural Resources (DNR) Division of Parks and Outdoor Recreation, Interpretation and Education Unit. 2010. "Dalton Highway Scenic Byway Corridor Partnership Plan." March 2010. Prepared for the DOT&PF State Scenic Byways Program.

[22] In FY2016, oil and gas revenue made up only 72% of the State's unrestricted revenue. (McDowell Group 2017).

[23] McDowell Group. 2017. The Role of the Oil and Gas Industry in Alaska's Economy. Prepared for Alaska Oil and Gas Association (AOGA). May 2017. http://www.aoga.org/sites/default/files/final_mcdowell_group_aoga_report_7.5.17.pdf

[24] 43 U.S. Code 1651. Congressional Findings and Declaration. November 16, 1973. https://www.law.cornell.edu/uscode/text/43/1651

[25] McDowell Group. 2017. The Role of the Oil and Gas Industry in Alaska's Economy. May 2007.

The Dalton Highway was initially open only to oil and mining support traffic. However, public interest in pleasure driving, sightseeing, camping, and hunting in the corridor put pressure on public officials.[26] Legislation to open the road year-round to Deadhorse was opposed by the North Slope Borough (NSB) and then-Governor Hammond. While federal funding and federal approvals had been obtained and issued to build the roadway, the "nature of the road as either a public highway or a development road" was not formally defined in documentation, and left room for interpretation: "the correspondence between the State and the [Federal Highway Administration] FHWA can support either interpretation."[27] At one point in the early 1980s, the NSB zoned the approximately 170 miles of the highway that occur within its boundary for industrial use only.[28] A 1983 article written about the road called the public access debate the "community-dividing haul-road access controversy."[29] A compromise was finally reached, and State legislation was passed in 1980 to allow private vehicle use during June, July, and August north to Dietrich Camp (MP 211 at Disaster Creek, 30 miles south of the NSB boundary) by permit. DOT&PF placed a vehicle checkpoint there, at an annual cost of approximately $350,000, to make sure only truckers continued past Dietrich Camp. By 1983, State cost-cutting measures eliminated the checkpoint. The DOT&PF Commissioner issued an order to open the Dalton Highway to permitted traffic to Dietrich Camp year-round, although permit-enforcement was minimal.

Construction of the Dalton Highway provided sport hunting access to non-local hunters, who were either driving the corridor or flying into abandoned construction camps that had useable airstrips. By 1989, the Alaska Department of Fish and Game (ADF&G) noted excessive hunting pressure on moose and declining subsistence use.[30] Debate on public access continued, and the NSB and Tanana Chiefs Conference eventually sued to keep the road closed. The NSB had argued that part of the purpose of the "James Dalton Highway Act" (Alaska Statute [AS] 19.40) was to control access to the Dalton Highway and specifically limit vehicle traffic on the northern portion (through the NSB lands) to commercial or industrial traffic. The NSB was concerned for two main reasons: (1) public safety and (2) protecting the wildlife and cultural resources, including subsistence resources and access. The highway was constructed for industrial truck use, and public and emergency support services were not sufficient to handle public use. At that time average daily traffic volumes were under 100 trucks per day.

In August 1994, the State Supreme Court[31] sided with DOT&PF, which permitted the opening of the Dalton Highway to public access along its entire length.[32] The court found that "one cannot reasonably conclude that the plain meaning (of part of the James Dalton Highway Act [AS 19.40.100 and AS 19.40.110]) restricts travel by the general public on the Dalton Highway. It follows that the DOT has

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[26] The summary of the public debate was pieced together from various articles of the Arctic Policy Review Newsletters, a publication of the North Slope Borough, Alaska. http://www.ebenhopson.com/apr/aprIndex.html. Specific articles include: *State Highway Officials try to use Land Use Council to open Arctic Haul Road to Pleasure Driving* (September 1983; pages 10-11) and *Managing the Haul Road: NSB Officials Conduct Inspection Tours* (October 1982; pages 4-7).

[27] State of Alaska Office of the Attorney General. 2002. Opinion by Paul R. Lyle, Assistant Attorney General regarding public uses. July 17, 2002. http://www.akleg.gov/basis/get_documents.asp?session=27&docid=11344.

[28] Arctic Policy Review. 1982. "Managing the Haul Road: NSB Officials Conduct Inspection Tours." October 1982.

[29] Arctic Policy Review. 1983. "State Highway Officials try to use Land Use Council to Open Arctic Haul Road to Pleasure Driving." September 1983.

[30] Haynes, Terry, and Sverre Pedersen. 1989. "Development and Subsistence: Life After Oil." ADF&G Subsistence. Nov.-Dec. 1989 issue.

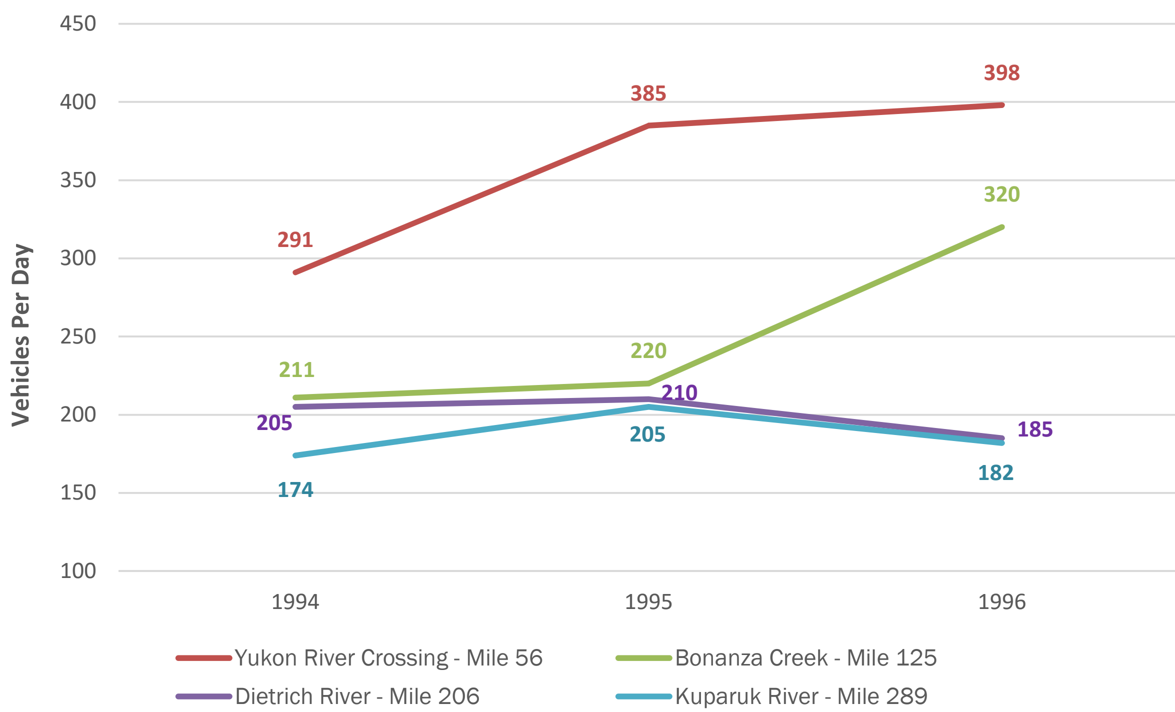
[31] DOT&PF and State of Alaska v. North Slope Borough and Tanana Chiefs (August 26, 1994), 879 P 2d 1009.

[32] DOT&PF. 2014. Alaska Roads Historic Overview: Applied Historic Context of Alaska's Roads. http://dnr.alaska.gov/Assets/uploads/DNRPublic/parks/oha/publications/akroadshistoricoverview.pdf

the general authority to open the entire length of the highway to unrestricted travel by the general public."[33]

After the State took over maintenance and operation of the highway in 1978 and access restrictions were eased in 1994, the Dalton Highway—including the Yukon River Bridge—saw an increase in traffic. According to the 1998 *Dalton Highway Master Plan*, prepared by the Dalton Highway Advisory and Planning Board[34], highway traffic jumped by nearly one-third the year it opened to the public; see Figure 2-3. for historic traffic volumes between 1994 and 1996. Historic traffic volumes for every year since the highway opened are not available. See Figure 2-5 and Figure 2-6 for other readily available traffic counts.

Figure 2-3. Historic Traffic Volume by Location on the Dalton Highway, 1994–1996



Source: *Dalton Highway Master Plan*, March 1998. Retrieved from: http://dnr.alaska.gov/mlw/planning/mgtplans/dalton_highway/

2.2.2 Current Use and Classification

The Dalton Highway is part of the National Highway System (NHS) and is a designated State Scenic Byway. The highway is also the only highway in Alaska that is considered a High Priority Corridor, as designated by Congress. The highway officially begins at MP 73 of the Elliott Highway near Livengood and terminates near the State-owned Deadhorse Airport at Prudhoe Bay. The highway crosses the Yukon River at MP 56.

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[33] DOT&PF and State of Alaska v. North Slope Borough and Tanana Chiefs (August 26, 1994), 879 P 2d 1009.
[34] The board was created in 1995 by then-Governor Knowles with the intent to create a plan for natural resource management and other issues related to economic development and public safety. The board existed for three years and, at the completion of the master plan, was intentionally disbanded.

The highway was built, and continues to serve, as a critical link for industrial traffic between Interior Alaska and North Slope oil facilities. The Dalton Highway connects northern communities to the road system, airport facilities, rail, and port facilities. It provides public access to adjacent lands for recreation, tourism, subsistence activities, and sport hunting.

Communities along the highway route include Coldfoot (MP 175), which is primarily a truck stop and more recently an increasingly popular winter tourist destination, and Wiseman (1 mile west of MP 189). Both communities have DOT&PF-owned airports; there is also a DOT&PF airport at MP 137 (Prospect Creek). Stevens Village is located approximately 26 miles upstream from the Yukon River Bridge, and a 28-mile winter trail connects it to the Dalton Highway. There has been ongoing interest in a permanent road connection from Stevens Village to the Dalton Highway.[35]

The area near the Yukon River Bridge is a jumping off point for many locals. For instance, a number of Stevens Village residents use their snow machines to travel from the community to the boat launch, which is located just downstream of the bridge. Seasonal tug or barge service also occurs along the Yukon River in summer, delivering freight and fuel to communities. In fall, hunting is a big draw, and there can be more than 100 boat trailers in the overflow and lessee lot/truck stop near the crossing. Figure 2-4 depicts the view of the truck stop at the northern end of the Yukon River Bridge.

Figure 2-4. Yukon River Bridge Crossing, Looking Northbound, 2011

Source: Google Imagery.

Functional Classification

The functional class of a highway is used to describe its role within the transportation system. It is based on the varying degree of its two primary functions: (1) providing regional mobility and (2) promoting local access. The entirety of the 414-mile-long Dalton Highway is classified by DOT&PF as a Rural Principal Arterial.

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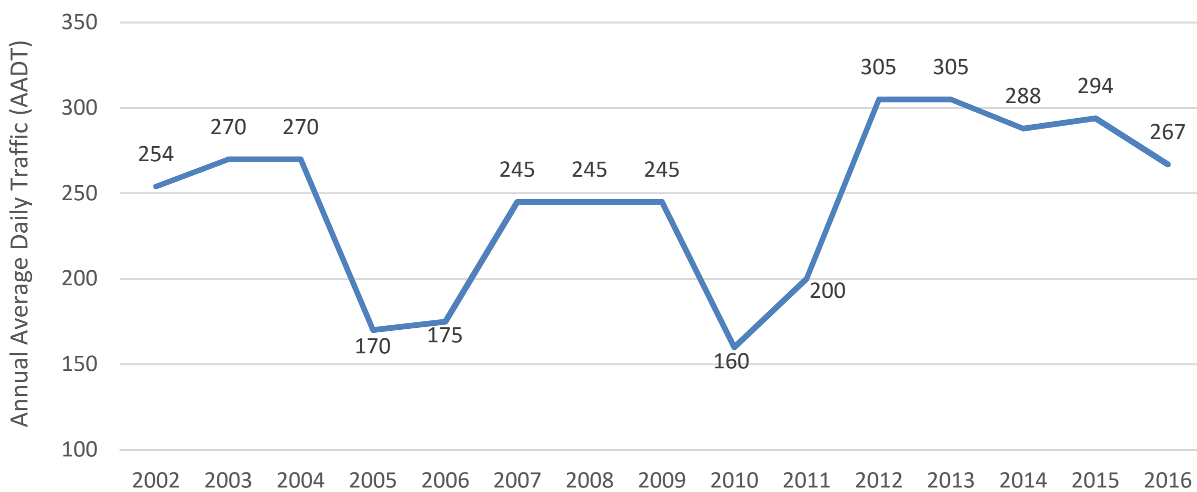
[35] DOT&PF. 2010. *Interior Alaska Transportation Plan*. http://www.dot.state.ak.us/stwdplng/areaplans/area_regional/iatp.shtml

Arterials represent the highest class of road and are intended to serve higher volumes of traffic—particularly through-traffic—at higher speeds. They also serve truck traffic and, as such, typically emphasize traffic movement over local land access. Arterial roads can be further designated as "major/principal" or "minor." Major/principal arterials have higher design speeds and fewer access points per mile, and usually do not permit direct private driveway access unless no other access is available. Minor arterials would connect to principal arterials.[36]

Traffic Volumes

Traffic volumes at the Yukon River Bridge have fluctuated slightly during the past five years. The rural, two-lane highway near the bridge had an average annual daily traffic (AADT) volume of 294 vehicles per day in 2015; this AADT represents traffic on the northbound approach to the bridge.[37] This is a slight increase compared to 2014 (288 vehicles), and in 2016 AADT decreased somewhat (267 vehicles).[38,39] North of the bridge, the 2015 AADT drops off slightly from 294 to 255 vehicles.[40] Figure 2-5 depicts the AADT at the bridge from 2002 through 2016, based on DOT&PF traffic data from multiple sources.

Figure 2-5. Traffic Volumes on the Dalton Highway at the Yukon River Bridge, 2002–2016



Sources:

2002 AADT: DOT&PF *Highway Bridge Incident Management Plan*, Summary Information for Critical Bridges, August 6, 2003.

2003-2014 AADT: DOT&PF, Northern Region – Annual Traffic Volume Reports. Retrieved from: http://www.dot.alaska.gov/stwdplng/transdata/traffic_past_reports.shtml.

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[36] DOT&PF. 2010. *Interior Alaska Transportation Plan*.

[37] DOT&PF. 2015. 2015 AADT GIS Map. http://www.dot.alaska.gov/stwdplng/transdata/traffic_AADT_map.shtml, accessed April 27, 2017.

[38] DOT&PF. 2015. *Annual Traffic Volume Report, 2013-2015*. Prepared by DOT&PF Northern Region Planning and Support Services in cooperation with FHWA. http://www.dot.alaska.gov/stwdplng/transdata/pub/Regional_Traffic_Reports/trafficdata_reports_nor/NR_2015_Traffic_Volume_Report.pdf, accessed April 27, 2017.

[39] DOT&PF. 2017. E-mail between DOT&PF Transportation Planner Scott Gordon Vockeroth and Project Manager Lauren Little. May 16, 2017.

[40] DOT&PF. 2015. 2015 AADT GIS Map.

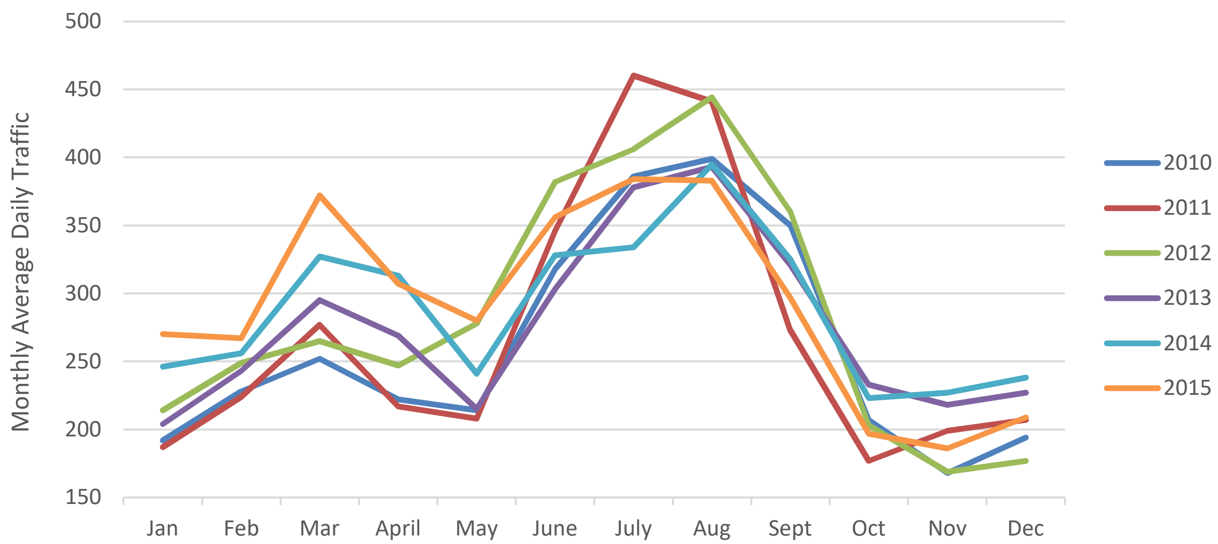
2015 AADT: DOT&PF 2015 AADT GIS Map. Retrieved from: http://www.dot.alaska.gov/stwdplng/transdata/traffic_AADT_map.shtml.

2016 AADT: DOT&PF. May 16, 2017. E-mail between DOT&PF Transportation Planner Scott Gordon Vockeroth and Project Manager Lauren Little.

Note: The routine bridge inspection reports for the Yukon River Bridge presented slightly lower AADT for 2012 and 2013 (250 and 220, respectively) compared to those listed in the DOT&PF annual traffic volume reports (305 for both years).

As expected, traffic volumes peak during the summer season, as depicted on Figure 2-6. In recent years, traffic volumes at the Yukon River Bridge have been spiking increasingly in March.

Figure 2-6. Yukon River Bridge Monthly Average Daily Traffic, 2010-2015



Source: DOT&PF. 2017. E-mail between DOT&PF Transportation Planner Scott Gordon Vockeroth and Project Manager Lauren Little. May 16, 2017.

Truck Traffic

Truck traffic represents a significant portion of total traffic volume along the Dalton Highway and at the Yukon River. Between 2014 and 2016, more than two-thirds of all vehicles at the Yukon River Bridge were trucks.[41] The Alaska Trucking Association confirmed this in response to the summer 2016 Study query that was distributed to industry-related stakeholders, stating that hundreds of commercial vehicles of all sizes cross the Yukon River every day, year-round. Available truck traffic data for the Yukon River Bridge indicates that the percent of truck traffic increases slightly north of the bridge, as shown in Table 2-1.

[41] DOT&PF. 2017. E-mail between DOT&PF Transportation Planner Scott Gordon Vockeroth and Project Manager Lauren Little. May 16, 2017.

Table 2-1. Percentage of Truck Traffic South and North of the Yukon River Bridge, 2014-2015

Year	South of Bridge	North of Bridge
2014	67.3%	71.5%
2015	68.4%	71.9%
2016	64.4%	69.0%

Source: DOT&PF. 2017. E-mail between DOT&PF Transportation Planner Scott Gordon Vockeroth and Project Manager Lauren Little. May 16, 2017.

The percentage of truck traffic north of the bridge has not changed significantly over the past 10 years. The 2010 Interior Alaska Transportation Plan indicated that truck traffic in 2007 accounted for approximately 70 percent of traffic south of Coldfoot (MP 175).[42] Similarly, in 1984, truck traffic accounted for about two-thirds of the traffic mix along the highway.[43]

The Dalton Highway north of Happy Valley (MP 334) has the greatest percentage of truck traffic in the entire state; in 2012, 82 percent of the AADT consisted of truck traffic.[44]

Road Conditions

In the study area, the existing highway roadbed is narrow, with soft shoulders, steep embankments, and steep hills. DOT&PF uses a road width guideline of 32 feet finished width for most of the Dalton Highway.[45] Some segments of the highway are paved (16 miles) or have an asphalt surface treatment (85 miles); the remainder is gravel.[46] The BLM Visitor Guide (2016) recommends that drivers use caution on dangerous curves and loose gravel, especially between Livengood and the Yukon River (MP 0–56).

The entire length of the Dalton Highway is posted for 50 miles per hour (mph). The design speed varies by section, and is either 50 mph or 60 mph both south and north of the bridge.[47]. The 2010 *Interior Alaska Transportation Plan* notes that capacity along the Dalton Highway is sufficient for the existing traffic volumes.[48]

Users

Industry

The Dalton Highway continues to be important for North Slope oil operations. Food, fuel, equipment, and supplies are trucked up the Dalton Highway from Fairbanks to Deadhorse year-round. The importance of the transportation link was illustrated in 2015, when floodwaters from the Sagavanirktok (Sag) River overtopped and eroded sections of the highway,[49] resulting in two separate road closures. The situation resulted in the Governor's declaration of a state of disaster to free up

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42 DOT&PF. 2010. *Interior Alaska Transportation Plan*. http://www.dot.state.ak.us/stwdplng/areaplans/area_regional/iatp.shtml
43 ERE SYSTEMS, LTD. 1984. Barrow Arch Transportation Systems Impact Analysis *Social and Economic Studies Program Alaska OCS Region*. Prepared for Minerals Management Service Alaska Outer Continental Shelf Region. December 1984.
44 DOT&PF. 2014. Alaska Statewide LRTP 2036 Update, Freight Advisory Committee Meeting #3 presentation, slide 13. October 29, 2014. http://dot.alaska.gov/stwdplng/areaplans/lrtpp2014/docs/20141029FAC3presentation.pdf, accessed April 25, 2017.
45 DOT&PF. 2010. *Interior Alaska Transportation Plan*.
46 DOT&PF. 2010. *Interior Alaska Transportation Plan*.
47 DOT&PF. 1997. Dalton Highway Design Speed Policy memorandum from DOT&PF Northern Region Pre-Construction Engineer David McCaleb to varying DOT&PF personnel (distribution list). May 27, 1997.
48 DOT&PF. 2010. *Interior Alaska Transportation Plan*.
49 DOT&PF. 2015. AKDOT&PF Dalton Highway Flood – After Action Review. July 9, 2015.

funds and streamline permit requirements to divert the waters and reopen the road. Loads of cargo were backed up in Fairbanks, and fuel and food necessary for oil field support had to be transported by air or special tundra trucks (called rollagons) at great expense. The cost to the State to handle the emergency was estimated at $15 million, and industry costs were likely substantially higher.

Local Residents

Local users include residents from communities along the highway (Wiseman, Chandalar, and Coldfoot), as well as those communities close to the highway (Stevens Village, Rampart, and Bettles). Yukon River communities, particularly Rampart and Stevens Village, since they are closest to the bridge, also use the river in summer and snow/ice trails in winter to travel and access the road system.

Tourism and Recreation Visitors

The opportunity to venture to the Arctic Circle and the diverse geologic terrain, including rugged mountains, large and small rivers, varied flora, and fish and animal populations, render much of the Dalton Highway corridor a visitor magnet. In summer and increasingly in winter, organized tours make routine trips north and south along the Dalton Highway. Some of these tours have become so popular that there are daily departures, in both summer and winter. Hunters and fisherman, eco-tourist groups, bird watchers, rock climbers, trekkers, off-road vehicle enthusiasts, and other private users rely on the relatively safe, all-weather overland access provided by the Dalton Highway and the Yukon River Bridge.

A seasonal inter-agency visitor center, the Arctic Interagency Visitor Center, is located in Coldfoot. Since 2001, casual observation by the visitor center's staff indicates a steady increase in the number of visitors traveling on the highway.[50] Personal observations by BLM staff indicate that the Dalton Highway is increasingly popular with non-local hunters, both Alaska residents and non-residents. Paving projects along the highway have smoothed out the rough gravel surfaces. While it used to take 8 hours to travel between Fairbanks and Coldfoot, now the distance can be covered in about 6 hours. BLM also cites recent films and Alaska-themed TV programs, such as Ice Road Truckers, as putting the highway "further on the map." Additionally, the designation of the Dalton Highway as a State Scenic Byway may also draw tourists in the future.[51]

The BLM maintains a number of other recreational features that support increased visitation along the Dalton Highway. These points of interest include overlooks, waysides, pullouts, and camping areas; they are sporadically located along the Dalton Highway. The BLM publishes a visitor guide every year that details these locations and the visitor services that are available.

Commercial tours are limited in their destinations due to lack of facilities; however, individual use of the Dalton Highway for tourism has grown dramatically in recent years according to Explore Fairbanks (formerly known as the Fairbanks Convention & Visitors Bureau).[52]

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[50] BLM. 2016. Analysis of Management Situation. *Central Yukon Resource Management Plan*. Prepared by the BLM Central Yukon Field Office, Fairbanks, Alaska. April 2016. https://eplanning.blm.gov/epl-front-office/projects/lup/35315/72940/80089/%20CYRMP_AMS_all_April_2016_Final.pdf, accessed June 16, 2016.

[51] DOT&PF. 2010. *Dalton Highway Scenic Byway Corridor Partnership Plan*. Prepared by Alaska Department of Natural Resources, Division of Parks and Outdoor Recreation, Interpretation and Education Unit for DOT&PF, State Scenic Byways Program. March 2010. http://www.dot.state.ak.us/stwdplng/scenic/daltoncpp/DaltonHighwayScenicBywayCorridorPartnershipPlan_FINAL.pdf, accessed June 9, 2016.

[52] Haul Road Safety Meeting Notes 2016.

Winter sees the greatest number of visitors along the highway, generally from January through March. Figure 2-6 depicts the spike in winter traffic at the Yukon River crossing. Explore Fairbanks has done extensive marketing in Asia, which has resulted in an increase in winter tourists to Fairbanks and farther north as part of northern lights (aurora borealis) tours. These tours typically involve some combination of driving and flying between Fairbanks and the Coldfoot area. A number of tour companies confirmed these visitor trends in their response to the Study questionnaire that was distributed to a number of tour companies in 2016. See Section 2.5 for a synopsis of these questionnaires.

The Northern Alaska Tour Company operates year-round and owns the truck stop at the Yukon River crossing. During winter, they travel across the Yukon River Bridge heading to their northernmost destination of the Arctic Circle. Some tours depart from Fairbanks and fly people to the Coldfoot area instead of driving the highway, which means that not all of the tours use the bridge crossing. Snowshoeing, dog mushing, and viewing the northern lights are some of the activities offered in Coldfoot. Other companies also provide a mix of year-round trips or seasonal trips. 1st Alaska Outdoor School uses vans for their tour groups, and Premier Alaska Tours use larger motor coaches.

Data collected by the BLM at the Arctic Interagency Visitor Center showed that 40 percent of visitors were part of a guided tour and 60 percent were independent travelers. The BLM keeps track of the number of visitor contacts made at the center; each person who walks into the building is considered a visitor contact. Between 2004 and 2016, the average number of contacts per year was approximately 8,500.[53] During these 12 years, the visitor center was open, on average, 109 days per season. Figure 2-7 depicts BLM visitor numbers at the visitor center in Coldfoot as well as at the Yukon River Bridge.

The BLM operates a visitor contact station located at the northeast end of the Yukon River Bridge. Visitor contact information is collected there every year, generally between Memorial Day and Labor Day.[54] On average, approximately 7,100 visitor contacts are made at this location during the summer season.[55] The contact station near the bridge was open, on average, 97 days per season between 2004 and 2016.[56]

Figure 2-7 depicts the visitor contacts recorded at the visitor centers both in Coldfoot and at the Yukon River crossing between 2004 and 2016. The data shows that the visitor counts fluctuated considerably during that timeframe. A large part of the fluctuation is the varying methodology for how visitors were counted. For instance, at the Yukon River crossing, up until 2016, any vehicle that pulled in received a manual count of how many passengers were on board. In 2016, only those who got out of their vehicles and came into the contact station were counted. Visitor counts are done manually and based on volunteers' observations, which may also contribute to the slight variation in how visitation is recorded. Regardless, the data gives a rough estimate of summer visitation as identified by the BLM. While Figure 2-7 depicts only the summer visitor counts, BLM indicated anecdotally that winter use is trending upward for the tourism industry, based on tour company bookings.[57]

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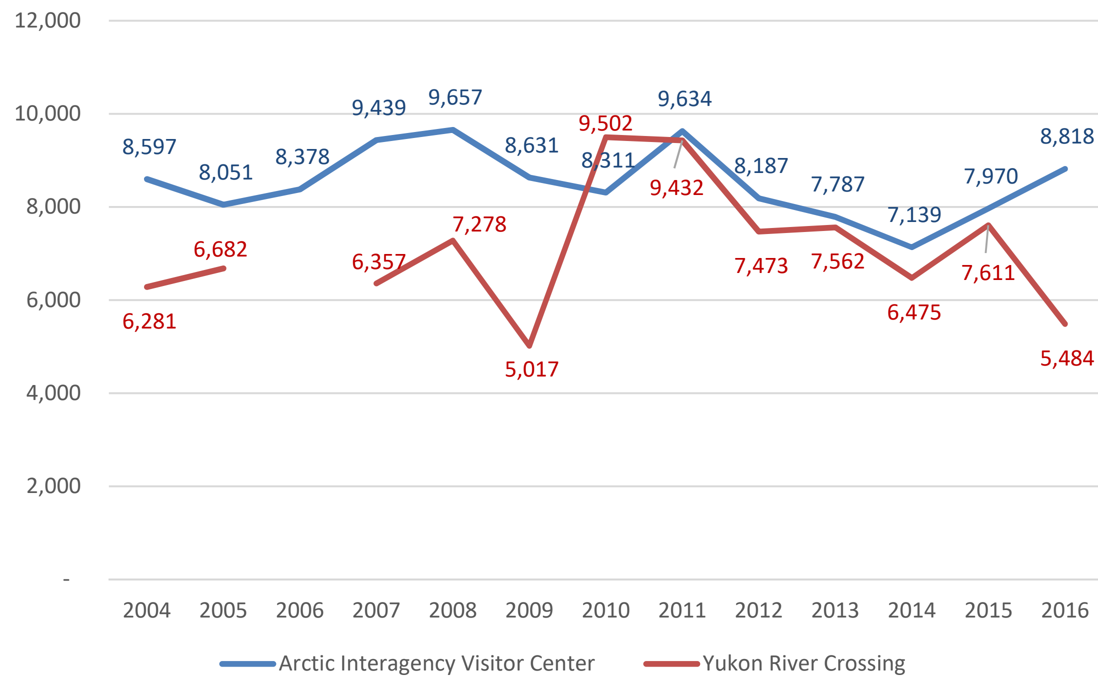
[53] Egger, Kelly. 2017. Telephone conversation between BLM Outdoor Recreation Planner Kelly Egger and HDR Planner Leslie Robbins. January 10, 2017.
[54] Egger, Kelly. 2017. Telephone conversation between BLM Outdoor Recreation Planner Kelly Egger and HDR Planner Leslie Robbins. January 10, 2017.
[55] Visitor numbers provided by BLM Outdoor Recreation Planner Kelly Egger.
[56] Visitor numbers provided by BLM Outdoor Recreation Planner Kelly Egger.
[57] Egger, Kelly. 2017. E-mail correspondence between BLM Outdoor Recreation Planner Kelly Egger and HDR Planner Leslie Robbins. January 10, 2017.

Figure 2-7. BLM Seasonal Visitor Contacts in Coldfoot and at the Yukon River Crossing, 2004-2016



Note: These visitor counts are general estimates and are included for general trend purposes only due to the variability in the methodology for how counts were obtained. Also, no data were collected in 2006 at the Yukon River Bridge.

Tourism and recreational use of the highway has increased since 1994. The statewide tourism industry is estimated to have generated $3.72 billion in spending in 2011–2012, with 16 percent of spending in the Alaska Interior and 1 percent in the Far North.[58] A 2007 University of Alaska-Fairbanks survey identified the top five primary recreation activities on the Dalton Highway as driving and sightseeing, photography, wildlife viewing, walking, and bird watching.[59]

Recreation is a major use of the public lands along the Dalton Highway corridor. This is evidenced in the number of recreation-related scoping comments submitted recently to BLM as part of their current effort to update their resource management plan (RMP) for the region that incorporates the Dalton Highway and Yukon River crossing (refer to Section 2.3.2. for additional info about BLM's RMP update). Nearly 3,000 scoping comments were submitted to BLM during the scoping phase; of the 13 issues identified, recreation/visitor services was one of the larger comment categories.[60] This is

[58] BLM. 2016. Analysis of Management Situation Central Yukon Resource Management Plan. Prepared by the BLM Central Yukon Field Office, Fairbanks, Alaska. April 2016. https://eplanning.blm.gov/epl-front-office/eplanning/planAndProjectSite.do?methodName=dispatchToPatternPage&currentPageId=45824, accessed June 13, 2016.
[59] BLM. 2016. Analysis of Management Situation Central Yukon Resource Management Plan. April 2016.
[60] BLM. 2015. Scoping Report for the Central Yukon Resource Management Plan. Prepared by the BLM Central Yukon Field Office, Fairbanks, Alaska. March 2015. https://eplanning.blm.gov/epl-front-office/projects/lup/35315/56047/60740/CYRMP_Scoping_Report_Web_Final.pdf, accessed August 15, 2016.

indicative of the importance and interest regarding access to recreation opportunities and visitor services.

In 1991, BLM prepared a Recreation Area Management Plan for the Dalton Highway because of "the recreational potential of lands along the Dalton Highway."[61] That plan said that "prior to road construction, recreational use of the area was very light and widely dispersed. With the construction and subsequent opening of the Dalton Highway to the public, the situation quickly changed, raising many issues related to current and anticipated recreational use."

Recreation covers a broad range of activities, and can include activities such as dispersed or more formalized camping, motorized and non-motorized recreation, and hunting, as well as support facilities such as parking areas and bathrooms that facilitate recreation use. There is a challenging balance between providing recreational opportunities (e.g., wilderness and wildlife) and managing access to these opportunities (e.g., infrastructure and development). That was one of the concerns about opening the Dalton Highway up to the general public: the increased pressure of recreation and visitors on natural resources. The 1991 Dalton Highway Recreation Area Management Plan cited the following four key issues related to increased visitation and recreation: (1) basic safety, health, and sanitation services; (2) resource protection; (3) developed recreation facilities and opportunities; and (4) information and interpretation on recreational opportunities and resources.

Continued improvements to the highway will make it more attractive to visitors. With the increase in public use along the Dalton Highway, the available traveler support services may become increasingly inadequate. From a maintenance standpoint, however, the impacts of increased recreational visitors would be negligible considering their relatively low traffic volumes and vehicle weights.

Research

The University of Alaska-Fairbanks operates an internationally recognized arctic research facility, Toolik Field Station, located at MP 284 of the Dalton Highway. The research station was established in 1975 and conducts studies on arctic ecosystems and global climate change. This facility draws summer research staff and visiting educators who hike recreationally in the mountains around the Dalton Highway.[62] The facility has a capacity of more than 100 users, though access to the station is by invitation only.[63] There are no public facilities located there. According to the Toolik Field Station website, the majority of the field station researchers and staff travel to and from the station twice weekly.

Services

Year-round commercial and emergency services with telephone and fuel are available at two locations along the Dalton Highway: Coldfoot (MP 175) and Deadhorse (MP 414). Gas, lodging, and food services are also available at the Yukon River crossing (MP 56) seasonally during summer.

The unincorporated village of Wiseman, with a year-round population of approximately 12 people, is located at MP 189, just north of Coldfoot. No other commercial public services are available along the Dalton Highway. Except for "Good Samaritan" help from other travelers and maintenance

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[61] BLM. 1991. *Dalton Highway Recreation Area Management Plan*. November 1991.
[62] BLM. 2016. Analysis of Management Situation. *Central Yukon Resource Management Plan*.
[63] Institute of Arctic Biology. 2016. Toolik Field Station Institute of Arctic Biology website. http://toolik.alaska.edu/, accessed August 16, 2016.

personnel at Alyeska pump stations or at DOT&PF maintenance facilities, travelers must be self-sufficient.

Overall, visitor services (e.g. outhouses, litter bins, lodging, campgrounds, and fuel stations) are limited along the Dalton Highway. Development of additional facilities to address the increase in travelers is not universally desired; this sentiment is generally held by those who wish to keep the Dalton Highway corridor a wild, non-commercialized experience. This was a concern identified not only in the recent BLM planning effort to update the RMP, but also back in the early 1990s as part of BLM's recreation area management plan for the Dalton Highway. The BLM has constructed outhouses and bear-resistant trash containers in 13 locations between the Yukon River and MP 355. The BLM maintains these facilities; however, costs have increased along with the cost of fuel. There are permanent outhouse facilities at the Yukon River Bridge near the pipeline on the northeast side of the crossing.

Public and emergency services are limited. The highway corridor crosses several federal, State, municipal, and private areas, complicating the determination of who is responsible for providing security, search and rescue, motorist aid, and emergency response.[64] The State of Alaska has jurisdiction over the entire length of the highway, but State Troopers normally do not respond north of MP 247 (north of Atigun Pass) unless the NSB makes a formal request. Calls for assistance south of MP 247 are handled by Troopers based in Fairbanks, which results in response times of several hours (or longer, depending on road/weather conditions). In emergency situations, Alaska Department of Public Safety Fish and Wildlife Protection offices in Coldfoot can provide assistance; however, they are often traveling in remote lands away from the highway. Assistance may also be provided by the one law enforcement ranger for BLM, or rangers from the National Park Service and U.S. Fish and Wildlife Service (USFWS) who seasonally patrol lands in the region.

The ability of public and private agencies to respond to accidents is a long-standing concern—one that was voiced in the 1980s and 1990s by the NSB in their opposition to unlimited public access to the highway. First responders are typically other drivers or Alyeska personnel,[65] since Alyeska pump stations are some of the only physical structures in the area. Although Alyeska responds to emergencies, liability for providing emergency services to recreational travelers complicates their business. Citizens' band radio is considered the only integrated communication system among agencies, communities, truck drivers, and private businesses; however, the highway's remoteness, as well as difficult weather and topography, can still limit communications. The increase in individual users, many of whom are not prepared for the challenges of the Dalton Highway, has led to close calls and a request for action from commercial users of the highway.[66]

2.2.3 Future Use and Classification

The Dalton Highway link to the North Slope will continue to be important to commercial users, local residents, subsistence users, and tourism and recreation visitors. The 2010 *Interior Alaska Transportation Plan* forecasted a 2030 AADT of 300 (low) to 340 (moderate) for the Dalton Highway corridor.

The recent decline in oil production and lower oil prices has had far-reaching implications for the State's economy, especially since the State's current revenue stream is dependent on both oil and gas production and price. However, potential oil and gas reserves continue to drive State and private

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64 DNR Division of Parks and Outdoor Recreation, Interpretation and Education Unit. 2010. "Dalton Highway Scenic Byway Corridor Partnership Plan." March 2010. Prepared for the DOT&PF State Scenic Byways Program.
65 DNR Division of Parks and Outdoor Recreation, Interpretation and Education Unit. 2010. "Dalton Highway Scenic Byway Corridor Partnership Plan." March 2010. Prepared for the DOT&PF State Scenic Byways Program.
66 Haul Road Safety Meeting Notes 2016.

development plans, particularly for a natural gas pipeline. These potential development plans and uses are further described in Section 2.3 and briefly introduced below.

The corridor for a potential AKLNG pipeline or ASAP would follow the Dalton Highway. These efforts are currently on hold or are in the planning stages, but may proceed and pick up momentum in the future. Governor Walker and his administration are actively pursuing potential buyers for liquefied natural gas (LNG) in the Asian market. The Dalton Highway, including the Yukon River Bridge, would become an important supply line for construction activities for either pipeline corridor. In addition, future arctic and subarctic oil and gas development could include new infrastructure such as pipelines, camps, and gravel pits that may add traffic to, or extend from, the Dalton Highway. Pursuit of hydraulic fracturing opportunities for unconventional shale production on the North Slope may also contribute to increased use of the transportation corridor in the future.

New roads to access local communities and other natural resources, such as the road to Umiat, Stevens Village (winter only), and the Ambler Mining District, are potential extensions from the Dalton Highway that could increase activity on the Dalton Highway. These proposed routes would extend from the Dalton Highway north of the Yukon River Bridge. The closest of these to the bridge is the proposed Stevens Village winter trail, which would depart from the Dalton Highway near MP 57.

The Dalton Highway is expected to remain a destination for recreational travelers. BLM's *Central Yukon Regional Management Plan* anticipates that the recent decrease in motor coach travel on the Dalton Highway will continue over the long term due to limited lodging opportunities and lack of emergency response facilities. Overall, however, the BLM anticipates that the Dalton Highway corridor and adjacent lands are areas with high potential for continued and expanded recreation as road conditions improve and private sector infrastructure increases.[67] BLM does foresee a slight decline or flat growth in the use of hunting guides due to enhanced management as a result of conflicts and concerns with the subsistence community. [68]

BLM anticipates overall road use north of the Yukon River Bridge will continue and likely grow with independent travel, motorcycle use, camping, birding, berry-picking, hunting, and sightseeing, as well as individuals accessing local air charters for off-road access.[69] As travel continues to grow, it will continue to stress already-stretched public and visitor services. Alyeska's implementation of automation at many pump stations will increase distances between services, resulting in fewer personnel to help road users.

Several tour companies responded to the surveys sent to interested stakeholders for this Study, stating that the tours they provide along the highway to the Arctic Circle and Deadhorse are becoming more popular and they foresee increased growth in the visitor industry along the highway corridor. Tour companies such as Northern Alaska Tour Company, 1st Alaska Tours, and Premier Alaska Tours provided this input in the returned survey questionnaires. Individual tourist traffic also continues to increase. Car rental companies, such as Alaska Auto Rental, stated in a returned survey questionnaire for this Study that they expect the volume of visitors along the Dalton Highway to increase in the coming years.

No changes are anticipated for the functional classification of the Dalton Highway. It would remain a Rural Principal Arterial, with limited community and development connections along its long length.

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67 BLM. 2016. Analysis of Management Situation Central Yukon Resource Management Plan. April 2016.
68 BLM. 2016. Analysis of Management Situation Central Yukon Resource Management Plan. April 2016.
69 BLM. 2016. Analysis of Management Situation Central Yukon Resource Management Plan. April 2016.

Section Highlights

Development Plans

- Exploration and development activities in the Northern and Interior parts of Alaska have been ongoing for more than a century. The Dalton Highway and Yukon River Bridge have aided those development efforts in the last half century.
- The Dalton Highway and Yukon River Bridge are located where state and federal land management agencies are actively preparing management plans. These include:
    - Bureau of Land Management (BLM): Central Yukon Resource Management Plan update
    - Alaska Department of Natural Resources (DNR): North Slope Management Plan

  Public comment related to use and development plans provided on these recent planning efforts is relevant to this Study. Popular topics commented on included access, travel management, mining, and recreation and visitor services.
- Specified and limited development nodes identified decades ago along the Dalton Highway include the Yukon River crossing location.
- The Yukon River Bridge would be utilized to support a number of proposed "Roads to Resources" that would extend from the Dalton Highway farther north from the bridge (e.g., Umiat and Ambler).
- Proposed Liquefied Natural Gas (LNG) projects have the potential to increase usage of the bridge and highway, especially during construction. Two LNG projects, the Alaska Gasline Development Corporation's ASAP and AKLNG, would locate pipelines approximately 1 mile downstream from the existing Yukon River Bridge.

2.3 Development Plans

The Dalton Highway was originally developed in support of resource extraction. Historic and future potential resource development activities indicate continued use for this purpose. Overall, the development plans reviewed did not include specific details about the Yukon River Bridge and the nearby portion of the Dalton Highway corridor; rather, planning materials emphasized the need to maintain the highway condition.

2.3.1 Historic Regional Natural Resource Exploration and Development

The history of the Yukon River Bridge and the Dalton Highway is contained within a century of natural resource exploration and development activities in Interior and Northern Alaska.

The Elliott Highway resulted from the transportation needs of gold exploration and mining efforts in the early twentieth century.[70] Gold was first discovered in Fairbanks in 1902, and there were additional gold discoveries north of the city over the next several years. In 1914, gold was discovered in Livengood. The original road to Livengood was a sled road for freight that was improved over several decades to accommodate wagons and then vehicles. It essentially constituted the northern end of the road system in Alaska.

[70] Brown, J., and R.A. Kreig. 1983. *Guidebook to permafrost and related features along the Elliott and Dalton Highways, Fox to Prudhoe Bay, Alaska*. Alaska Division of Geological & Geophysical Surveys Guidebook 4.

With the late 1960s oil discovery near Prudhoe Bay, winter roads over land and frozen rivers were used for materials transport to the North Slope from the end of the established road system at Livengood.[71] In 1969, construction of the Dalton Highway from Livengood to the North Slope was begun in order to support construction of TAPS. In conjunction with the construction of the Yukon River Bridge, Alyeska paid for additional work to route the pipeline along the upstream side of the bridge.

Although the Haul Road to Alaska's North Slope was initially established by private interests to provide year-round overland access to the developing petroleum field at Prudhoe Bay and for the delivery of supplies for TAPS, the roadway also provided an immediate boost to the established placer mining industry in the northern interior.

Chief beneficiaries of the highway have been and continue to be the petroleum, mining, tourism, and support services industries, but increasing numbers of private citizens are making use of the existing infrastructure to access areas along the Dalton Highway and beyond into the backcountry.

Additionally, the Alaska Department of Natural Resources (DNR) is planning to publish a *North Slope Management Plan* in late 2017 that will be used as a guide for land use development along the North Slope. This plan covers approximately 12 million acres of State lands, which include lands north of where the Dalton Highway goes through Atigun Pass.[72] The plan will contain information about natural resources, including present and past land use, and may be useful to help identify additional needs along the highway or related to the Yukon River Bridge.

2.3.2 Adjacent Land Management and Support Services

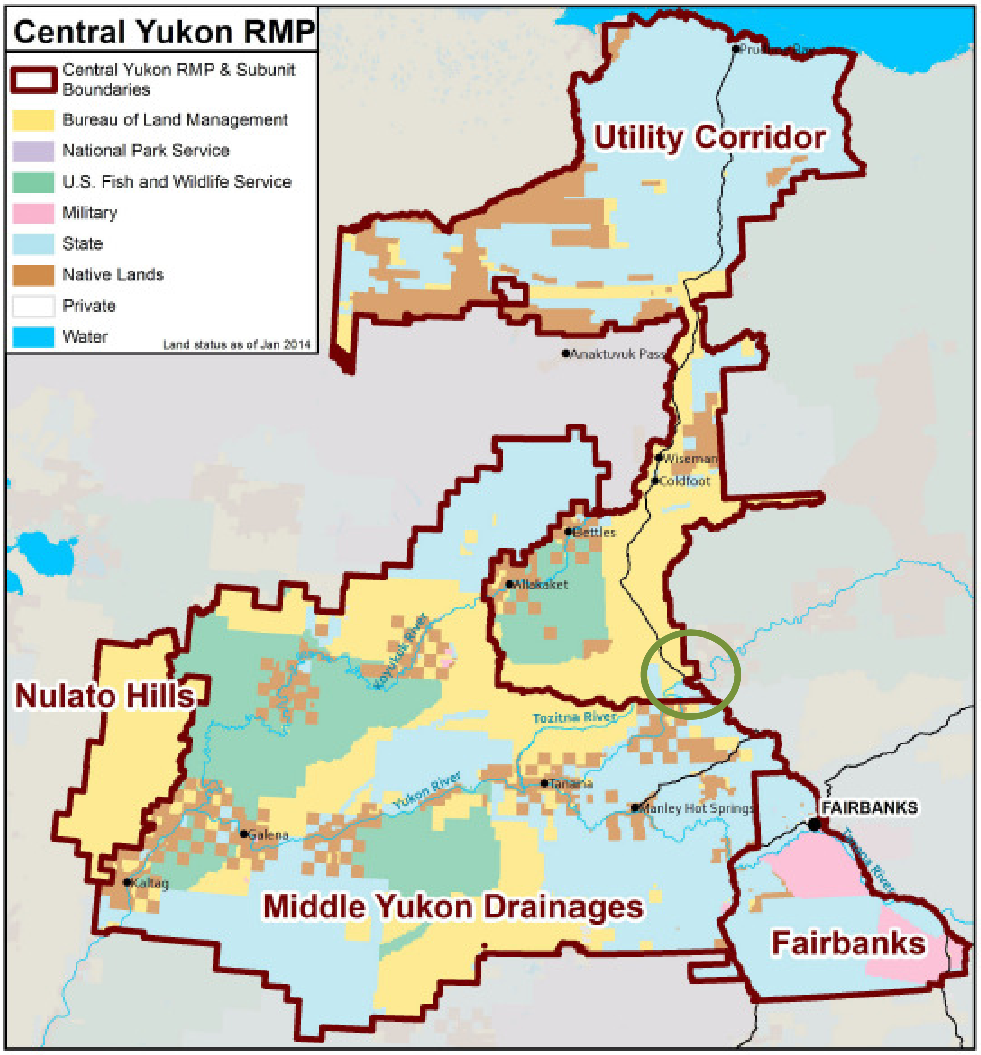
BLM lands abut nearly 60 percent of the Dalton Highway corridor between the Yukon River crossing and Deadhorse.[73] As of early 2017, the BLM is in the process of preparing an updated land use plan for the region. This plan, the *Central Yukon Resource Management Plan*, includes analysis of the Dalton Highway corridor and its crossing of the Yukon River. The Dalton Highway crosses the Yukon River within the southern end of BLM's RMP Utility Corridor subunit, as shown on Figure 2-8.

[71] Brown, J., and R.A. Kreig. 1983. *Guidebook to permafrost and related features along the Elliott and Dalton Highways, Fox to Prudhoe Bay, Alaska*. Alaska Division of Geological & Geophysical Surveys Guidebook 4.

[72] DNR, Division of Mining, Land and Water. North Slope Management Plan webpage. http://dnr.alaska.gov/mlw/planning/mgtplans/nsmp/, accessed December 15, 2016.

[73] BLM. 2011. The Dalton Highway: A Brief History. PowerPoint slides. Slide 13. https://eplanning.blm.gov/epl-front-office/projects/lup/35315/57181/61872/BLM_Dalton_Corridor_history_2011_final.pdf, accessed June 13, 2016.

Figure 2-8. Bureau of Land Management Central Yukon Planning Area and Subunits



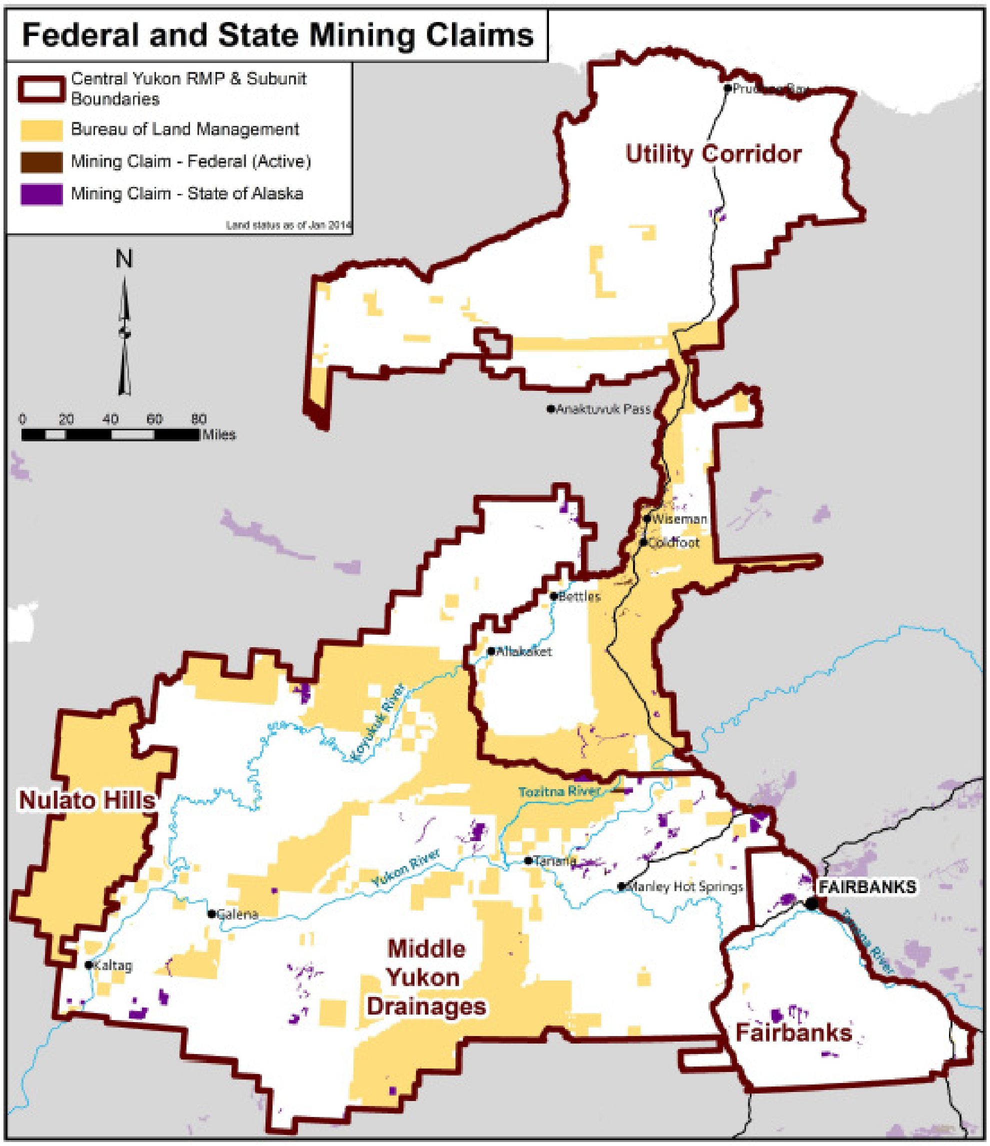
Source: Excerpted from *Analysis of Management Situation Central Yukon Resource Management Plan*, Figure 1.1, BLM 2016. *Note: A green circle has been added to this figure to indicate the location of the Yukon River Bridge.*

BLM will publish an environmental impact statement (EIS) with the RMP, which is expected in fall 2018. A Record of Decision is anticipated in 2019. The planning effort was initiated in 2013, and data collection and outreach have been ongoing since then. In some of their planning documentation, the BLM identified an increasing need to expand material pits and locate new sources for aggregate materials on the Dalton Highway[74] to allow DOT&PF to maintain and upgrade the highway. Alyeska also uses mineral materials to maintain the TAPS and pipeline access roads.[75] Should future developments such as a gas pipeline or other roadways be constructed, much of the needed mineral

[74] BLM. 2016. Analysis of Management Situation. *Central Yukon Resource Management Plan.* Prepared by the BLM Central Yukon Field Office, Fairbanks, Alaska. April 2016. https://eplanning.blm.gov/epl-front-office/projects/lup/35315/72940/80089/%20CYRMP_AMS_all_April_2016_Final.pdf, accessed June 13, 2016.
[75] BLM. 2016. Analysis of Management Situation. *Central Yukon Resource Management Plan.*

materials will come from existing or new mineral material pits along the Dalton Highway. Many of the more than 1,200 federal mining claims for locatable minerals in the BLM RMP planning area are located along the Dalton Highway.[76] More than 5,200 State mining claims occur within BLM's RMP study area, as depicted on Figure 2-9.

Figure 2-9. Federal and State Mining Claims Located in BLM's Central Yukon Resource Management Planning Area



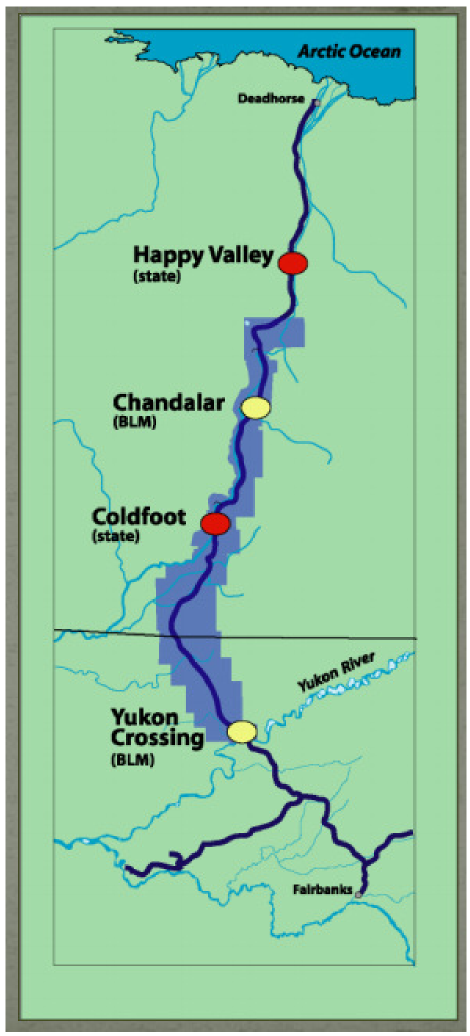
Source: Excerpted from *Analysis of Management Situation Central Yukon Resource Management Plan*, Figure 2.3, BLM 2016.

[76] BLM. 2016. Analysis of Management Situation. *Central Yukon Resource Management Plan.*

More than 30 years ago, the BLM's 1986 *Utility Corridor RMP* attempted to address the increasing need for visitor services by designating a number of locations along the highway as specific "development nodes," where development of privately owned businesses offering travelers such services as fuel sales, dining, and overnight lodging would be encouraged.[77] BLM's identified development nodes along the Dalton Highway include (1) the Yukon River crossing, (2) Coldfoot, (3) Chandalar (MP 239), and (4) Happy Valley (MP 334), as identified on Figure 2-10. The Happy Valley and Coldfoot nodes have since been conveyed to the State of Alaska.[78]

The BLM and other government entities use the highway corridor to supply fire-fighting camps, and the residents and visitors who frequent the area are dependent upon this transportation corridor for emergency services. With an increase in tourism, additional commercial facilities and government-provided infrastructure are possible north of the Yukon River.

Figure 2-10. Bureau of Land Management Dalton Highway Development Nodes



Source: Excerpted from Dalton Highway Corridor History PowerPoint, Slide 15, BLM 2011.

[77] BLM. 1986. *Resource Management Plan for the Central Yukon Planning Area, as cited in* BLM 2016, Analysis of Management Situation, *Central Yukon Resource Management Plan*, p. 124.
[78] BLM. 2016. Analysis of Management Situation. *Central Yukon Resource Management Plan.*

2.3.3 "Roads to Resources"

Alaska has a diverse natural resource base. Some of the natural resource deposits or prospects are world-renowned and are considered some of the largest in the world, such as the Red Dog zinc and lead mine in the Northwest Arctic Borough. Surface access to most of these resource development opportunities is minimal or non-existent. Providing access to these natural resources is anticipated to increase the opportunity for job creation and regional economic growth, which in turn support funding for essential State programs and boost the State's treasury.

In 2003, to facilitate resource exploration and development of minerals, coal, and oil and gas, the State of Alaska initiated its Industrial Roads Program, also known as "Roads to Resources." This initiative was created to help identify possible partnerships between the State and resource industries, which in turn could identify and construct possible surface access needs and opportunities. Encouraging resource development by making access to resource exploration, development, and production opportunities less challenging could increase financial feasibility. Many of the Roads to Resources projects are selected based on a "broad range of technical and social criteria including state and regional economic benefit through creation of local jobs, improved transportation access and reduced cost of living for rural Alaskan communities, and evaluation of impacts to cultural, subsistence, and environmental resources."[79]

Although the initiative consists of projects across the State, in recent years, the larger Roads to Resources initiatives have generally focused on roads in Alaska's Arctic Region: the roads to Umiat, Ambler, and Tanana. The roads to Umiat and Ambler are located north of the Dalton Highway crossing of the Yukon River and are relevant to this assessment, whereas the road to Tanana is located south of the Yukon River crossing. A synopsis of the Umiat and Ambler road projects is provided below. The Yukon River Bridge would be utilized for supply transport for these projects. Traffic generation during exploration, construction, and maintenance of those proposed roadways would be significant; however, volumes are speculative because the details of those potential projects have yet to be developed. These areas and other related resource locations are shown on

Figure 2-11.

- The proposed road to Umiat, also known as the *Foothills West Transportation Access Project*, would facilitate oil and gas exploration and development in the northern foothills of the Brooks Range and improve access to the National Petroleum Reserve-Alaska (NPR-A) via Umiat. An approximately 75-mile road from the Dalton Highway to the Gubik gas field is proposed. Eventually the road would be extended across the Colville River to the State airport in Umiat. The DOT&PF initiated a variety of engineering and environmental studies for this project in 2009. Several winter trails serve as a historical access corridor for oil exploration in the area.[80]

  A road to Umiat is not a new concept. A 1965 memorandum discussing possible Fairbanks-North Slope roadway routes cites a 1951 map regarding a possible route proposed by the

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[79] Technology & Operations Subgroup. 2015. Roads to Resources Program – State of Alaska, Paper #7-8. Working Document of the NPS Study: Artic Potential: Realizing the Promise of U.S. Arctic Oil and Gas Resources. March 27, 2015. http://www.npcarcticpotentialreport.org/pdf/tp/7-8_Roads_to_Resources_Program-State_of_Alaska.pdf, accessed August 17, 2017.

[80] DOT&PF. 2016. Foothills West Transportation Access Project. DOT&PF webpage. http://foothillsroad.alaska.gov/study_area.shtml, accessed June 14, 2016.

Alaska Road Commission between Livengood and Umiat.[81] Public comments submitted within the past few years as part of DNR's North Slope Management Plan indicated concern about the potential impacts to subsistence and wildlife.[82]

- The road to Ambler, also known as the *Ambler Mining District Industrial Access Project*, would consist of an approximate 211-mile road on the south side of the Brooks Range, extending west from the Dalton Highway to the Ambler Mining District.[83] The road is intended to only be open to mining-related industrial use. The DOT&PF initiated a number of environmental baseline studies in 2009 and a number of corridors were identified.[84] In addition to the Dalton Highway connection, other routes previously considered included a connection from the mining district westward to a port in Western Alaska. During its 2013 session, the Alaska State Legislature appropriated $8.5 million for this industrial road to connect with the Dalton Highway. Management of this project shifted from DOT&PF to the Alaska Industrial Development and Export Authority (AIDEA) in 2013. Currently, the BLM is advancing the preparation of an EIS as the next phase of this effort.

Recent State budget constraints have prevented these projects from moving forward in the near term. For the Foothills West Transportation Access Project, a Withdrawal of the Notice of Intent was published in the *Federal Register* in January 2015, signifying the suspension of the EIS process.[85] For the Ambler Mining District Industrial Access Project, recent activity included AIDEA's submission of revised applications (SF299 pursuant to the Alaska National Interest Lands Conservation Act) to several federal agencies on June 30, 2016.[86] The BLM published a Notice of Intent in the *Federal Register* on February 28, 2017, to initiate public scoping for the upcoming EIS process. AIDEA's SF299 application was accepted on May 1, 2017 by the responsible federal agencies, with BLM designated the lead federal agency, which will allow the application process to move forward into the EIS preparation phase. BLM's scoping period for the Ambler Road EIS concluded at the end of January 2018, though funding beyond scoping is uncertain as of early 2018.

Development of these roads may result in load restrictions and increased truck traffic along the Dalton Highway and at the Yukon River crossing. These roads, if opened to the public, would also increase opportunities for remote recreation and would open lands that are currently difficult to access. Increased public access is expected to have negligible effects on the bridge crossing at the Yukon River.

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[81] DOT&PF. 1965. Fairbanks-North Slope memorandum from State of Alaska District Highway Engineer Woodrow Johansen to Department of Highways Commissioner D. A. McKinnon. August 23, 1965.
[82] DNR. 2015. DNR-Mining, Land & Water Online Public Comments for the North Slope Management Plan. http://dnr.alaska.gov/mlw/planning/mgtplans/nsmp/pdf/nsmp_scoping_comments.pdf, accessed August 16, 2017.
[83] BLM. 2017. Amber Road Environmental Impact Statement (EIS) Fact Sheet. https://eplanning.blm.gov/epl-front-office/projects/nepa/57323/125627/153376/Ambler_Road_EIS_Fact_Sheet.pdf, accessed March 1, 2018.
[84] Alaska Industrial Development and Export Authority (AIDEA). 2016. Project website. http://www.ambleraccess.org/projects/ambler/index.html, accessed June 14, 2016.
[85] *Federal Register*. January 5, 2015. Termination of Environmental Impact Statement (EIS) for the Alaska Department of Transportation & Public Facilities Foothills West Transportation Access Project. https://www.federalregister.gov/articles/2015/01/05/2014-30862/termination-of-environmental-impact-statement-eis-for-the-alaska-department-of-transportation-and, accessed August 15, 2016.
[86] AIDEA. 2016. AMDIAP – Ambler EIS Project Current Status Information Sheet. July 2016. http://www.aidea.org/Portals/0/PDF%20Files/PFS_Amdiar.pdf, accessed August 15, 2016.

Figure 2-11. Resource Areas in Context of "Roads to Resources" in the Study Area

Source: GIS data from DNR, ASAP, AKLNG.

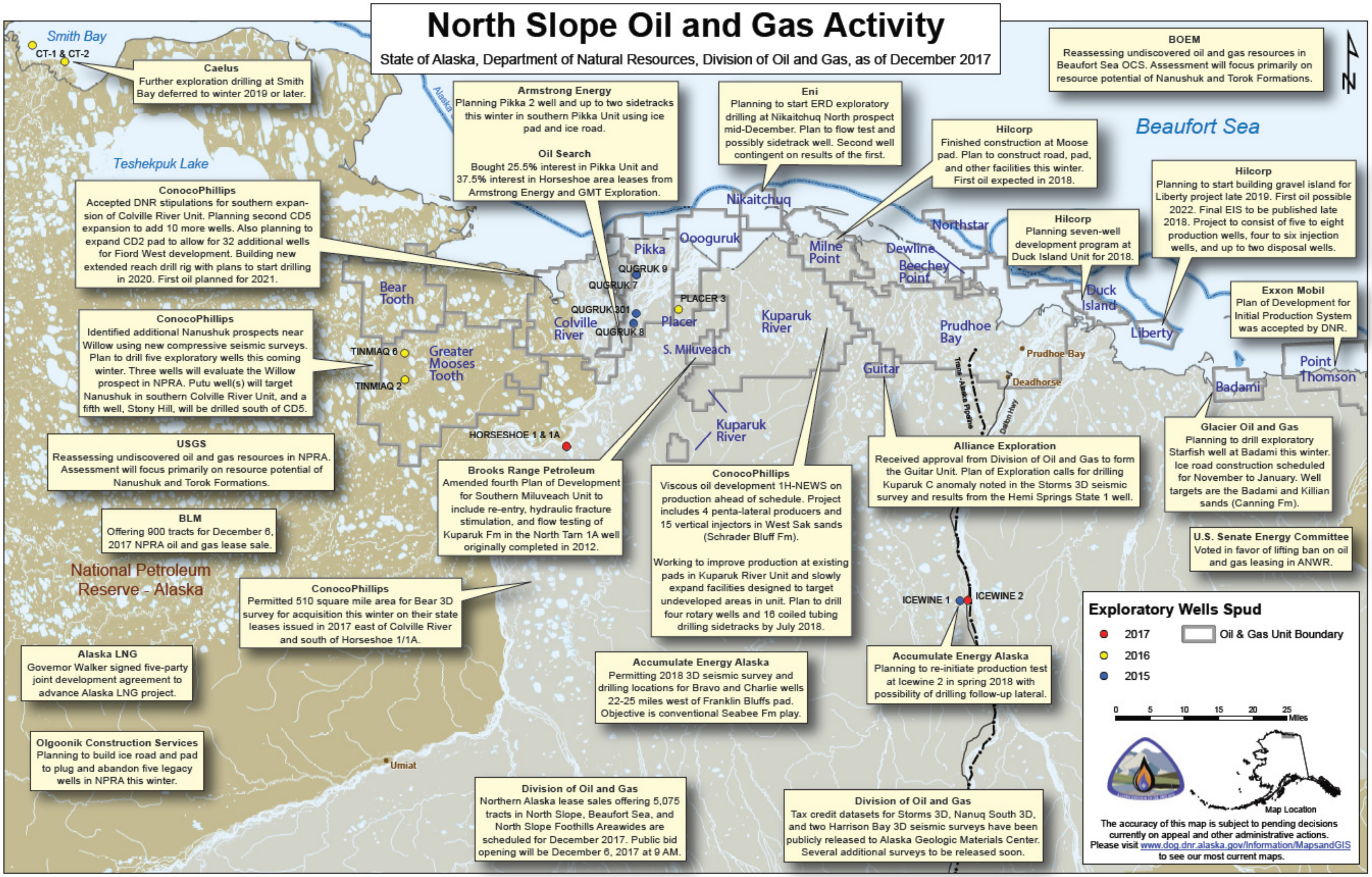
2.3.4 Petroleum

The vast petroleum basins of Alaska's North Slope continue to be developed and maintained, in large part because of the consistent, reliable, and safe overland access provided by the Dalton Highway. Since the opening of the Yukon River Bridge and Dalton Highway, the petroleum-based infrastructure on the North Slope has expanded from Prudhoe Bay east to the Arctic National Wildlife Refuge boundary and westward into NPR-A. The development of producing fields, including Point Thomson, Badami, Liberty, Endicott, Kuparuk, Milne Point, Spy Island, Ooogruk, Mustang, Alpine, and CD-5 within NPR-A, relies on the Dalton Highway. The community of Deadhorse at the northern terminus of the Dalton Highway has become a critical supply point for several villages, including Kaktovik, Nuiqsut, Atquisuk, and Utqiaġvik (formerly known as Barrow).

The most recently available oil and gas activity map from the DNR Division of Oil and Gas depicts many of these North Slope units and activities, as shown on Figure 2-12. These activity maps are updated periodically throughout the year. The North Slope oil production in State FY 2017 was about 3 percent higher than the year before.[87]

[87] First National Bank. 2017. *Alaska's Economy*, Volume 5. Prepared by Scott Goldsmith, Professor Emeritus of Economics, Institute of Social and Economic Research at the University of Alaska Anchorage. July 2017. https://www.fnbalaska.com/application/files/1515/0188/9822/9489JULYp3.pdf, accessed August 16, 2017.

Figure 2-12. Alaska Division of Oil and Gas North Slope Oil and Gas Activity, December 2017



Source: DNR, Division of Oil and Gas. Retrieved from: http://dog.dnr.alaska.gov/Documents/Maps/ActivityMaps/NorthSlope/NS_ActivityMap_December2017_KMT.pdf.

Uninterrupted access provided by the Dalton Highway and the Yukon River Bridge is essential for the continued economic operation and planned expansion of the North Slope petroleum fields. Other potential sites in the foothills of the Brooks Range include the Umiat area, as described previously, where DOT&PF is already evaluating a route for an access road. The Yukon Flats Basin, east of the Dalton Highway, is a target for studies of petroleum potential.[88] The Dalton Highway and Yukon River Bridge will continue to be important infrastructure to support petroleum development, not just on the North Slope, but also in Interior Alaska. According to the DNR, of the 53 oil reservoir discoveries identified on the Arctic Slope since 1945, approximately 50 percent (26 reservoirs) in seven fields have begun development and are producing.[89] As of 2004, the cumulative production from these 26 reservoirs is nearly 15,000 million barrels.[90]

Additionally, in 2012, the U.S. Geological Survey (USGS) completed an assessment of undiscovered, technically recoverable oil and gas resources in three source rock units of the North Slope.[91] The USGS found that while some of the oil and gas resources gradually migrated away from the source rock into the conventional accumulations, including the Prudhoe Bay field, continuous resources such as shale oil and shale gas remain trapped within the original source rock. Therefore, these shales likely retain oil and gas that did not migrate. The estimates range from zero to 2 billion barrels of oil and from zero to nearly 80 trillion cubic feet of gas.[92] The USGS continues to analyze the amount of potential source-rock petroleum, preparing a scientific investigation report as recently as 2016.[93] Further exploration and development of resources like these—such as employing subsurface fracking—would likely continue to rely heavily on the Dalton Highway corridor (and Yukon River Bridge). Furthermore, the Alaska Oil and Gas Conservation Commission has completed an extensive rulemaking process and has developed regulations governing hydraulic fracturing for conventional oil, gas, and geothermal development in anticipation of increased interest in this form of petroleum development.

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[88] Reifenstuhl, R.R. 2006. *Yukon Flats basin, Alaska: Reservoir characterization study*: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2006-1. http://dggs.alaska.gov/webpubs/dggs/ri/text/ri2006_001.pdf, accessed August 16, 2017.

[89] DNR. 2004. *The Historical Resource and Recovery Growth in Developed Fields on the Arctic Slope of Alaska.* Prepared by Jack Hartz, DNR Division of Oil & Gas; Paul Decker, DNR Division of Oil and Gas; Julie Houle, DNR Division of Oil and Gas; and Bob Swenson, DNR Division of Geologic and Geophysical Surveys. http://dog.dnr.alaska.gov/ResourceEvaluation/Documents/Resource_and_Recovery_Abstract.pdf, accessed December 15, 2016.

[90] DNR. 2004. *The Historical Resource and Recovery Growth in Developed Fields on the Arctic Slope of Alaska.* Prepared by Jack Hartz, DNR Division of Oil & Gas; Paul Decker, DNR Division of Oil and Gas; Julie Houle, DNR Division of Oil and Gas; and Bob Swenson, DNR Division of Geologic and Geophysical Surveys.

[91] USGS. 2012. *Assessment of Potential Oil and Gas Resources in Source Rocks of the Alaska North Slope, 2012. Fact Sheet 2012-3013*. February 2012. http://pubs.usgs.gov/fs/2012/3013/pdf/fs2012-3013.pdf, accessed August 18, 2016.

[92] USGS. 2012. *Assessment of Potential Oil and Gas Resources in Source Rocks of the Alaska North Slope, 2012. Fact Sheet 2012-3013*. February 2012.

[93] USGS. 2016. *Modified method for estimating petroleum source-rock potential using wireline logs, with application to the Kingak Shale, Alaska North Slope*: USGS Investigations Report 2016-5001. http://pubs.usgs.gov/sir/2016/5001/sir20165001.pdf, accessed August 18, 2016.

2.3.5 Liquefied Natural Gas

The State of Alaska has sought to export LNG from the North Slope as far back as the 1970s.[94] The effort to commercialize North Slope gas is dynamic, with projects and entities ramping up and slowing down based on market factors and drivers.

A number of proposed LNG projects have the potential to increase usage of the Dalton Highway and the Yukon River crossing. Three such projects include the ASAP project, AKLNG project, and Interior Energy Project (IEP), as described below. The status of these projects is such that none have obtained the regulatory authorizations necessary to begin the construction phase. Therefore, none of these are likely to impact the Dalton Highway and Yukon River crossing in the near term (i.e., next five years). Construction of such facilities and infrastructure would likely temporarily generate a substantial amount of traffic, but after construction traffic volumes would not be significantly altered from the existing volumes.

Alaska Stand Alone Gas Pipeline

The Alaska Gasline Development Corporation (AGDC) was created in 2013 to advance an "Alaska Stand Alone Gas Pipeline." The ASAP is a State-sponsored effort to design a small "bullet line" natural gas pipeline from the North Slope to tidewater in Southcentral Alaska. This project aims to provide natural gas access to as many Alaskan communities as possible along the way, such as Fairbanks, with the goal of distributing affordable, long-term energy to Alaskans. The proposed approximate 730-mile, low-pressure pipeline would run from Prudhoe Bay to Point MacKenzie, with a 30-mile lateral line between the main pipeline and Fairbanks.[95] In 2015, AGDC published revised environmental evaluation documents. More recent efforts entailed the U.S. Army Corps of Engineers (USACE) publishing a Notice of Availability on June 30, 2017, for the draft supplemental EIS; the comment period closed on August 14, 2017.[96] Construction is anticipated to begin in 2019, with gas delivery to communities by 2023.[97]

The location of the proposed ASAP crossing near the Yukon River is depicted on Figure 2-13. The 36-inch natural gas pipeline would be either located on an aerial crossing (a suspension bridge) or installed by horizontal directional drilling at the Yukon River. For either option, the proposed pipeline would be located approximately 1 mile downstream of the existing bridge.

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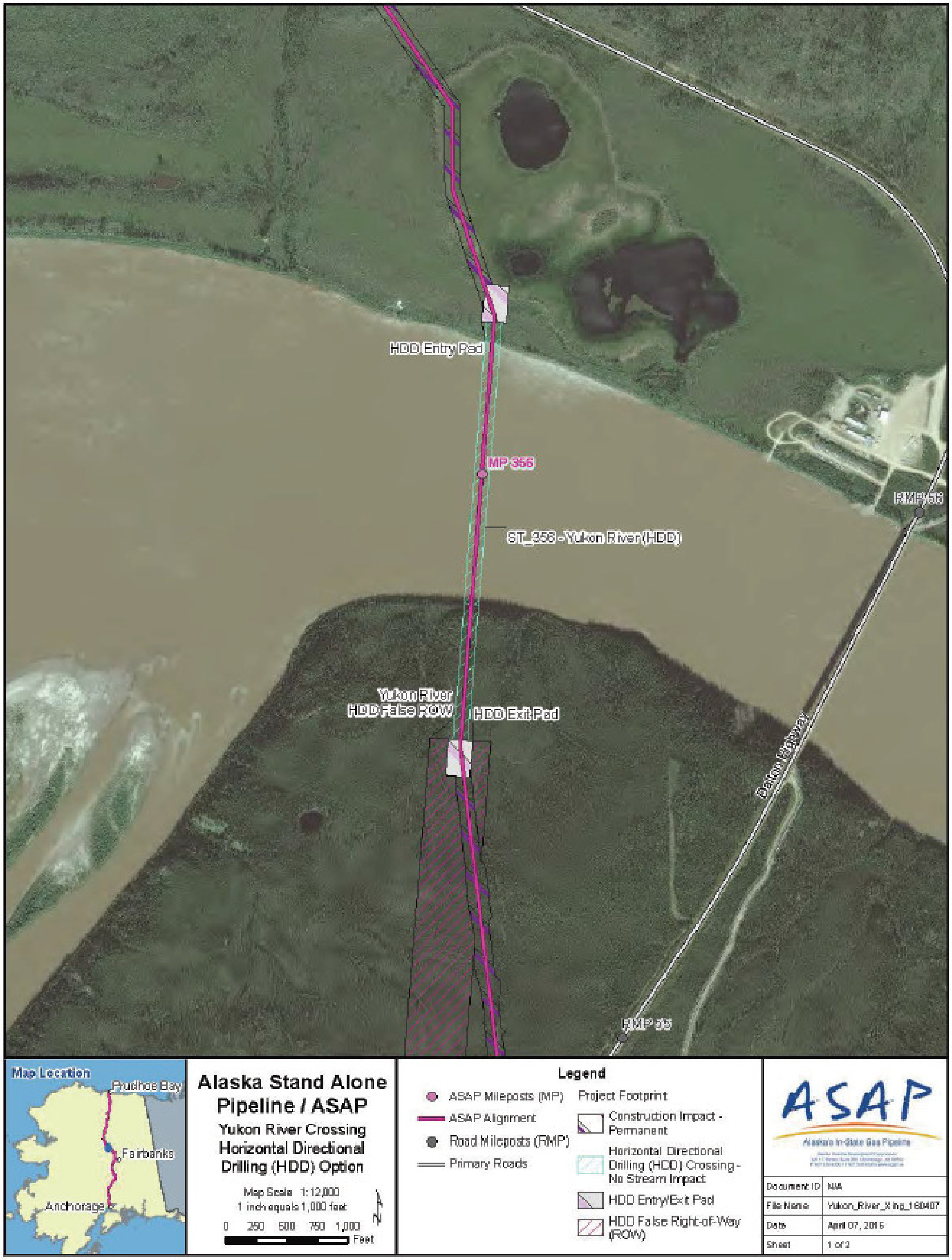
[94] State of Alaska, Office of the Governor. 2015. *Summary Report on the Review of the Alaska LNG Project Process*. September 24, 2015. https://gov.alaska.gov/Walker_media/documents/gasline/20150924_aklng-review-summary-report.pdf, accessed August 18, 2016.
[95] AGDC. 2016. Alaska's In-State Gas Pipeline project webpage. http://asapgas.agdc.us/, accessed August 18, 2016.
[96] USACE. June 30, 2017. Public Notice of Application for Permit and Notice of Availability for Draft Supplemental Environmental Impact Statement. http://www.poa.usace.army.mil/Portals/34/docs/regulatory/publicnotices/POA-2017-06-16,%20MWW_%20PN%20for%20ASAP%20EIS%20and%20Application.pdf?ver=2017-06-21-182213-957, accessed August 16, 2017.
[97] ASAP project website. http://asapgas.agdc.us/index.html, accessed August 16, 2017.

Figure 2-13. Alaska Stand Alone Gas Pipeline Proposed Pipeline Crossing of the Yukon River



Source: Excerpted from *ASAP Draft Supplemental EIS*, AGDC, Figure 2.2-20 Yukon River Crossing Horizontal Directional Drilling Option, June 2017. Retrieved from: http://www.asapeis.com/documents/CompleteASAPDSEISChapters1-8.pdf.

Alaska Liquefied Natural Gas Project

The AKLNG Project is an LNG export project anchored by the Prudhoe Bay and Point Thomson fields and is expected to transport approximately 3.3 billion cubic feet of natural gas per day.[98] This proposed project includes a natural gas conditioning plant and transmission lines connecting the project to gas-producing fields, an 800-mile gas pipeline from the North Slope to Southcentral Alaska, and a natural gas liquefaction plant and storage facilities and associated export terminal located in Nikiski on the Kenai Peninsula.

A number of environmental and socioeconomic resource reports were published in 2015 and 2016 as part of the Pre-Front-End Engineering and Design (Pre-FEED) phase. A socioeconomics resource report published in July 2016 forecasted that AKLNG operations-related AADT on the Dalton Highway would range from a low of 19 vehicles in 2026 to a high of 82 vehicles in 2022–2024, as depicted on Figure 2-14.

Figure 2-14. Alaska Liquefied Natural Gas Project Forecasted Traffic on the Dalton Highway

TABLE 5.4.2-3

Estimated Annual Average Daily Traffic by Route Segment

	2020	2021	2022	2023	2024	2025	2026
Steese/Elliott/Dalton Highways							
Project-related Traffic	50	69	82	82	82	79	19
Estimated Non-Project Daily Traffic on Dalton Highway (MP 339)	160	160	160	160	160	160	160

Source: Excerpted from *Draft Socioeconomics Resource Report No. 5*, Alaska LNG, July 2016.

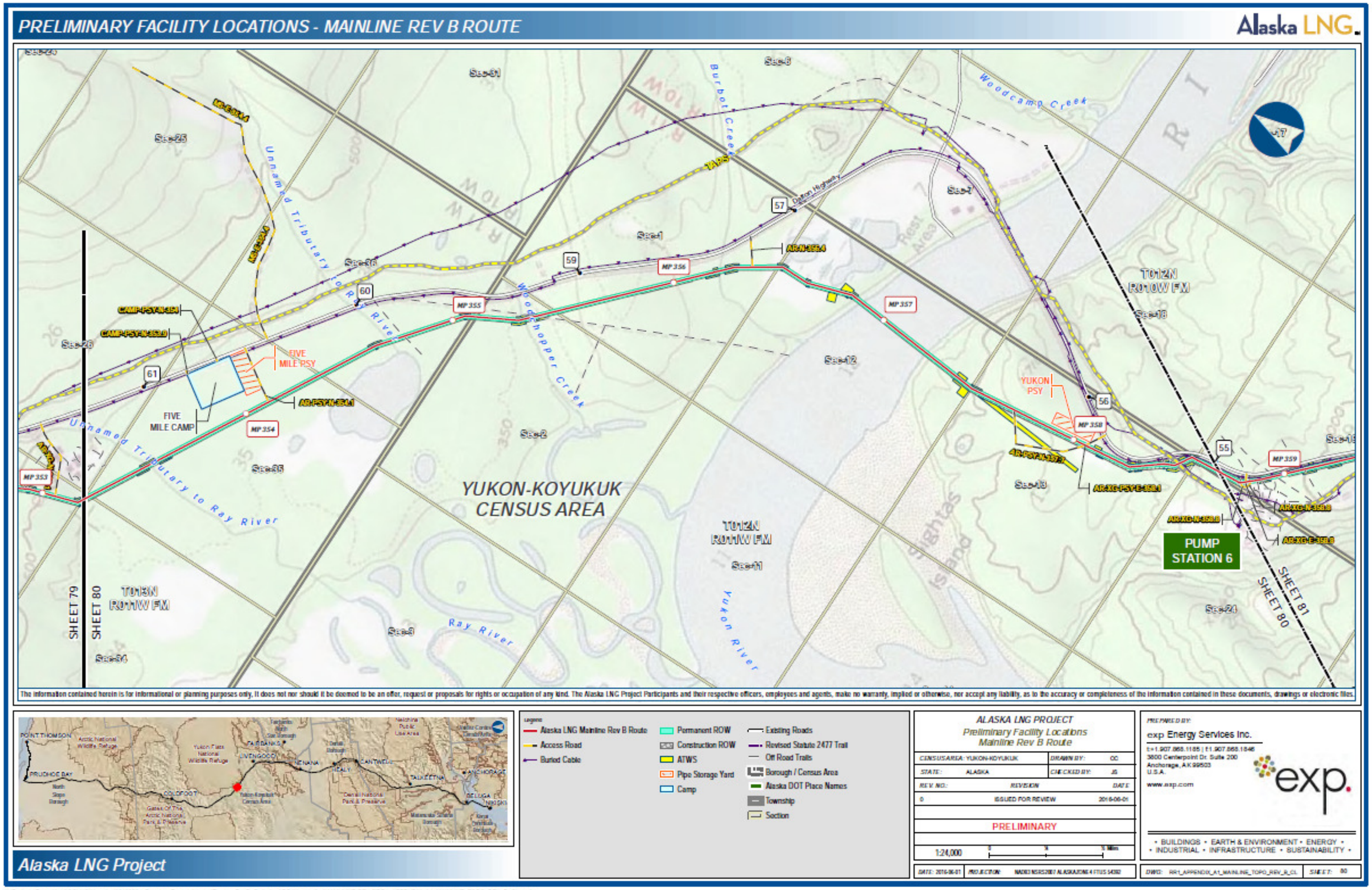
In mid-2016, a proposal was made for AGDC to take the project over from the producers (ExxonMobil, BP, and ConocoPhillips). In early 2017, the project was fully transitioned to AGDC leadership. Approximately $500 million has been invested in data collection, engineering, design, and plan development.[99]

Since the completion of the Pre-FEED phase, the project has slowed down due to lower gas prices and State budget challenges associated with low oil prices. Governor Walker and his administration continue to advance the project and pursue potential customers and partners. On April 17 2017, AGDC submitted a project application to the Federal Energy Regulatory Commission (FERC) pursuant to the Natural Gas Act for "authorization to site, construct and operate an integrated LNG project for the purpose of liquefying supplies of natural gas from Alaska for export in foreign commerce and for in-state deliveries of natural gas." As part of the project application, AGDC anticipates FERC to initiate an EIS to lead to an expedited FERC decision by the end of 2018 for the AKLNG project. Construction is anticipated to begin as early as 2019, with the first LNG production in 2024.

The proposed AKLNG crossing would be west of the highway bridge, as depicted on Figure 2-15.

[98] Alaska LNG. 2016. Alaska LNG project website. http://ak-lng.com/project/overview/, accessed June 14, 2016.
[99] AGDC. 2017. *Alaska Moving Forward: Alaska LNG Project Update.* Presentation made to the Alaska Support Industry Alliance. January 26, 2017. http://alaskaalliance.com/wp-content/uploads/2013/10/012617_-Alliance-Breakfast-AGDC-presentation.pdf, accessed April 26, 2017.

Figure 2-15. AKLNG Proposed Pipeline Crossing of the Yukon River



Source: Excerpted from Draft Resource Report 1, Appendix A – Aerial Imagery and USGS Mapping of Preliminary Facility Locations, Alaska LNG, June 14, 2016. Retrieved from: http://www.kpb.us/images/KPB/MYR/LNG_Project/Resource_Report_No._1_1st_appendix_of_maps-op.pdf.

Interior Energy Project

Led by AIDEA, the IEP is a project designed to bring low-cost energy to as many residents and businesses of Interior Alaska as possible, as quickly as possible.[100] Proposed options were narrowed to sourcing natural gas from Cook Inlet or the North Slope and bringing the product to Fairbanks and the greater Interior Alaska region. In March 2016, AIDEA made the decision to proceed with a company that would supply natural gas from the Cook Inlet region.

AIDEA had initially considered a variety of transportation modes (e.g., rail, truck) for moving LNG. LNG trailers currently in use in Alaska have a capacity of approximately 10,500 gallons each.[101] Within the last few years, AIDEA participated in a pilot study to test LNG trailers. This study involved numerous hauls from Cook Inlet to Fairbanks and from the North Slope to Fairbanks to ascertain deliverability and operability issues with the prototype trailer. While AIDEA's preferred option is currently to ship LNG from the Cook Inlet region, it is possible that the consideration to ship LNG via truck from the North Slope could resurface as no plan has been implemented to date.

2.3.6 Minerals

Alaska's mining industry includes exploration, mine development, and mineral production. The gold-bearing streams in the Slate Creek/Wiseman area and elsewhere along the southern flank of the Brooks Range have been known to exist since the early twentieth century, and limited mining in the area has been ongoing. With the advent of year-round access via the Dalton Highway and Yukon River Bridge, the mining industry in the area has grown, and established communities have developed at Coldfoot and Wiseman and in the area of Linda Creek. The commercial facilities at Coldfoot serve as a supply center for the area, including the community of Bettles, which is dependent on a winter-only snow/ice road.

There are a number of small operations in the vicinity of the Dalton Highway corridor. The closest exploration site near the Yukon River crossing of the Dalton Highway is likely Ucore Rare Metals Inc.'s claims, which are located in the Ray Mountains northwest of the crossing. Ucore is planning expanded exploration for rare earth metals at the site.[102] Ucore states that access to the area is via the Dalton Highway and seasonal barge service along the Yukon River.

According to DNR's most recent *Alaska's Mineral Industry Special Report* (2015), a gold placer mine located near Chandalar—Goldrich Mining Company's "Little Squaw"—is producing gold, having produced 3,800 ounces of fine gold in 2015.[103] In 2016, 8,200 ounces of gold was produced.[104] Infrastructure at the mine includes a 75-person camp, an airstrip, and its own roadway network.[105] While it appears there is no current activity, Silverado Gold Mines Ltd. has historically explored for

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[100] AIDEA. 2016. *Interior Energy Project Quarterly Report to the Alaska State Legislature*. April 5, 2016. http://www.interiorenergyproject.com/Resources%20and%20Documents/IEP%20Q2_2016_Report_Final.pdf, accessed June 14, 2016.

[101] AIDEA. 2016. *Interior Energy Project Quarterly Report to the Alaska State Legislature*. April 5, 2016.

[102] Ucore Rare Metals Ray Mountains project webpage. http://ucore.com/projects/ray-mountains-alaska, accessed December 16, 2016.

[103] Goldrich Mining Company, Chandalar gold district webpage. http://www.goldrichmining.com/chandalar-gold-district/overview.html, accessed March 1, 2018.

[104] DNR, Division of Geological & Geophysical Surveys with Division of Mining, Land & Water. 2015. *Alaska's Mineral Industry 2015, Special Report 71*. http://pubs.dggsalaskagov.us/webpubs/dggs/sr/text/sr071.pdf, accessed December 15, 2016.

[105] Goldrich Mining Company, Chandalar gold district webpage.

gold in the Nolan Creek vicinity, which is located approximately 5 miles northwest of Wiseman.[106] Silverado's site is connected to the Dalton Highway via an access road.

If metals prices increase, interest in the area will continue to develop. As mineral exploration continues along the transportation corridor, there is potential for hard-rock mineral development as well as increased placer activity. As discussed previously, the ongoing AIDEA analysis of access to the copper, zinc, gold, and lead deposits of the Ambler mining district could support road access to these deposits. Rare-earth deposits are present in the Ray River area.[107] Prospecting, development, and production of mineral resources depend on access provided by the Dalton Highway and Yukon River Bridge.

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[106] USGS. Mineral Resources On-Line Spatial Data for Nolan Creek. https://mrdata.usgs.gov/ardf/show-ardf.php?ardf_num=WI101, accessed December 16, 2016.
[107] Freeman, L.K., J.E. Athey, P.S. Lasley, and E.J. Van Oss. 2015. *Alaska's mineral industry 2014*: Alaska Division of Geological & Geophysical Surveys Special Report 70.

Section Highlights

Relationship with Industry and Commercial Stakeholders

- A diverse set of industry and commercial stakeholders – trucking companies, North Slope Oil and Gas operators, and tour companies – rely on the Yukon River Bridge to provide access across the Yukon River.
- Proponents of proposed projects, especially LNG projects, would rely on the Yukon River Bridge to provide access during the construction and operation of such projects.

2.4 Relationship with Industry and Commercial Stakeholders

This section briefly describes several key industry and commercial-related stakeholders who have influence on the Yukon River Bridge study area and future bridge needs. The Yukon River Bridge was constructed to support industrial development on the North Slope, and it remains the only road crossing of the Yukon River today. As such, any proposed improvements or changes to the river crossing would need to address industrial stakeholder needs.

Industry-related stakeholders were sent survey questionnaires seeking information on use of the bridge, importance of the bridge, and impacts and tolerances for shutdowns related to the bridge and Dalton Highway. Returned responses included comments stating that the bridge is a "necessity" for the industry and is the "lifeline" for transporting freight to the North Slope and other activities north of the Yukon River.

Table 2-2 identifies industry and commercial stakeholders and their potential influence on the study area and future project need.

Table 2-2. Issues Identified by Yukon River Bridge Industry and Commercial Stakeholders

Stakeholder	Current Relationship with the Yukon River Bridge	Interest Category	Description of Potential Impacts
Trucking Companies	Direct user	Access	Loss of structure or implementation of load limitations on the structure would cause significant financial distress to the trucking companies.
Alyeska Pipeline Service Company (Alyeska)	Direct user with ownership stake	Access and Pipeline	Loss of structure or any structural degradation could cause significant financial loss to Alyeska due to the pipeline's presence on the bridge. Security of the pipeline is also a concern, as the bridge is a shared facility. Alyeska has facilities north of the Yukon River Bridge that require access across the bridge. Loss of structure or load limitations on the structure could cause financial impacts.
North Slope Oil & Gas Operators	Secondary user	Access	The Yukon River Bridge is the only year-round overland access for goods and services from the Port of Anchorage or Valdez to the North Slope oil fields. Loss of structure or load limitations on the structure would cause significant financial distress to North Slope oil and gas operators.

Stakeholder	Current Relationship with the Yukon River Bridge	Interest Category	Description of Potential Impacts
Tour Operators	Direct user	Access	Loss of structure or load limitations on the structure would cause significant financial distress to tour operators operating north of the Yukon River Bridge.
Alaska Gasline Development Corporation (AGDC)	Potential direct future user and ownership stake	Access and Pipeline	The AGDC-led Alaska Liquefied Natural Gas (AKLNG) and Alaska Stand Alone Pipeline (ASAP) pipeline projects would both utilize a horizontal directional drilling bore under the Yukon River and would not require use of the current or future Yukon River Bridge for supporting the pipeline. If project timing were to change, use of a new Yukon River Bridge would be considered lower risk for the pipeline projects and may be desirable, but at this time construction timelines do not match. At one time, AGDC funds were under consideration for use in concert with FHWA funds to construct a new bridge. Delivery of construction supplies and workers for construction of the AKLNG or ASAP pipelines would require use of the Dalton Highway and Yukon River Bridge and loss of structure or load limitations on the structure would cause financial impact to the project.
Interior Energy Project (IEP)	Potential future direct user	Access	At this time, IEP plans call for Cook Inlet natural gas as the primary supply, with trucking and potential shipment on the Alaska Railroad as the primary means for delivery of natural gas to Interior Alaska users. No impacts related to the Yukon River Bridge are anticipated with the current IEP plan.

Sources: AGDC. *Alaska Stand Alone Pipeline Map Book C.* http://asapgas.agdc.us/maps.html;
AKLNG. *Draft Resource Reports 1 & 10*. http://alaska-lng.com/regulatory-process/resource-reports/;
IEP. http://www.interiorenergyproject.com/resources.html.

Section Highlights

Study Questionnaire Survey Results

- To gauge the need for and feasibility of a new or rehabilitated Yukon River crossing of the Dalton Highway, DOT&PF sent out surveys to more than 200 interested stakeholders.
- More than a dozen surveys were returned, representing tourism companies, transportation-related companies providing services to the North Slope, and area Native allotment holders.
- Respondents in all categories generally felt that the most acceptable alternatives to the bridge crossing, in case of emergency, were ferry and ice road; air transport was the third-most chosen acceptable alternative.
- Tourism and industry respondents indicated that the longest they could tolerate a bridge outage without suffering severe consequences was a few days; one respondent stated that they could possibly manage for up to one month.

2.5 Affected Stakeholders' Input from Study Survey Questionnaires

The majority of the information included in this report was based on a literature review of readily available information. To supplement this data and seek additional industry and area knowledge and input on the needs associated with crossing the Yukon River, DOT&PF distributed a Study survey questionnaire to three main user groups. These included tourism-oriented stakeholders, industry-related stakeholders, nearby Native Allotment holders, and other affected stakeholders. More than 200 separate entities were e-mailed a questionnaire; see Appendix D for the full list of stakeholders. DOT&PF distributed these questionnaires in mid- to late 2016. Responses were received during that timeframe and into early 2018. A total of 17 surveys were returned; refer to Appendix C for returned surveys.

2.5.1 Tourism

DOT&PF distributed surveys to nearly two dozen Fairbanks-based tourism businesses that were identified as having business associated with travel north of the Yukon River. DOT&PF received six completed surveys, primarily from companies that provide vehicle rentals or guided tours. All six respondents provide services during the peak summer season; all but one company indicated they provide services year-round. None reported driver or guide concerns or improvements needed on the existing bridge. Every respondent identified that their business depends on vehicular access across the Yukon River, and could only tolerate bridge closures of days or weeks before suffering severe consequences to their business. In the event of a temporary closure, most respondents indicated that ferry or ice bridge alternatives would suffice.

Tourist businesses expressed confidence in continued interest and growth in travel north of the Yukon River, citing increased growth in independent travelers seeking access to the north, Arctic Circle travel increasing as Fairbanks grows as a tourist destination, and customers from Asia as a rapidly growing market.

2.5.2 Industry

DOT&PF sent surveys to major oil and gas industry and services companies and received five completed surveys. When asked about the need for improvement to the existing bridge, a single user expressed concern regarding the bridge's narrow width and slick surface under wet or icy conditions. The others responded that the bridge served their needs and was a strong component of the road corridor in terms of weight and size restrictions, and advocated for efforts to ensure the bridge's structural integrity. Most of the respondents representing the oil and gas industry and service companies stated that they use the Yukon River Bridge daily on a year-round basis, and anticipated additional industry and vehicle traffic growth should the AKLNG or ASAP projects move forward.

2.5.3 Native Allotment

DOT&PF identified area allotment holders and distributed questionnaires asking about their own or their community's use of the bridge. DOT&PF enlisted the help of the Tanana Chiefs Conference to transmit the survey. DOT&PF received six responses. Respondents typically view the bridge as an important link to hunting, fishing, and other traditional use areas. Rampart, Tanana, and Stevens Village were identified by the respondents as communities whose residents use and depend on the bridge. The area is used by villagers to haul items to the bridge and then transfer to boats destined for other locations along the river. Other villages such as Minto and Koyukuk Village were also cited by one of the native allotment holders, which indicates the Dalton Highway's far-reaching role in providing access to people and cargo. If the bridge were not available, goods would need to be flown in at higher costs.

When asked about the need for changes to the crossing, most respondents cited the need or desire for a new bridge. Safety was identified as driving the need; however, additional details and requests were made, including:

- "Fix the slide [south approach] or move the bridge and return the land back as close as possible to what it was before the pipeline days."
- "Please be careful around the eddy. That is considered a Historical site."
- "It should be rebuilt upriver 1-1 ½ miles."
- "….would not mind if the old south side access was improved and parking available on that side as well."
- "I believe a new structure would be beneficial for decades to come to foster economic development."

In the survey responses, Native stakeholders indicated that expanding access to fishing, hunting, and recreation would have a neutral to negative impact on their communities. Multiple respondents explained that the existing highway and bridge has already had a negative impact with regard to increased access.

To further evaluate and identify the opportunities and challenges associated with Yukon River access, additional community-level information regarding use of the bridge is needed to understand existing use of the boat and vehicle access points at the Yukon River Bridge by rural communities within the Yukon River watershed.

2.5.4 Key Points from Returned Surveys

Table 2-3 summarizes some of the key responses regarding importance of the bridge and future use.

Table 2-3. Summary of Key Points in Returned Surveys

Stakeholder	Importance of Yukon River Bridge (YRB) to stakeholder	Changes in the future and how that might influence the use of the YRB or Dalton Hwy in the vicinity?	General comments
Tourism business/ organization			
A+ Dog Sled Excursions & Tours	The bridge is one of the sites where our tour stops	(No response provided)	No companies saw a need to improve the bridge, but all stated that without the bridge business would suffer or they would no longer be able to operate. Companies generally stated that they could do without the bridge only for a short period of time (generally around 3 days) during the tourist season. Acceptable emergency alternatives included primarily ferry, as well as ice road and pontoon bridge.
Alaska Auto Rental	The bridge provides access for our tourist customers to travel north. It also provides access for hunting customers.	Expect to see an increased volume of visitors to travel across the bridge in the next decade compared to the past decade	
Northern Alaska Tour Co.	Majority of tours go north of the bridge	Anticipate using the bridge more and more heavily	
GoNorth Car and RV Rental	Many renters want to drive north of the bridge	Anticipate no changes	
Premier Alaska Tours	Have seen an increased number of tours heading north	Foresee using the bridge and highway more frequently	
Alaska Outdoor School, LLC	The bridge enables guests to go to the Arctic	Anticipate we will visit the Arctic Circle more	
Industry			
Alaska West Express	Majority of our business involves supplying the North Slope oilfields	Anticipate our use of the bridge will increase over time	Businesses use the bridge anywhere from a few times per year to daily, during all seasons. Industry respondents generally indicated that they could do without the bridge for a few days at most; one respondent stated that a month might be acceptable. Acceptable emergency alternatives included ferry, ice road, pontoon bridge, and air. Types of vehicles used include Class 5 to Class 13 vehicles, semi-tractor/trailers, flatbeds, bulk fuel tankers, straight tankers, and pup and heavy haul trailers.
Alaska Trucking Association	It is the only land link to the North Slope oil fields; the integrity of the bridge needs to be ensured	The number of commercial vehicles should increase if commercial activities increase	
Carlile Transportation Systems	Enables movement of general cargo and fuel along TAPS and to the North Slope	Depending on the Alaska Gas Line Project, we would see an increase in traffic on the bridge	
CPD Alaska, LLC	Enables hauling fuel to customers north of the bridge	Foresee change with market growth north of the bridge	

Stakeholder	Importance of Yukon River Bridge (YRB) to stakeholder	Changes in the future and how that might influence the use of the YRB or Dalton Hwy in the vicinity?	General comments
Colville Transport	Enables hauling fuel to our tank farm in Prudhoe Bay	No response provided, other than a reliable structure across the river is necessary for business operations	
Native Allotment			
Native Allotment for Estate of Harold Greenaway	Provides access across the river, near allotment	Because the bridge is aging, a remodel of the existing bridge or a new bridge would be a good safety measure	All respondents who answered noted that the YRB is “Very” important to personal use activities. All respondents historically use the bridge for access to hunting, fishing, recreation, and traditional use areas; half use it for travel to and from home and employment. Acceptable emergency alternatives included air, ferry, ice road, and a parking/boat landing/staging area on the south side. Most respondents saw expanded access as negative.
Former resident (#1) of Rampart	Provides access to multigenerational family traditional uses, family gatherings, and a small graveyard	Because of safety rumors, it should be rebuilt upriver 1 to 1.5 miles; would not object if the old south side access was improved and parking added	
K’oyitl’otsina, LTD.	Provides access to our villages via water in summer and snowmobile trails in winter	We are looking at an ice road from Allakaket/Alatna to Bettles to access the highway for winter commerce; access to Fairbanks is important	
Stevens Village Tribal Member #1	Use it to access employment, traveling to Pump Six and Fairbanks	New structure would great; safer access for and to the community	
Former resident (#2) of Rampart	Provides access to boat launch and property on north and south sides of river	A new structure would benefit economic development; safety and oil spill prevention are top priorities	
Stevens Village Tribal Member #2	Allows my family easy access to the river, and makes it easier to pick berries and to fish	Fix the slide or move the bridge and return the land as close to pre-pipeline days as possible	

Section Highlights

Existing Transportation Plans

- Proposed infrastructure projects – LNG pipeline, rail, roadways – as described in a number of planning documents prepared by varying departments of the State of Alaska have the potential to affect traffic and use along the Dalton Highway and the Yukon River Bridge.
- Alaska Statewide Long Range Transportation Plan, 2016: This plan identifies the potential need for upgrades to the highway and bridge to support proposed gas pipeline projects.
- Interior Alaska Transportation Plan, 2010: This plan reiterates the need for upgrades to the highway to support gas pipeline construction. The plan recognizes the highway corridor is characterized by tourism growth and costly maintenance.
- Alaska State Rail Plan, November 2016: A relevant goal in this plan is to promote economic development in Alaska. The plan recommends analyzing the need for a rail extension to the North Slope, which may reduce highway maintenance costs.
- Northwest Alaska Transportation Plan, Community Transportation Analysis, 2004: This plan doesn't mention the bridge specifically. The plan mentions two potential road connections extending from the Dalton Highway which would be located south of the bridge. These proposed roads may negligibly divert northbound Dalton Highway traffic away from crossing the bridge.

2.6 Existing Transportation Plans

Existing transportation plans that include the Dalton Highway and Yukon River Bridge were evaluated and needs and problem statements related to the highway and bridge were extracted. The primary element in the transportation plans related to the Yukon River Bridge is the potential for a gas pipeline that could dramatically increase traffic demands during construction on the Dalton Highway and the bridge. Increased tourism was also mentioned, with all primary destinations being located north of the Yukon River crossing.

2.6.1 Alaska Statewide Long Range Transportation Plan, 2016

As of fall 2017, DOT&PF is in the process of updating their Alaska Statewide Long-Range Transportation Plan (LRTP). The previous version, *Let's Get Moving 2030*,[108] identified the Dalton Highway as an NHS route that primarily serves industrial traffic, with some tourist and local traffic. The difficult environment, commercial use, and proposed gas pipeline project(s) would require approximately 100 miles of the Dalton and several bridges, including the Yukon River Bridge, to be upgraded at an estimated cost of $1.5 billion (which includes 25 miles of Elliott Highway work).

2.6.2 Interior Alaska Transportation Plan, 2010

The *Interior Alaska Transportation Plan*[109] (IATP) is a 20-year regional transportation plan developed to guide future DOT&PF investment in transportation projects for Interior Alaska and is a component of the overall LRTP. Figure 2-16 depicts the IATP study area.

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[108] DOT&PF. 2008. *Let's Get Moving 2030*, Alaska Statewide Long Range Transportation Plan. February 2008. http://dot.alaska.gov/stwdplng/areaplans/2030/index.shtml
[109] DOT&PF. 2010. *Interior Alaska Transportation Plan*. November 2010. http://dot.alaska.gov/stwdplng/areaplans/area_regional/iatp.shtml

Figure 2-16. Interior Alaska Transportation Plan Study Area

Source: Excerpted from IATP 2010, Figure 1.

The IATP discusses the Dalton Highway in several sections, but three key themes stand out:

1. Improvements are needed to the Dalton Highway to support gas pipeline construction.
2. Tourism is a growing industry on the Dalton Highway.
3. Maintenance costs for the Dalton Highway are some of the highest in the State due to its remoteness and challenging terrain, relatively primitive construction, and the Yukon River Bridge.

A thorough review of the IATP was conducted and its relevance to the Yukon River Bridge is summarized in Table 2-4.

Table 2-4. 2010 Interior Alaska Transportation Plan Topics Relevant to the Yukon River Bridge

IATP Section	IATP Description	Relevance to the Yukon River Bridge (YRB)
IATP Executive Summary		
Resource and Economic Development Impacts	The possibility of increased access needs for activities such as mining, tourism, and gas pipeline construction are the most pertinent transportation issue currently facing the Interior region.	The YRB, as a component of the Dalton Highway, is a critical link to much of the State's resource development areas, as well as a link for the growing tourist industry in the corridor.
Recommendations and Implementation	The Dalton and Richardson Highways are identified as having the most recommended improvements in the current plan. For the Dalton Highway, most projects identified are classified as short term with a total recommended investment of $310.4 million.	Limited as none of the Statewide Transportation Improvement Program projects identified in the IATP are located near the YRB, although the deferred maintenance line items could include re-decking and other improvements near the YRB. The IATP's statement does reflect recognition of the importance of the Dalton Highway corridor in support of commerce, as well as the high maintenance costs associated with its relatively primitive construction.
Section 1.7 Planning Issues		
Gas Pipeline	Access is a critical component to gas pipeline development plans.	All major gas pipeline routes identified to date utilize the Dalton Highway corridor both for the pipeline routing and support for construction, maintenance, and operation of the gas pipeline. Gas pipeline construction and operation would result in an increase in traffic on the Dalton Highway and across the Yukon River.
Tourism	Increased cultural tourism occurring in areas like Arctic Village/Arctic Circle, Fort Yukon, Yukon River, and Anaktuvuk Pass.	All locations identified for increased cultural tourism require travel across the YRB or by airplane.
3.1 Existing Highway System		
3.1.6 Scenic Byways	The Dalton Highway is a Scenic Byway (MP 0-414, 1/15/1998), with intrinsic qualities of "scenic, natural, historic, cultural, archaeological, and recreational."	Scenic byway status may lead to increased tourism on the route. The intrinsic qualities should also be considered in any design alternatives moving forward.

IATP Section	IATP Description	Relevance to the Yukon River Bridge (YRB)
3.1.7 Waysides and Pullouts	There are 7 public toilets, with an average spacing of 34 miles on the Dalton Highway. The tourist industry recommends a rest stop/public restroom facility every 50 miles.	There is a public wayside near the Yukon River currently, and access should be maintained or the facility relocated if the crossing is moved.
3.1.9 Highway Project History	$148 million of capital project funding has been spent on the Dalton Highway between 1994 (when the State opened the route to the public) and 2006, making it one of the costliest National Highway System routes in Northern Region (the only route more expensive was the Parks Highway at $155 million between 1987 and 2007; the Richardson Highway was third at $117 million between 1987 and 2007).	Preliminary estimates for a new YRB exceed the amount of capital funds spent on the entire Dalton Highway over the 14-year period in the IATP. Depending on the route chosen, costs could exceed the amount of capital funds spent on the entire Northern Region portion of the haul route from Anchorage to Prudhoe (Parks, Elliott, and Dalton Highways) over the 20-year period ($340 million)
3.1.11 Highway Corridor Assessments – Dalton	The largest bridge is the YRB, and it requires redecking approximately every 5-10 years due to length, grade, and heavy truck traffic (tire chains in winter). It is ineligible for federal bridge funding.	Maintaining the bridge surface to handle the heavy truck traffic is cost-prohibitive, and the steep grades present a safety hazard for wintertime truck traffic. Because the bridge is not structurally deficient, however, it is not eligible for federal bridge funding.
3.6 Existing River Transportation System		
3.6.2 Description	Only the Yukon and Tanana Rivers serve barge traffic in the study area. They are generally ice free from mid-May through mid-October. Crowley delivers 150-200 tons of bulk materials to Fort Yukon and about 2,360 tons of fuel annually, utilizing the Yukon River.	Barge service could be an alternative to a second Yukon River crossing with an ice road in the winter; however, shoulder season access could be problematic.
4 Resource and Economic Development Impacts		
4.1 Mineral Industry	None of the active mineral exploration areas mentioned in the IATP would require the YRB for access.	Based on the IATP, the YRB is not critical for mineral exploration growth in Alaska.
4.2.1.5 Oil and Gas Industry Current Conditions – Yukon Flats Basin	Geologic reports indicate deep basins of oil and gas in Stevens Village, Beaver, and Fort Yukon. Doyon, Limited, has conducted exploration in the Yukon Flats area and would require access.	Development of oil and gas fields in the Yukon Flats area would likely increase traffic demands on the Dalton Highway; however, access identified to date would tie in near Livengood and not require the YRB.
4.2.1.8 Potential Gas Lines	Enstar proposed a small-diameter gas pipeline along the Dalton and Parks Highways to increase natural gas supplies to Southcentral Alaska in light of dwindling Cook Inlet gas.	Cook Inlet gas supply forecasts have reversed since the IATP, and Enstar is no longer considering a small-diameter pipeline.
4.2.3 Oil and Gas Industry Potential Access Needs	If a small-diameter “bullet line” (such as the one Enstar proposed) were constructed, the YRB is a logical location for an off-take point to serve down-river villages with natural gas.	If an in-state gas supply is pursued, which has continued to be mentioned with projects like ASAP, the area around the YRB may require further development; this could necessitate improvements to or relocation of the YRB.

IATP Section	IATP Description	Relevance to the Yukon River Bridge (YRB)
4.3.1.2 Alternative Energy – Hydroelectric Power	A preliminary permit has been issued for small water turbine technology on the Yukon River.	Based on limited research, it appears that this technology has been installed in Ruby and Eagle and would have no dependence on the YRB.
4.7.1 Commercial Fishing Current Conditions	Commercial fishing exists on the Yukon River, often as a supplement to subsistence lifestyle. Subsistence fishing and personal use fisheries exist along the river, with personal use fisheries at the YRB.	Design of any improvements or a new Yukon River crossing should take into consideration the important salmon fisheries on the Yukon River, as well as maintain similar access for users to personal fisheries near the existing highway bridge.
5.3 Highway Traffic Forecasts		
5.3.1.3.1 Alaska Natural Gas Pipeline	The proposed pipeline route would generally parallel the Dalton Highway. While the highway has adequate capacity for regional traffic growth, "a surge in construction activity resulting in not only higher truck volumes, but longer and more frequent truck trips, would trigger the need for major infrastructure improvements."	A new gas pipeline paralleling the Dalton Highway would require infrastructure improvements to the entire corridor, likely including the YRB.
5.3.1.3.2 Enstar Gas Pipeline	The most likely route for this pipeline also follows the Dalton Highway, triggering issues similar to those for the Alaska Natural Gas Pipeline.	A new gas pipeline paralleling the Dalton Highway would require infrastructure improvements to the entire corridor, likely including the YRB.
5.3.2 2030 Forecast Traffic Volumes	The Dalton Highway has an annual growth forecast of 0.25%-1.0% (average annual daily traffic [AADT] 2030 of 300–340 vehicles per day).	AADTs on the Dalton Highway will remain well below AADTs of connecting routes such as the Parks Highway.
6.1.2 Roadway Conditions and System Needs		
6.1.2.1 Planned Improvements	The construction of a gas pipeline along the Dalton Highway corridor would result in the greatest near-term impact to the transportation system of any potential resource development, and the anticipated increase in truck traffic would result in a heavy impact on highway operations and existing infrastructure. (NOTE: this topic is also mentioned in Section 6.1.6.2 Dalton Highway corridor assessment)	A new gas pipeline paralleling the Dalton Highway would require infrastructure improvements to the entire corridor, likely including the YRB.
8 Recommendations and Implementation		
8.1.1 Recommended Highway Capital Projects	Table 8-3 identifies priority gas line projects. The Dalton Highway MP 49-90 segment is identified as needing projects to support construction of the natural gas pipeline. The YRB is specifically identified as a chokepoint in the legislative briefing cited.	While the gas pipeline project considered at the time of the IATP has changed, the routing along the Dalton Highway has not. Reconstruction of the Dalton Highway and improvements to the YRB are likely needed in advance of a new gas pipeline project.

IATP Section	IATP Description	Relevance to the Yukon River Bridge (YRB)
8.2.1 Recommended Community Transportation Capital Projects	A proposed Community Transportation Project is to build a road from the Dalton Highway to Stevens Village (Stage 1 – Trail, $500,000 short-term project, Stage 2 – Road, $35 million long-term project) This route has been studied using a Denali Commission grant. (NOTE: This route was also mentioned in Section 3.1.11, Section 3.4.1 [trails], 3.4.2 [oil and gas industry potential access needs].)	Utilizing the proposed Stevens Village access road corridor for a new Yukon River crossing could accomplish the community goal of having road access.

Economic Development Implications

According to the IATP, increased access needs for activities such as mining, tourism, and gas pipeline construction are the most pertinent transportation issues currently facing the Interior region. The Yukon River Bridge, as a component of the Dalton Highway, is a critical link to much of the State's existing and potential resource development areas, as well as a link for the growing tourist industry in the corridor.

While the Yukon River Bridge is not a critical component of any proposed or current mineral development scenarios described in the IATP, it is critical for many proposed oil and gas developments, as described below.

- Geologic reports indicated deep basins of oil and gas in Stevens Village, Beaver, and Fort Yukon, which would require new road access in the vicinity of the Yukon River Bridge.
- All proposed gas pipeline concepts to date require a crossing of the Yukon River in the general vicinity of the highway bridge and would utilize the current crossing for transporting construction equipment and personnel for gas pipeline construction.

Maintenance, Operations, and Capital Expenditures

Between 1994 (when the State opened the Dalton Highway to the public) and 2006, $148 million of capital project funding has been spent on the Dalton Highway. These expenditures make it one of the costliest NHS routes in the State. The only route more expensive was the Parks Highway, at $155 million in capital expenditures between 1987 and 2007. The Richardson Highway ranked third, at $117 million between 1987 and 2007. By comparison, preliminary estimates for a new Yukon River Bridge exceed the amount of capital funds spent on the entire Dalton Highway over the 14-year IATP planning period.

The Yukon River Bridge is the largest bridge on the Dalton Highway, and requires redecking approximately every 5 to 10 years due to length, grade, and heavy truck traffic (tire chains in winter). It is currently ineligible for federal bridge funding because it is not considered structurally deficient.

No Statewide Transportation Improvement Program projects are identified for the Yukon River Bridge area in the plan. However, under priority gas line projects, the Dalton Highway MP 49-90 (the bridge is MP 56) is identified as having needed upgrades to support the gas pipeline construction, with the Yukon River Bridge specifically identified as a chokepoint in a legislative briefing from 2008.[110]

A Community Transportation Capital project was identified in the IATP that proposed a road from the Dalton Highway to Stevens Village (Stage 1 – Trail, $500,000 short-term project, Stage 2 – Road, $35 million long-term project). This route has been studied using a Denali Commission grant. Utilizing the proposed Stevens Village access road corridor for a new Yukon River crossing could accomplish the community goal of having road access.

2.6.3 Alaska State Rail Plan, November 2016

DOT&PF's latest *Alaska State Rail Plan*[111] (ASRP) was submitted to the Federal Railroad Administration for their review and acceptance in early 2017. The ASRP outlines several goals and objectives, but Goal 1, promote economic development in Alaska, is consistent with the purpose of the Dalton Highway and Yukon River Bridge.

The ASRP identified an objective to specifically plan for rail support for AKLNG projects, including addressing both the capability and service area of the existing system as well as prospective rail extensions to support the gas project.

Currently no rail access exists along the Dalton Highway corridor, making the Dalton Highway, and subsequently the Yukon River Bridge, the only year-round overland access in support of LNG development. While the ASRP states that the large quantities of material to be moved would be best supported by rail, an economic analysis of the cost of rail extension needed versus the cost of upgrading the Dalton Highway has not been completed to validate this for areas not currently served by rail.

The draft ASRP outlines several short- and long-term investments and studies, including a recommendation for analysis of a rail extension to the North Slope, presumably in support of the ASRP's Goal 1 (which is to promote economic development in Alaska) (see Figure 2-17).

A rail extension to the North Slope would provide system redundancy for the Dalton Highway, including at the Yukon River crossing, and could significantly reduce the annual maintenance costs on the Parks Highways if commercial goods were put on the railroad at the Port of Anchorage and brought to the North Slope via rail. Dalton Highway maintenance costs may not see the same reduction due to the presence of extensive warm permafrost under and surrounding the highway.

A rail extension could also support increased and safe tourism opportunities in much the same way it operates along the Parks and Seward Highway corridors. Challenges to this rail option include high construction cost (planning level estimate is $7 billion), significantly more limiting design standards to meet with respect to grades and curvature as compared to highways, and the implications of long-term maintenance and operations costs of two facilities.

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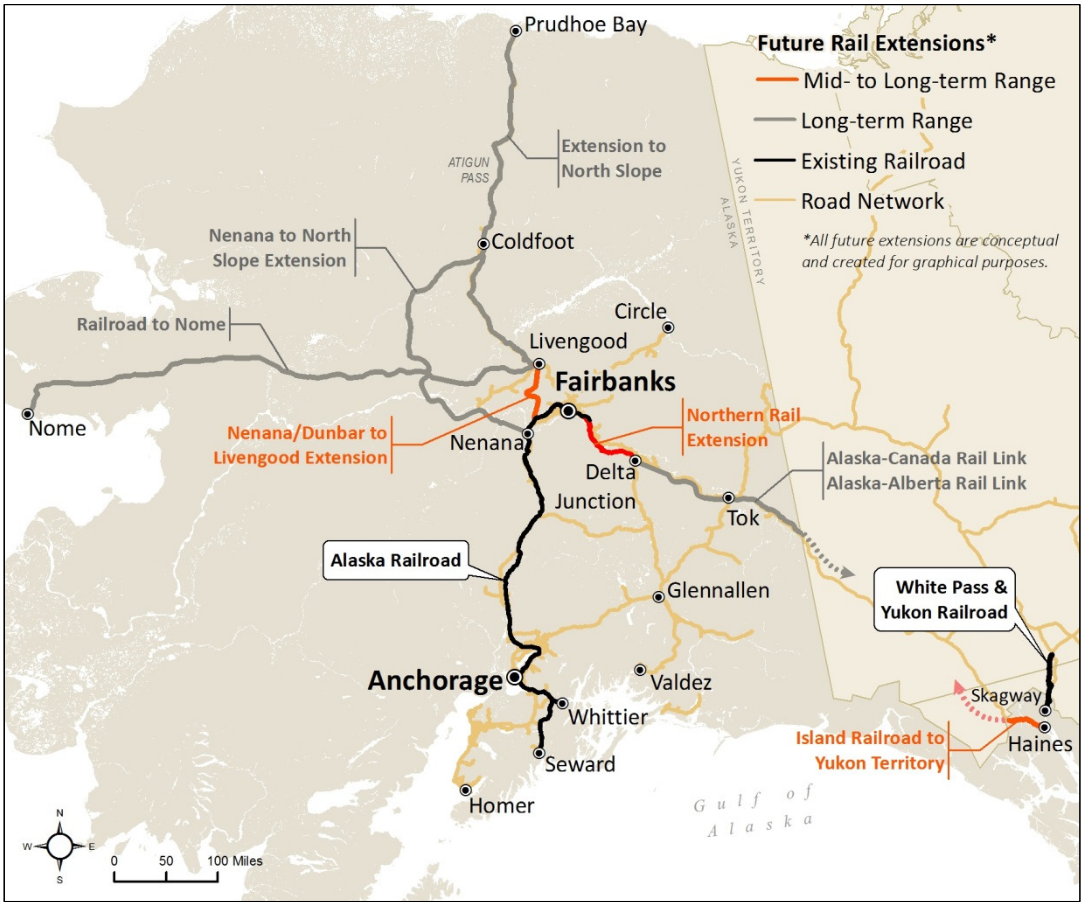
[110] DOT&PF Legislative Briefing, *Gas Pipeline Corridor Prudhoe Bay to Canadian Border*. June 13, 2008.
[111] DOT&PF. 2015. *Alaska State Rail Plan Draft*. November 2015. http://dot.alaska.gov/railplan/index.shtml

Figure 2-17. Alaska State Rail Plan Proposed New Freight Rail Initiatives



Source: Excerpted from the draft Alaska State Rail Plan Figure 5-1, DOT&PF 2015.

2.6.4 Northwest Alaska Transportation Plan, Community Transportation Analysis, 2004

The 2004 *Northwest Alaska Transportation Plan*[112] (NWATP) does not mention the Yukon River Bridge explicitly. The Dalton Highway is the only year-round road connection for the NSB and other Interior Alaska communities. Air service and trails are the predominant transportation modes for most communities in the NWATP boundary, and river access is also mentioned.

One potential new road connection mentioned was the Yukon River Highway. This conceptual road would connect the Seward Peninsula and communities along the Yukon River with the Elliott Highway near Manley Hot Springs. While not a part of the Dalton Highway corridor, this route could serve for some system redundancy, depending on the rest of the needs identified. At the time of the NWATP, the route was being considered for a more formal feasibility study.

[112] DOT&PF. 2004. *Northwest Alaska Transportation Plan*, Community Transportation Analysis. February 2004. http://dot.alaska.gov/stwdplng/areaplans/area_regional/assets/nw/nw_cta_final.pdf

The Stevens Village to Dalton Highway project was also identified in the NWATP, at an estimated cost of $20 million to provide the community all-season surface transportation access to the Dalton Highway for improved fuel, freight, and personal transport.

The DOT&PF is currently kicking off a multi-year effort to update the 2004 NWATP.[113]

[113] https://www.nwatp.org/, accessed October 24, 2017.

Section Highlights

Legislative Intent

- Alaska State Senate Bill (SB) 138, signed into law in 2014, required DOT&PF to consult with AGDC and evaluate the design and construction of a new, separate bridge across the Yukon River. The bridge would accommodate both vehicular traffic and the AKLNG gas pipeline.
- In response to SB 138, DOT&PF prepared a preliminary bridge design memorandum in 2014 that identified three potential second Yukon River crossing locations.
- The DOT&PF is preparing this study partially in response to SB 138.

2.7 Legislative Intent

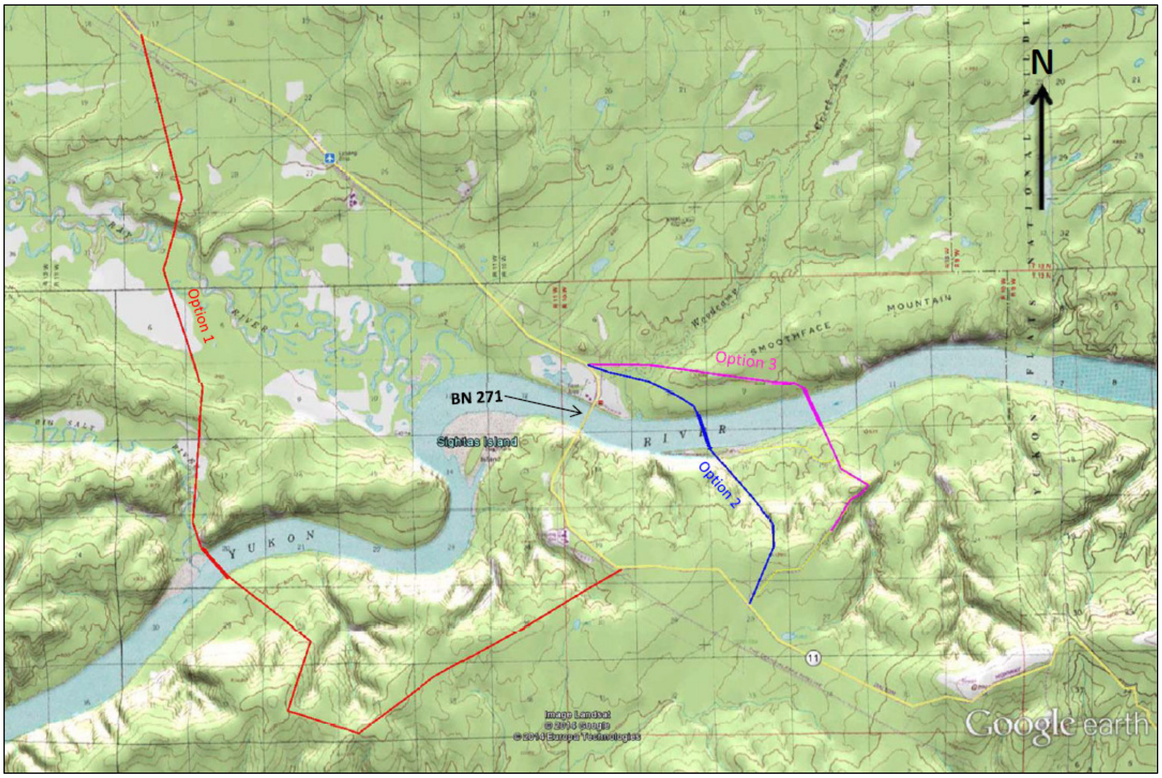
Other than legislation several decades ago naming the Yukon River Bridge the E.L. Patton Bridge, only one recent piece of legislation addresses the Yukon River Bridge directly. SB 138, signed into law on September 19, 2014, requires that DOT&PF, in consultation with AGDC, evaluate the design and construction of a new, separate bridge across the Yukon River that would accommodate both vehicular traffic and a gas pipeline resulting from an AKLNG project. The purpose of SB 138 was ultimately to expand AGDC's authority to include having primary responsibility for developing an AKLNG project on the State's behalf.[114] A copy of SB 138 is included in Appendix A.

Personal communications with Joseph Kemp, P.E., at the State Pipeline Coordinator's Office, indicated that the inclusion of the Yukon River Bridge evaluation in SB 138 was DOT&PF's idea. The Yukon River Bridge had been previously identified as a critical piece of infrastructure that lacked redundancy. Studies conducted by DOT&PF and the State Pipeline Coordinator's Office indicated that the current structure may not be capable of carrying the gas pipeline and the TAPS. This combination of factors led to DOT&PF pursuing evaluation of a second crossing with the goal of leveraging both State of Alaska (via AGDC) and FHWA funding.

A preliminary bridge alternative and cost report memorandum was generated by DOT&PF's Statewide Bridge Section to satisfy SB 138 (see Appendix B). The nine-page memorandum included preliminary analysis of three bridge option locations, as shown on Figure 2-18.

[114] AGDC. AGDC project website. https://www.agdc.us/about.html, accessed August 12, 2016.

Figure 2-18. Preliminary Bridge Crossing Locations



Source: Excerpted from Yukon River Second Crossing preliminary bridge design memorandum between DOT&PF Chief Bridge Engineer Richard Pratt and DOT&PF Commissioner Pat Kemp, May 30, 2014.

Further analysis of a second crossing is being conducted under this Study.

Beyond legislation specifically addressing the Yukon River Bridge and this Study, it is worth noting that several State House and Senate legislative initiatives have been proposed but not passed since at least 2006 to expand the marine highways system to Yukon River communities.

3 EXISTING CONDITION AND LIFE EXPECTANCY OF THE YUKON RIVER BRIDGE

Section Highlights

Existing Yukon River Bridge Conditions

Synopsis: Overall, the bridge is serving its purpose well. As a result of routine maintenance, the bridge is currently in relatively good or satisfactory condition. However, the bridge condition is dependent on frequent maintenance and inspection.

- Age: 42 years (opened in 1975)
- The 6 percent grade meets the minimum geometric requirements; however, the steep grade is one of several factors contributing to the need to redeck the bridge.
- Structure: a six-span continuous steel girder
  - Superstructure: in good condition, with no appreciable decline in 35 years (2016)
  - Substructure: in satisfactory condition, with minimal decline in 35 years (2016)
- Load limitations: The bridge is currently open to legal highway loads and can accommodate relatively heavy overweight loads.
- Bridge deck: orthotropic steel top flange/deck with timber planks
  - The orthotropic deck has protruding parts that prevent vehicles from driving directly on the steel deck surface. Thus, a timber deck with timber running planks was installed so vehicles could drive across.
  - Timber Wearing Surface: in good condition (2016)
  - Timber decking deteriorates quickly and requires frequent replacement. The timber deck requires replacement every 12 to 14 years. The timber running planks require replacement every 6 to 7 years. The running planks were last installed in 2007.
  - Immediately following deck replacement, the deck is in “good” condition, but can drop to an unacceptable condition within 5 to 10 years. When not in “good” condition, the deck presents hazards to vehicles crossing the bridge, such as an uneven or slippery surface and exposed spikes/screws.
  - No other suitable alternative to timber has been identified that would meet the cold climate demands and sufficiently cover the deck.
- Fatigue-prone details: The weldment of the deck rib to floor beam and the weldment of the floor beam to the box girder occur in numerous locations and are known fatigue prone details.
- Fracture Critical Designation: The bridge is classified as fracture critical, which requires field inspection of critical elements every 24 months.
- Bridge Inspection Reporting: The most recent inspection indicates a structurally-sufficient bridge. The 2016 inspection indicates a 7 out of 9 (with zero being failure and 9 representing new construction in good condition) superstructure condition factor. This scoring has been generally consistent since 2000. Wear and rot were observed in the running planks in 2016.
- Current Sufficiency Rating: 93 out of 100 (This value has remained relatively unchanged over the past decade; the value indicates the bridge is serving its purpose well.)

Other

- Underwater inspection of the bridge piers is required and is conducted on a 5-year cycle.
- Additional analysis to assess vulnerability to seismic events is recommended.
- The bridge is designed to accommodate two 4-foot-diameter oil pipelines.

3.1 Existing Bridge Condition

3.1.1 Bridge Structural Description

The Yukon River Bridge is a six-span continuous steel girder bridge, as shown on Figure 3-1. In cross section, the superstructure consists of two rectangular steel box girders with an orthotropic steel top flange/deck. The bridge deck and wearing surfaces are timber planks. Each end span is 320 feet long and the four intermediate spans are each 410 feet long. The typical section is shown on Figure 3-2.

The total out-to-out bridge length is 2,294 feet, 11 inches. The total bridge width is 31 feet measured from outside of deck. The total width between the inside faces of the bridge railing is 30 feet.

The substructure of the bridge consists of steel towers supported on concrete piers and footings. The abutments are founded on driven H-piles, and all but Pier 4 of the piers are founded on rock.

During construction, unexpected variations in the bedrock surface elevation and integrity were identified at the Pier 4 footing location. In order to address the field conditions, driven piles were installed under a portion of the concrete footing, while the remaining portions of the footings are founded on rock. Vertical repositioning of the remaining pier footing was required to accommodate the observed rock elevation at each location.

3.1.2 Load Limitations and Fatigue Prone Details

The bridge is currently posted as "open, no restriction," functioning at/above legal load with a HS-20 design rating factor of 1.1 for Inventory (girder bending) and 2.8 for Operating.[115] The load rating for the bridge is limited by compressive buckling of the bottom flange and web near the splice located approximately 228 feet from the abutment bearings in the first and sixth spans. This load limiting location is near a point of contra flexure in which the dead load moment is slightly positive and live load moment is negative, due to reversal of force effects when the adjacent span is loaded. At this location, the bottom flange and lower portion of the web are unstiffened and are susceptible to elastic compression buckling.

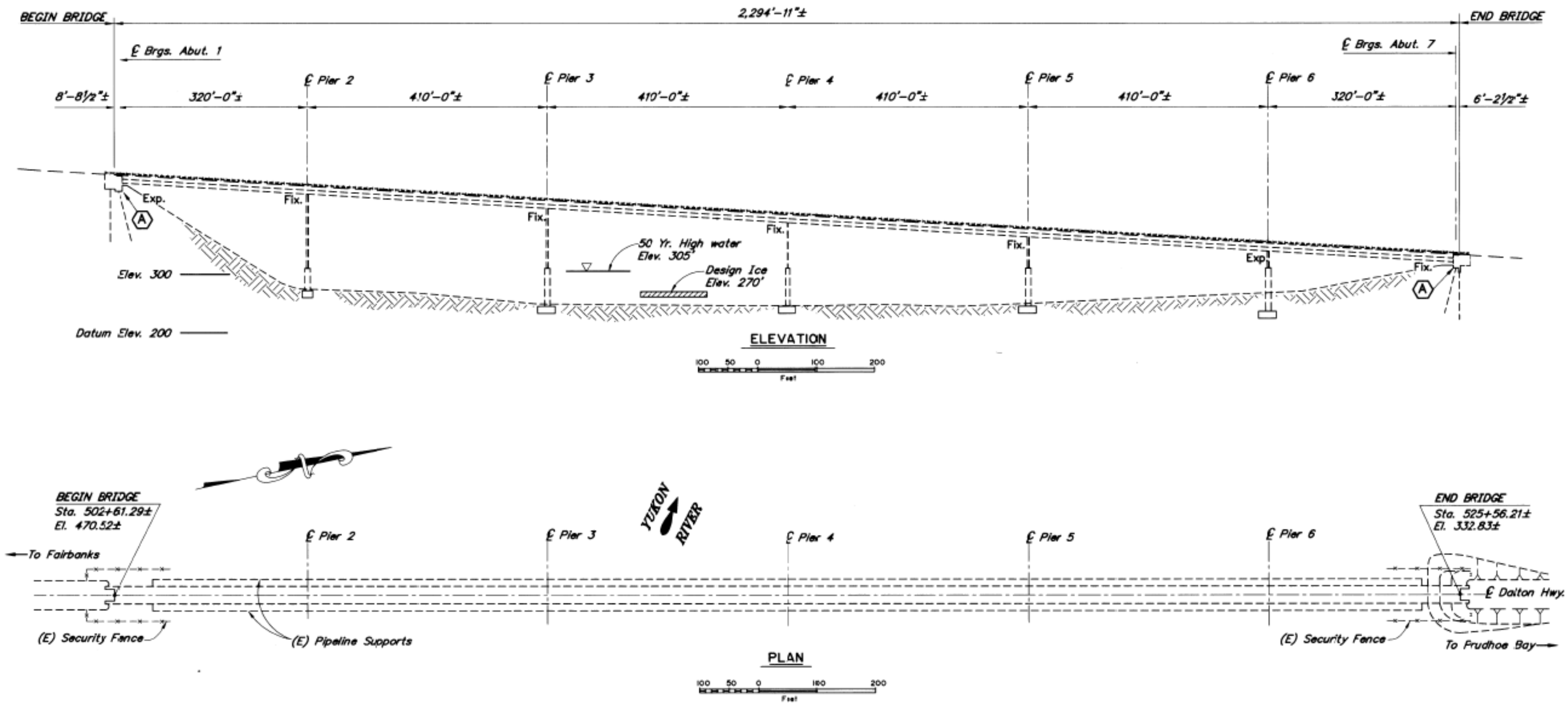
Fatigue Prone Details

Orthotropic steel bridges are sensitive to live-load-induced fatigue cracking. Locations where live load creates tension and compression stress reversals are particularly vulnerable (see Figure 3-3). There have been no significant cracks observed to date, nor has a plan been developed for mitigation or crack repair; however locations known to be prone to fatigue cracking include the following:

- **Weldment of the deck rib to the floor beam.** As wheel loads pass over the floor beam, the floor beam experiences a flexural reversal due to the continuous deck rib rotation. Cracking may occur at the bottom flange deck rib to floor beam connection.
- **Weldment of the floor beam to the box girder.** This location has an intersecting weld with a complex stress field due to flexure, shear, and torsion. As wheel loads pass over the floor beam, the floor beam develops negative bending at the connection to the girder. Also, the floor beams are resisting torsional rotation due to the continuous deck rib rotation. Cracking may initiate in the corner of the floor beam web near the deck plate.

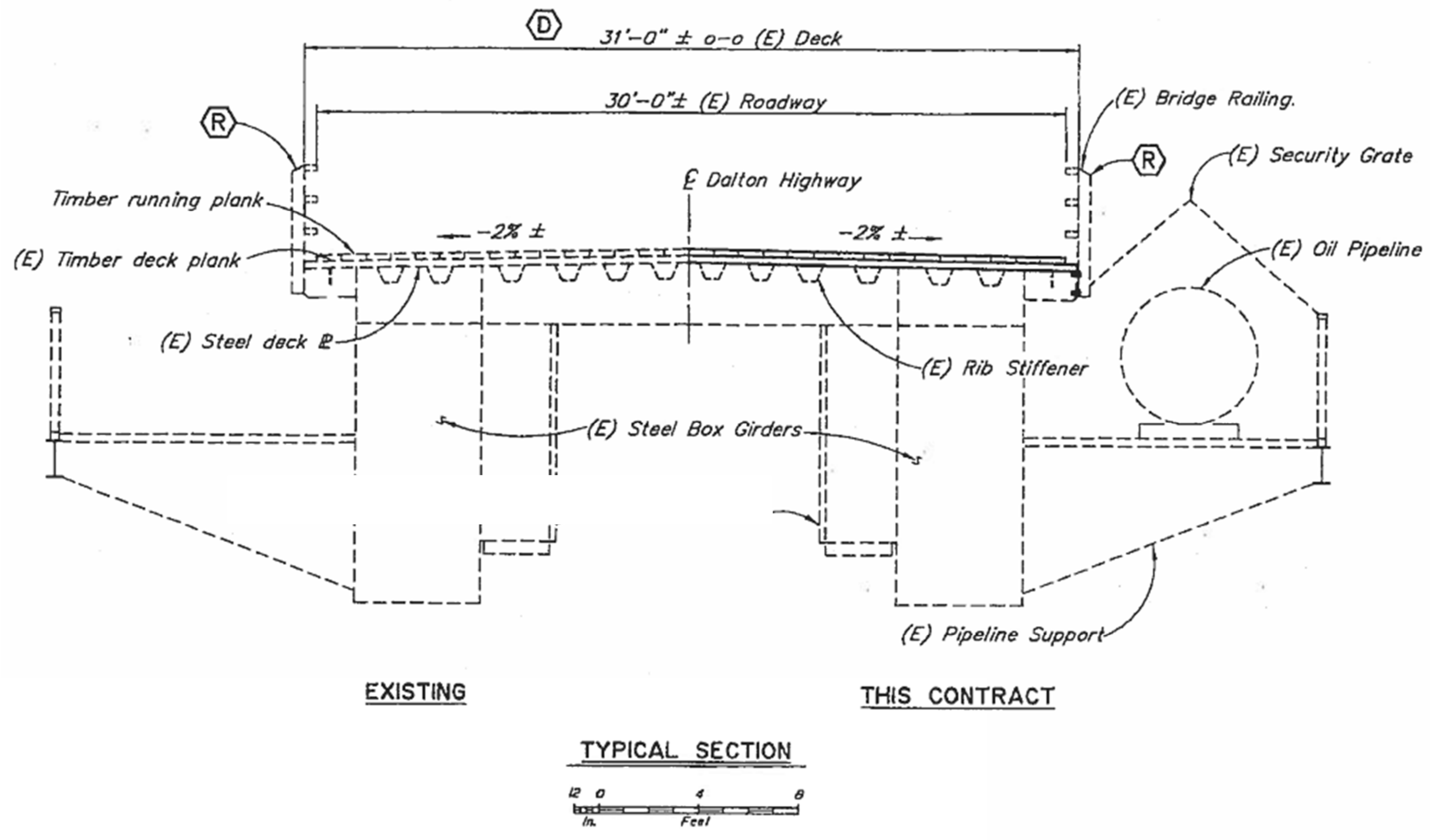
[115] Rating by DOT&PF. Design loading of HS-20 with load rating factors greater than or equal to 1.0 demonstrate that the supporting members of the structure can safely carry all legal loads at the operating level. Permit vehicles require additional analysis.

Figure 3-1. Yukon River Bridge Plan and Profile



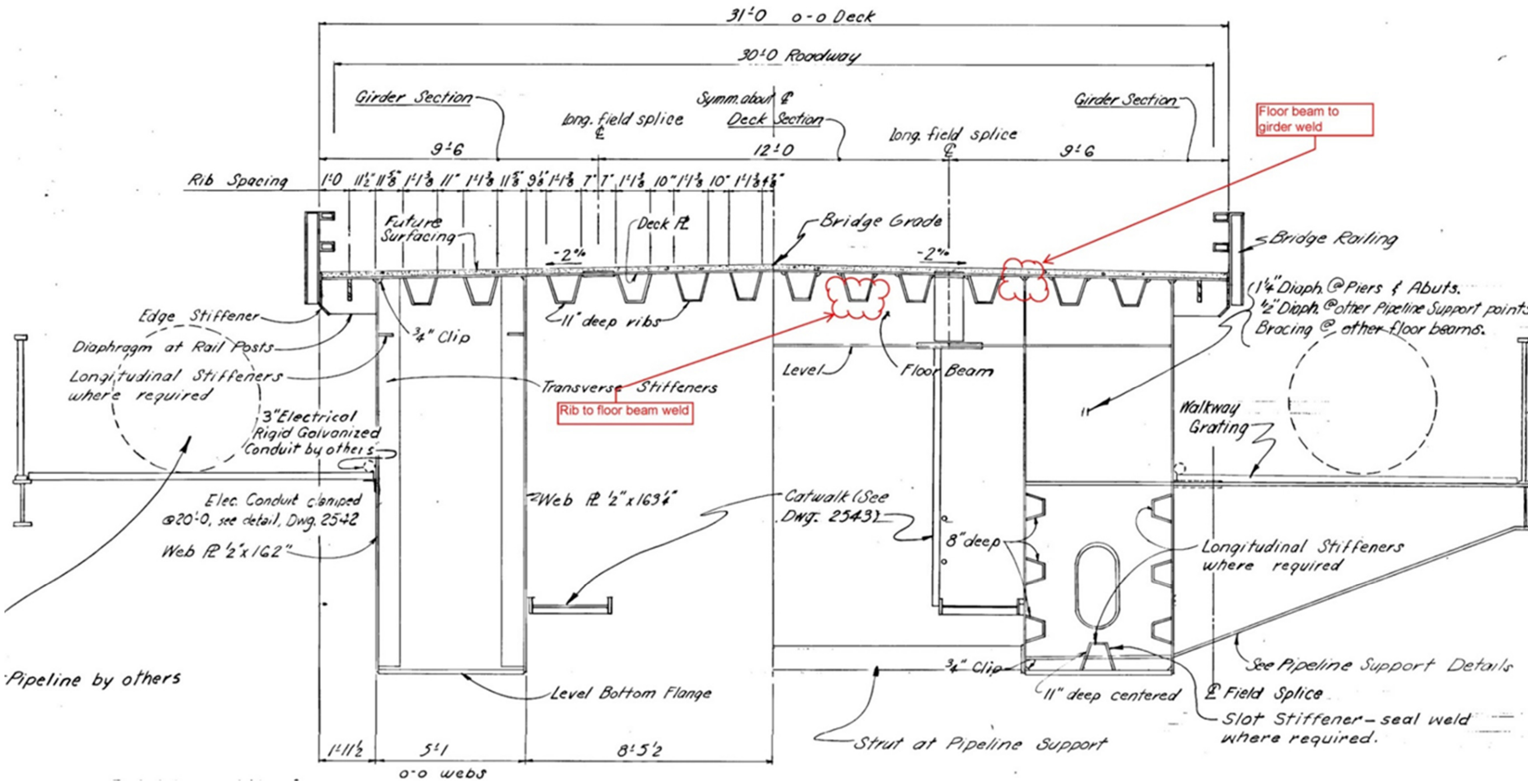
Source: Yukon River Bridge Seismic Retrofit General Layout Plans, Project NH-065-2(13)/60431, 2010.

Figure 3-2. Yukon River Bridge Superstructure Typical Cross Section



Source: Proposed Highway Project NH-065-2(15)/76874 Yukon River Bridge re-decking and bridge rail, As-Built Plans, February 2, 2007.

Figure 3-3. Critical Areas for Inspection of Orthotropic Steel Bridges



Source: Yukon River Bridge Load Rating Summary, January 29, 2013.

3.1.3 Design Criteria

The design criteria for the bridge are provided in the report titled *Designing the Yukon River Bridge,* dated May 1972. The most significant design criteria are summarized in the following sections.

Design Specifications

The 1969 American Association of State Highway Officials (AASHO) (now known as the American Association of State Highway and Transportation Officials [AASHTO]) Standard Specifications for Highway Bridges were used as the basis for the design. At that time, only the Allowable Stress Design (ASD) method was addressed in the code provisions and, consequently, was used for the load combinations, stress calculations, and stress interaction verification. AASHTO currently mandates that new bridge structures be designed in accordance with the Load and Resistance Factor Design (LRFD) methodology.

The two design methodologies differ significantly in their philosophical approaches to bridge design, thus rendering a direct comparison between the two very difficult. ASD utilizes calculated member stresses due to applied loadings and then applies a safety factor to the calculated member capacity, reducing the calculated capacity. LRFD methodology utilizes load factors applied to the calculated loads so these factored loads can then be compared to the member capacity. Variable resistance factors are applied to the calculated capacity, depending on the limit state being investigated. Load and resistance factors were developed based on research and a statistical study considering the probability and frequency of certain load combinations and the consistency and behavior of materials used for construction.

Live Loads

The bridge was designed to accommodate two lanes of HS-20 live loads (approximately 20 percent less than current HL-93 standard). Each steel box girder was designed to accommodate 1.2 lanes of the live load demands to account for the eccentric positioning of live loads on the bridge.

The fatigue loading criteria was based upon 100,000 load cycles of the design HS-20 live load. Because "actual" fatigue loading stresses are of much lower magnitude than the full design live load demands, the number of fatigue cycles used for the design should not be misinterpreted to represent the actual number of times a truck crosses the bridge. For example, if a typical "legal load" truck crossing the bridge results in about half the design live load stress range, the actual number of permissible fatigue cycles may be an order of magnitude or more than the 100,000 cycles used as the basis for the design (the current bridge design specifications include a fatigue loading condition that better correlates to a more realistic number of loading cycles). AADT in 2015 was 294 vehicles per day[116] (as included previously in the traffic volumes discussion in Section 2.2.2), and approximately two-thirds of the traffic at the bridge consisted of trucks.[117]

[116] DOT&PF. 2015 AADT GIS Map.
[117] DOT&PF. 2017. E-mail between DOT&PF Transportation Planner Scott Gordon Vockeroth and Project Manager Lauren Little. May 16, 2017.

Dead Loads

In addition to its self-weight, the bridge was designed to accommodate two 4-foot-diameter oil pipelines and a deck overlay wearing surface. The weight of each pipeline and associated hardware was taken to be 1,500 pounds per foot.

A uniform loading on the deck of 30 pounds per square foot (PSF) was included in the design to address the wearing surface weight. This loading is equivalent to approximately 2.4 inches of asphalt overlay or about 6.5 inches of timber decking. Highway bridges are typically designed to accommodate a 50 PSF wearing surface (i.e., 4 inches of asphalt overlay).

Ice Loads

The uncertainty and magnitude of the Yukon River ice thickness and strength were of great concern to the original bridge design engineers. Measurements of ice thickness and bending strength are noted in the historic bridge records, but no reports prior to the 1971 design were available. Based upon the available information and engineering judgment, two ice load combinations were developed. Both load combinations are based upon an ice thickness of 5 feet applied at an elevation of 270.0 feet. Ice observations collected following bridge construction appear to justify the design ice elevation.

The first load combination applies a concentrated 2,600,000-pound ice force parallel to the longitudinal pier axis at the same time as a 1,300,000-pound force applied perpendicular to the pier. The second load combination applies a 2,600,000-pound ice force oriented perpendicular to the pier with no force acting parallel to the pier.

Based upon the current design code provisions, the effective ice crushing strength used for the Yukon River Bridge would be approximately 30,000 PSF, very nearly the maximum value specified in the code. The two ice load combinations used for this design are similar to, although more severe than, the two load combinations specified in the current code.

Temperature Effects

The design temperature range was taken to be -60° to 100° Fahrenheit (F). The construction installation temperature was assumed to be 20°F. The towers are required to deform along the length of the bridge to accommodate the thermal expansion and contraction of the superstructure. These thermally induced tower deflections result in stresses at the base of all towers except for Pier 6, where the tower is pinned to the pier. Abutment 7 (the downhill, north end of the bridge) is restrained so that each support is required to accommodate an increasingly larger movement proportional to the distance from the abutment. The total thermal movement range at Abutment 1 is approximately 30 inches (total movement ranging from the anticipated extreme cold temperature to the extreme hot temperature).

Wind Loads

Wind records from the region suggested that the design wind speed should be approximately 80 mph. Because there were little reliable data near the bridge site, the design wind speed was conservatively estimated to be 100 mph.

The AASHO Group V load combination addresses wind loads applied simultaneously with other loads. This load combination includes a 40 percent increase in the allowable stress to account for the unlikely situation that peak force effects act concurrently. In a departure from the AASHO bridge specifications, the Group V wind load combination was modified to further account for the unlikely scenario of the design wind occurring simultaneously with the lowest temperature. Specifically, two combinations were introduced:

- 100 percent of the wind loads and 50 percent of the temperature loads
- 100 percent of the temperature loads and 50 percent of the wind loads

The aerodynamic stability of the bridge was examined using numerical techniques. Although wind tunnel testing of models was not performed on the structure, the results of previous studies on bridges shaped similarly were considered. The results of the analysis predicted that vertical oscillations would occur with 70 mph winds and that flutter would occur with 140 mph winds. Although no specific AASHO code requirements existed for the threshold aerodynamic wind speed limits, the proposed values were considered acceptable for the structure. (There have been no wind-induced deformations recorded in the bridge records).

Earthquake Demands

Whereas the 1969 AASHO seismic provisions were based upon a simplistic, singular equivalent lateral load approach, the Yukon River Bridge seismic design is based upon a somewhat more developed methodology. Specifically, elastic seismic acceleration response spectra were developed (by Dr. Nathan Newmark of the University of Illinois) for the bridge site. The designers calculated the effective transverse period of each pier, assuming that each was a single, inverted pendulum. The equivalent seismic acceleration retrieved from the spectra was then multiplied times the pier's dead load reaction to determine an equivalent lateral force demand and resulting shear and moment resultants.

Based upon correspondence with Dr. Newmark, there was some confusion by the design engineers as to the assumed ductility that was included in the response spectra as well as the equivalent damping that should be used for design. Therefore, additional evaluation of the structure's vulnerability to and expected performance during seismic events should be performed using current analysis techniques and seismic hazard maps.

Other Considerations

According to statements made by the design engineer[118], the superstructure was designed to accommodate the failure of one box girder without collapsing the bridge. That is, the flexural and torsional strength of one box girder would be of adequate strength to carry the weight of the entire superstructure section, including the pipeline. Refer to Section 6.2.1 for more discussion on this topic.

3.1.4 Wearing Surface

During the design phase, it was assumed that an epoxy or asphalt overlay material would be used as surfacing on the bridge in a subsequent phase of work. At the time the project was bid, no satisfactory overlay material had been identified, but several were under investigation by the DOT&PF research section.

The orthotropic deck has protruding splice plates and bolts that prevent vehicles from driving directly on the steel surface. Consequently, immediately following the bridge's completion in 1975, a timber deck with timber running planks was installed so that construction equipment could cross the bridge. Timber is lighter than most other decking materials, can deform to accommodate local and global bridge movement, and allows for removal and subsequent inspection of the orthotropic steel deck. On the other hand, the timber wearing surface provides a low coefficient of friction between vehicle tires and the bridge deck for the 6 percent bridge grade and deteriorates quickly under the heavy truck

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[118] Alaska Department of Highways Design Section. 1972. *Designing the Yukon River Bridge.*

traffic. Vehicles with chains for winter driving further deteriorate the timber decking. As noted earlier, the bridge was designed to accommodate a 30 PSF wearing surface, which would be equivalent to 2.4-inch-thick asphalt concrete overlay. The maximum overlay is relatively thin and contributes to three significant concerns. First, the tops of the bolt heads extend approximately 1.25 inches above the top of the deck, leaving relatively little cover over the tops of bolt heads that splice the bridge together. Second, thin overlays tend to debond from the steel plate when subjected to tire and thermal loading. Third, braking forces on the 6 percent bridge grade result in transverse forces that tend to shove and debond the asphalt from the deck.

Numerous research studies and investigations[119,120,121,122] have been undertaken in order to identify an overlay material that can successfully resist the demands in this cold climate without exceeding loading requirements but still provide sufficient cover to protect the deck. To date, no material has been identified, and timber continues to be the preferred wearing surface.

The timber deck and running planks require frequent replacement. Based upon the replacement schedule shown in Section 5.1.1, it is anticipated that the running planks will continue to require replacement on a 6- to 7-year cycle and the underlying timber deck will require replacement on a 12- to 14-year cycle. Additionally, the steel deck will need to be cleaned and repainted with each timber deck replacement.

3.1.5 Fracture Critical Designation

The Yukon River Bridge is classified as "fracture critical." Based upon the FHWA definition, a "fracture critical" element must meet the following criteria:

- The element is made of steel,
- The element is subjected to tension, and
- The failure/fracture of the element would lead to the catastrophic failure of the structure (i.e., the element is "non-redundant").

The fracture critical classification requires that the Yukon River Bridge have special field inspection of all fracture critical elements at a distance no greater than arm's length on a 24-month cycle. Thus, the deck, superstructure, and substructure are routinely inspected every year with a required fracture critical element inspection conducted every two years. The cost of a fracture critical inspection is typically between ten and twenty-five times more expensive –and between two and four times as long to complete than that of the more common "routine inspection" required of non-fracture critical bridges.

The most recent fracture critical inspection available for the bridge was completed in 2017 with no mention of cracks observed.. Refer to Section 3.1.6, which summarizes the information contained in the bridge inspection reports between 1979 and 2016. Figure 3-4 depicts the fracture critical locations, which are indicated by solid lines.

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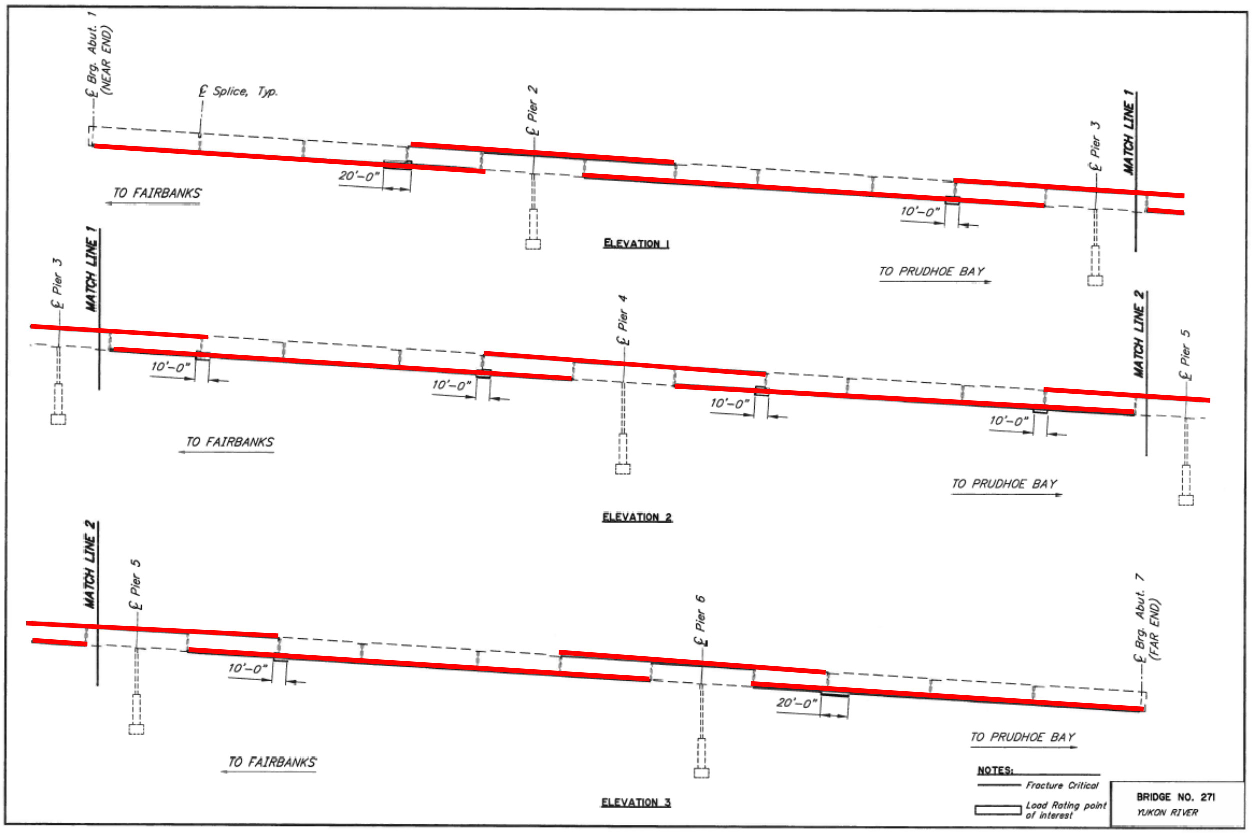
[119] Hulsey, J.L., Ph.D., P.E., S.E.; Richard Ward, and Elliot Anderson. 2015. *Wearing Surface Testing and Screening: Yukon River Bridge.* September 1, 2015.
[120] Hulsey, J.L., Ph.D., P.E., S.E.; Ty Wardell, and Patrick Brandon. 2012. *Wearing Surface Testing: Yukon River Bridge.* December 1, 2012.
[121] Hulsey, J.L., Ph.D., P.E., S.E.; Z. Jerla, and W. Muench. 2009. *Evaluation of Wearing Surfaces for the Yukon River Bridge.* July 1, 2009.
[122] Hulsey, J.L., Ph.D., P.E., S.E.; L. Yang, K. Curtis, and L. Raad 1995. *Yukon River Bridge, Deck Strains and Surfacing Alternatives*, p. 133. September 1995.

Figure 3-4. Yukon River Bridge Fracture Critical Locations



Source: DOT&PF. 2015. Fracture Critical Inspection Report – 8/5–6/2015.

3.1.6 Summary of Previous Bridge Inspections

By FHWA mandate[123], all bridges open to the public must be routinely inspected at intervals not to exceed two years, in accordance with Section 2.3 of the AASHTO Manual.[124] As mentioned previously, because the Yukon River Bridge is classified as fracture critical, it is provided with an additional "fracture critical" inspection on a 24-month cycle that is alternated with a routine inspection.

A bridge is provided with a sufficiency rating based on bridge inspection observations, structural analysis, detour length, average daily traffic, and other considerations. The sufficiency rating is generated by a formula developed by FHWA. The sufficiency rating formula provides a numeric value presented as a percentage in which 100 represents a fully sufficient bridge and 0 (zero) represents an insufficient bridge. The sufficiency rating is used as one consideration in predicting a bridge's capability to remain in service.

In addition to the sufficiency rating, each major component of the bridge (e.g., deck, superstructure, and substructure) is assigned a numeric rating between 0 (failure) and 9 (new construction in good

123 23 Code of Federal Regulations §650, Subpart C.
124 American Association of State Highway and Transportation Officials. 1983. *Manual for Maintenance Inspection of Bridges*, plus subsequent interim changes.

condition).[125] A value of 4 or less classifies a bridge as structurally deficient. Also, a value of 4 suggests that structural impacts are imminent unless corrective action is taken. A value of 3 or less is generally considered to be of significant structural concern.

The Yukon River Bridge inspection reports indicate that the bridge has some minor deficiencies, but it is not considered structurally deficient. Many of the reported bridge defects appear to have occurred as a result of initial construction operations. Recurring problems have been noted with the timber wearing surface and south end expansion joint.

Table 3-1 summarizes the historic condition of the Yukon River Bridge as reported in the routine bridge inspection reports from 1979 through 2016.

Table 3-1. Summary of Yukon River Bridge Inspection Reports and Historic Condition, 1979-2016

Year	Sufficiency Rating	Deck Condition	Superstructure Condition	Substructure Condition	Comment
2016	92.8	7	7	6	Wear and rot noted in the running planks
2014	92.9	7	7	7	
2012	92.7	7	7	7	
2010	93.5	7	7	7	
2008	92.7	7	7	7	New deck in 2007
2006	93.4	7	7	7	
2004	92.5	7	7	7	
2002	80.3	7	7	7	Reversal of the National Bridge Inventory (NBI) appraisal codes back to 7s
2000	80.3	5	5	5	Policy NBI appraisal code changed 7s to 5s
1998	79.8	5	5	5	Policy NBI appraisal code changed 7s to 5s
1996	91.2	6	7	7	
1994	91.1	7	7	7	
1992	87.3	4	7	7	Deck rating likely left over from 1990
1990					Missing NBI data. New timber deck in 1991/1992
1988	79.3	6	7	5	
1986	89.4	7	7	7	
1984	90.5	7	7	7	
1982	90.2	7	7	7	
1980					Missing NBI data; new timber deck in 1981
1979	92.2	8	8	8	First year of condition factor

Source: DOT&PF.

125 FHWA. 1995. Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges. Report No. FHWA-PD-96-001. https://www.fhwa.dot.gov/bridge/mtguide.pdf

3.1.7 Current Bridge Condition Factors

As of March 2018, the bridge was most recently inspected on August 10-11, 2017 during a fracture critical inspection.[126] This section details the existing conditions that were observed during the most recent route inspection, which occurred on July 23, 2016.[127]

Superstructure

The superstructure is in good condition with no appreciable decline in 35 years.

Substructure

The substructure is in satisfactory condition with minimal decline in 35 years.

Deck (Timber Wearing Surface)

Although this bridge has an orthotropic steel deck, the deck rating factor has been assigned based on the condition of the timber deck wearing surface. The timber decking is provided in two layers. The lower layer is mechanically connected (bolted) to the steel deck and covers the steel bolt heads and splice plates. The upper layer is provided as a sacrificial wearing surface and, as such, requires more frequent replacement.

The condition of the deck wearing surface is a function of the most recent deck replacement project. Immediately following deck replacement, the deck has been classified as being in "good" condition, but within 5 to 10 years drops to an unacceptable condition. When not in good condition, the deck presents some hazards to vehicles crossing the bridge. These hazards include an uneven surface on a steep grade, slippery surface, and exposed spikes/screws.

The timber wearing surface was most recently noted as being in good condition with a condition factor of 7; however, damage, rot, and wear were observed in the running planks (installed in 2007).

Hydraulic Adequacy

During the original design, comparatively little information was available regarding the hydraulic characteristics at the bridge site. The design was based on a design flood with a 2 percent annual chance of exceedance in 100 years (Q50[128]). The design was also required to consider a flood with a 0.2 percent annual chance of exceedance in 100 years (Q500).

The design high water (DHW) surface elevation predicted for the Q50 flood event was 305 feet (in terms of the 1973 design datum[129]). The top of the concrete piers is at elevation 310.15 feet, approximately 5 feet above the Q50 DHW elevation. Likewise, the low chord elevation at the north abutment (Abutment 7) is approximately elevation 319.17 feet, about 14 feet above the DHW elevation.

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[126] DOT&PF. 2017. *Fracture Critical Inspection Report.* #0271 Yukon River. 08/10-11/2017. DOT&PF. 2016. *Bridge Inspection Report.* July 23, 2016.
[127] DOT&PF. 2016. *Bridge Inspection Report.* July 23, 2016.
[128] Q50 = The 50-year design flow is defined as the discharge that has a 2 percent chance of being equaled or exceeded during any given year. Note: Q100 = the 100-year design flow is defined as the discharge that has a 1 percent chance of being equaled or exceeded during any given year.
[129] Peratrovich & Nottingham, Inc. 1981. Yukon River Bridge Use Risk Analysis Criteria Development. Prepared for DOT&PF Division of Planning and Programming, Research Section, Fairbanks, Alaska.

The bridge was also designed in consideration with the Standard Project Flood[130], which correlates to the Q500 event. In 1976, the DHW surface elevation associated with the Q500 event was taken to be 321 feet[131]. This water surface elevation is about 11 feet above the top of the concrete piers and about 2 feet above the low chord elevation; that is, the tower legs and bottom of the box girders would be within the waterway during this event. Considering the large amount of debris (e.g., trees) and ice in the river, this situation would be of significant concern.

The above notwithstanding, additional monitoring stations have been added along the Yukon River. Based upon this newer, more comprehensive data set, it has been shown that the original 1973 Q500 flow was significantly overestimated. Using the newest discharge estimate, it is now predicted that the Q500 DWH surface elevation would not exceed the top of the concrete piers.

Current Sufficiency Rating

The most current sufficiency rating is essentially unchanged over the last 10 years and remains around a value of 93 out of 100. This relatively high value indicates that the bridge is serving its purpose well.

Combining inspection information with non-structural considerations such as bridge geometry, average daily traffic, detour length, and waterway adequacy into a "sufficiency rating" may be used as a metric when bridges are compared in a programmatic context. Although no longer used as a funding requirement, previous bridge projects required a sufficiency rating below 80 and a bridge condition factor below 4 to qualify for federal bridge rehabilitation funds.[132] The Yukon River Bridge currently has a sufficiency rating of 93.5 and a minimum condition factor of 7. As such, under the previous funding mechanism, the bridge would not have qualified for rehabilitation funding under the rules of the older transportation authorization.

Live Load Rating

The bridge was designed to accommodate HS-20 live loading (refer to the section on Live Loads, above). Over time, the live load capacity of the bridge is expected to decrease due to wear, corrosion, and damage. As of 2015, the bridge load rating, including the single oil pipeline, values for the primary members (shown below) exceed the design live load.

- **Girder / Orthotropic Deck Bending**
  Inventory HS-21.7
  Operating HS-61.9
- **Girder Shear**
  Inventory HS-56.2
  Operating HS-232

3.1.8 Inspection Access and Limitations

Limited inspection access, combined with the configuration of the bridge structure components, limits the ability to thoroughly conduct an assessment of the bridge and has a corresponding potential to jeopardize the safety of the individual(s) performing the inspection. The orthotropic deck carries "local" tire loads as well as "global" flexural demands. The deck is stiffened with closed, trapezoidal

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130 The volume of streamflow expected to result from the most severe combination of meteorological and hydrologic conditions that are reasonably characteristic of the geographic region involved, excluding extremely rare combinations.
131 See Hydraulic Summary on the second page of the contract bridge plans.
132 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users requirements for Highway Bridge Program funds are available for review at http://www.fhwa.dot.gov/indiv/hbrrpeli.cfm.

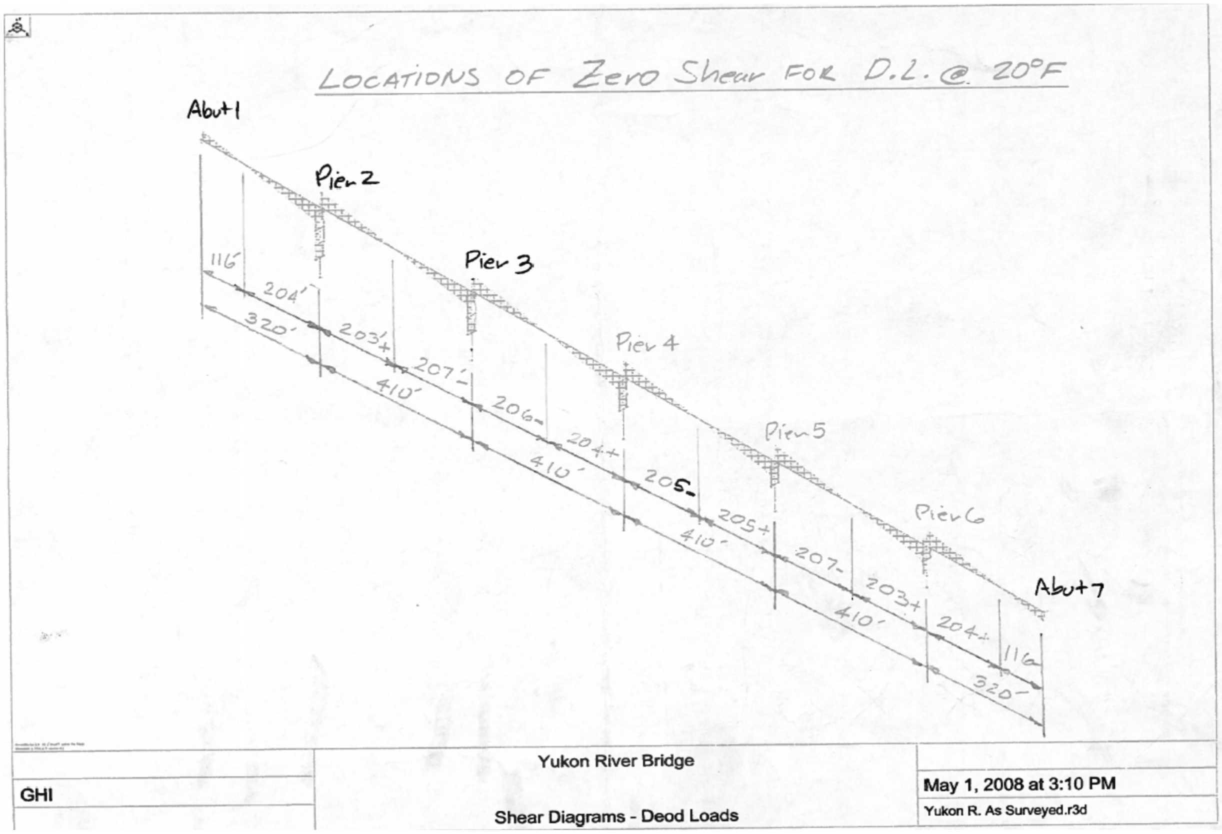
stiffeners that prevent inspection from the underside of the bridge. Furthermore, the timber deck and running planks prevent visual inspection of the steel deck from above. Currently, the steel deck is visually inspected during each full timber deck replacement operation, and portions of the steel deck are inspected less frequently by removing a patch of the timber overlay.

The closed steel box girders are classified as confined spaces and require special authorization, training, and equipment to inspect. Obtaining permission to inspect the box interiors is not problematic, but providing for inspector safety has proved to be a challenge. Specifically, the interior of the box is filled with both diaphragms and open cross frames. These elements require inspectors to climb up ladder rungs, pass through holes, and crawl under framing members to advance the length of the girder. Extracting an inspector from within the box would be extremely challenging and time consuming. Plans have been made for cutting holes in the interior girder webs at points of zero dead load shears nearest a disabled inspector. The locations have been marked on the interior webs of the box girders. Figure 3-5 depicts the interior of a box girder and the confined space. Figure 3-6 depicts the locations of zero shear for dead load (extraction locations).

Figure 3-5. Interior of Box Girder / Confined Space

Source: DOT&PF. 2009. Fracture Critical & Special Inspection Report – 8/14–16/2009.

Figure 3-6. Calculations for Determining Inspector Emergency Extraction Locations



Source: DOT&PF.

Underwater inspection of the bridge piers is also required and is conducted on a 5-year cycle. The relative depth, speed, and opaqueness of the water complicate diver inspection. Consequently, DOT&PF has utilized side scanning sonar inspection in the most recent inspection cycle. Underwater inspection has identified that the footings below Piers 2, 3, 4, and 5 are exposed above the riverbed. The pier footings are anchored to the underlying bedrock with steel post-tensioning bars. Because the foundation is considered to be non-erodible material, corrective action (e.g., riprap blankets over the footings) is not required, but continued observation and monitoring is necessary.

The post-tensioning rock anchor hardware is cast into the concrete footings and covered with concrete "mounds" for added protection. The concrete mounds are visible as the uniformly spaced protrusions on the top surface of the footing in Figure 3-7. Inspection of the post-tension system would be very difficult because the system is contained within the concrete footings and grouted into the underlying bedrock.

Figure 3-7. Image of Side Scanning Sonar Inspection of Yukon River Bridge Pier Footing

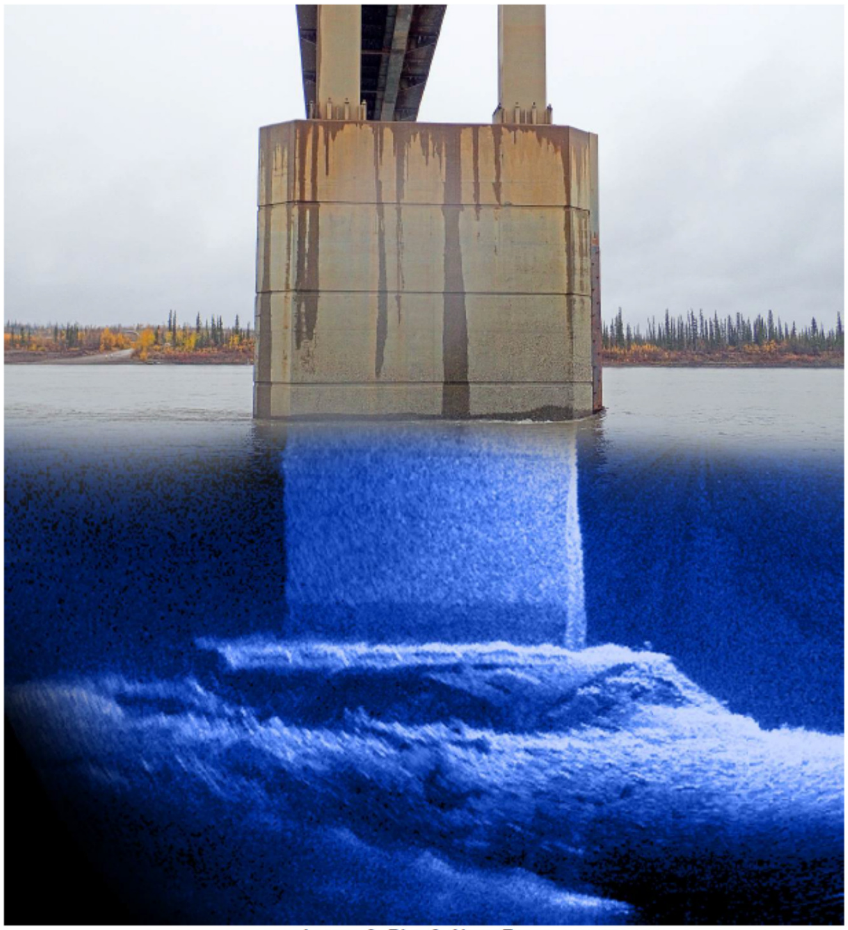


Image 2. Pier 3, Near Face

Image provided by DOT&PF.

3.2 Bridge Life Expectancy

Section Highlights

Yukon River Bridge Predicted Life Expectancy

- The predicted life expectancy is difficult to determine, and there are no well-established industry accepted methodologies for predicting the remaining bridge service life.
    - A gross estimate of bridge life can be derived using several metrics, including bridge inspection reports, sufficiency rating, condition rating, original design life, live load demands, and environmental exposure conditions.
- The bridge condition has been in slow decline over its 42-year life span.
- A "structurally deficient" rating is anticipated sometime between 2035 and 2050, nearly 20 years from now when the bridge would be between 60 and 75 years old.
- The timber wearing surface is the quickest component of the bridge to deteriorate; however, continuous rehabilitation of these parts does not reduce the bridge life expectancy.

3.2.1 Predicted Life Expectancy

The life expectancy of the bridge is difficult to predict. While there is no well-established or industry-accepted algorithm for predicting remaining bridge service life, some metrics exist to provide a gross estimate of bridge life. These measures include bridge inspection reports, sufficiency rating, condition rating, original design life, live load demands, and environmental exposure conditions.

Life Expectancy Based upon Previous Condition Factors

According to inspection reports,[133,134] the superstructure and substructure of the bridge are in good condition, with no appreciable deterioration in 4 decades. The most current ratings classify the bridge as being in "satisfactory" condition. Slow decline has been observed over the 40-year life span of the bridge. Based upon the current rate of deterioration, the bridge is not expected to receive a superstructure or substructure condition factor of 4 (thereby classifying it as "structurally deficient") until sometime between 2035 and 2050.

Based on current inspection reports, the components that are deteriorating the fastest are the exposed surfaces of the timber decking. Figure 3-8 depicts the deterioration of the timber decking. Although the timber wearing surface reaches a condition rating of 4 about every 7 years, provided that the current deck rehabilitation cycle is maintained, the deck is not anticipated to reduce the bridge's life expectancy. Specific components related to the deck members would require more complicated and costly rehabilitation scenarios, but rehabilitation of all bridge components is certainly possible for the bridge and it should reach and likely exceed its 50-year design life.

[133] DOT&PF. 2013. Final Underwater Inspection Report. Yukon River Bridge, Structure 271, Dalton Highway. August 20-21, 2013.
[134] DOT&PF. 2013. Low Water Inspection Report. Yukon River Bridge. May 23, 2013.

Figure 3-8. Yukon River Bridge Timber Deck Repair Maintenance Needs

Figure 1.1 Timber deck repair, a maintenance activity.

Source: Excerpted from *Evaluation of Wearing Surfaces for the Yukon River Bridge, Figure 1.1.* Prepared for DOT&PF Research & Technology by the Alaska University Transportation Center/ University of Alaska, Institute of Northern Engineering. July 2009.

Life Expectancy Based upon Remaining Fatigue Life

Fatigue is the apparent weakening of materials caused by repetitive (cyclic) loading and unloading at stress levels below the yield point of the materials. Fatigue loading may produce progressive and localized structural damage near regions of stress flow discontinuity (e.g., at reentrant corners, weld terminations, holes, and cracks). Cracks may initiate near these discontinuity regions and then propagate under continued loading. Sudden failure of the steel member may occur if these cracks propagate to a critical size.

The formation and propagation of cracks can be eliminated by:

- Reducing the magnitude of the cyclic stresses
- Reducing the number of stress cycles
- A combination of stress and load cycle reduction
- Using details that produce little stress flow discontinuity

The AASHTO Load and Resistance Factor Bridge Design Specifications address fatigue in steel members by defining the design "fatigue load" and permissible fatigue stress limit for various types of stress flow discontinuities (i.e., fatigue-prone details). If the cyclic stress range and number of load cycles generated by the fatigue load are less than the permissible values, then fatigue is not anticipated to be problematic.

The unfactored maximum fatigue stress range generated by the fatigue load on the Yukon River Bridge is approximately 2.9 kilopounds per square inch (1 kilopound = 1,000 pounds). The most restrictive fatigue detail (category E') for an infinite number of fatigue load cycles is 2.6 kilopounds per square inch. Assuming conservatively that the maximum stress occurs at a category E' detail location, then the bridge would be limited to about 38 million fatigue load cycles. Over a 50-year life span with an Average Daily Truck Traffic value of 120 trucks per day and 1.5 load cycles per truck passage, the bridge is predicted to experience less than 4 million cycles.

Fatigue loading is not anticipated to reduce the life expectancy of the bridge.

3.2.2 Structural Integrity

The most recent routine and fracture critical inspection reports[135,136] have not noted significant structural problems. The inspection has individually coded the deck, superstructure, and substructure condition ratings of 7 (good). Damage to the running planks (installed in 2007) was observed, however, and historically, within 5 to 10 years after a timber deck replacement, the deck classification drops from "good," to "unacceptable." As the deck condition degrades, in addition to increased exposure to previously protected structural elements, hazards are presented for vehicles crossing the bridge. These hazards include an uneven surface on a steep grade, slippery surface, and exposed spikes/screws.

The existing bridge is capable of accommodating transport loads for AKLNG construction, provided that the proposed pipeline adheres to the loading condition previously outlined in Section 3.1.3. Refer to Figure 3-2 for a visual of the current pipeline support and the in-place infrastructure to accommodate its mirrored counterpart. If the proposed transport loads exceed the original design load, an additional analysis is necessary to determine whether the current structure has the capacity or if strengthening is required to safely handle the additional load.

3.2.3 Impacts of a Future Pipeline on the Bridge

Reduced Live Load Rating

The Yukon River Bridge was designed to accommodate two oil pipelines. The current load rating is based upon the "as-is" condition with only one oil pipeline, so the load rating is slightly higher than the HS-20 design load. If the second pipeline is added, there will be about 5 percent reduction in inventory and operating rating factors. The inventory rating would remain above the design load, with no restrictions on legal highway loads. Strengthening of the bridge is not anticipated for a second pipeline; refer also to Section 5.2.5.

Change in Seismic Response

The added weight of a second pipeline would increase the bridge superstructure mass by approximately 20 percent. This increase in mass would increase the fundamental period and seismic deformation demand by approximately 10 percent. A 10 percent increase in the seismic deformation demands is not anticipated to significantly reduce the bridge's ability to withstand the design seismic event.

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135 DOT&PF. 2014. Routine Inspect Report, Bridge No. 271. July 15, 2014.
136 DOT&PF. 2017. Fracture Critical Inspection Report. August 8–10, 2017.

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4 TRAFFIC SAFETY AND CAPACITY

Section Highlights

Traffic Safety and Capacity

- Traffic safety
  - The number of crashes in the vicinity of the Yukon River Bridge is not unusual. Available data on the limited number of crashes in the vicinity (n = 3) between 2010 and 2011 showed that ice or water was present on the roadway in all crash instances mentioned in this section.
  - There is not a safe and adequate space to stop on the bridge nor is it encouraged to do so.
  - On the bridge, there are no accommodations for separate pedestrian and cyclist travel.
- Traffic capacity
  - The traffic volumes would have to increase significantly over the current numbers to see a decline in existing level of service (LOS). LOS is a term used to qualitatively describe roadway and intersection traffic operations using “letter grades” ranging from A (best) to F (worst).
  - While an increase in traffic would have to be substantial to effect LOS, an increase in traffic could lead to an increase in crashes.
  - An increase in passenger vehicle traffic could also lead to a higher incidence of passenger vehicle/commercial vehicles accidents.

4.1 Current Safety Concerns

Currently, the grade meets the minimum geometric requirement for grades at 6 percent, which (with a posted speed limit of 50 mph), is based on the type of terrain.[137] However, there are no accommodations for separate pedestrian and cyclist travel.

The expected safety performance of the road is strongly related to its context (e.g., traffic volume, location, design type, or terrain). DOT&PF reports show that there have been two commercial motor vehicle crashes within a 20-mile radius of the Yukon River Bridge since January 2, 2010. A crash at MP 55 involved a tow truck and another one occurred at MP 45.5 that lacked details.

Available information on crashes in the vicinity of the bridge from 2010 to 2011 Alaska State Troopers reports includes three crashes, as reported in Table 4-1.

Table 4-1. Dalton Highway Crashes (in the Yukon River Bridge Vicinity), 2010–2011

ROADNAME	CROSSSTREET	ACCSEVERITY	EVETYPE	EVELOC	WEATHER	SURFACECOND	LIGHT	V1_HUMANCIRC1
DALTON HIGHWAY	MILEPOST 57.8	PROPERTY DAMAGE ONLY	VEH - REAR END	ROADWAY	CLEAR	ICE	DARK - ROADWAY NOT LIGHTED	OTHER*
DALTON HIGHWAY	MP 58.8	NON-INCAPACITATING	DITCH	ROADWAY	CLOUDY	ICE	DARK - ROADWAY NOT LIGHTED	DRIVER INATTENTION
DALTON HIGHWAY	MP 53	FATALITY	RAN OFF ROAD	SHOULDER	CLOUDY	WATER	DAYLIGHT	DROVE OFF ROAD

Source: DOT&PF. July 14, 2017. E-mail between DOT&PF engineer Pamela Golden and Project Manager Lauren Little.

137 Transportation Research Board. 2010. *Highway Capacity Manual*. Fifth edition.

The three crashes included a rear ending, a running into the ditch due to driver inattention, and a vehicle running off the road. The run off the road crash involved a motorcycle and resulted in a fatality. The only notable pattern was that ice or water was present in all three crashes. Winter conditions often require drivers to use chains to cross the bridge; there are few areas near the bridge where a driver can safely stop to put on chains, and the deck geometry makes it difficult to stop on the bridge itself. In terms of safety based on available data, the crash data for the Yukon River Bridge do not indicate unusual crash metrics in terms of frequency, rate, type, or severity compared to other facilities with similar characteristics.

Hazards to vehicles due to poor deck condition, as discussed in Section 3.2.2, are also a consideration for traffic safety due to potential for punctured tires.. As Section 3.1.4 noted, no material has been identified to date that can successfully resist the demands in this cold climate without exceeding loading limitations and timber decking continues to be the preferred wearing surface.

4.2 Dalton Highway Safety

The Haul Road Safety Committee was formed to discuss safety issues along the Dalton Highway. The group is composed of a number of stakeholders, including oil/gas producers, contractors, trucking companies, motor carriers, federal and State agencies, and other users of the roadway. They meet in Fairbanks on a quarterly basis or more frequently if necessary. Meeting minutes from the June 16, 2016, meeting indicated safety concerns about increased numbers of tourists driving the highway and not having the full understanding of the conditions of the remote roadway and limited available services.

4.3 Future Traffic Capacity

The relationship between highway type and appropriate LOS is summarized by criteria for acceptable degrees of congestion. Highways should seek to reach LOS C. LOS D may be fitting to particular conditions; however, this level should be used sparingly. The current AADT count of 294 (in 2015)[138] vehicles would have to increase to more than 1,700 passenger cars per hour (equivalent to a route like the Parks Highway between Fairbanks and Nenana) to have a significant effect on the roadway LOS.

One important measure of the future operating condition of a roadway is the amount of time spent in travel. The current and trending data used to project future use of the Yukon River Bridge structure have not shown reason for significant safety concern in regard to an increase in traffic volume. Where speed and travel time are considered to be an effective tool in defining the LOS of a facility, increased congestion or traffic density increases the chances of collisions with other vehicles in the system. There can be a correlation between decreasing LOS and an increase in vehicle accidents or the nature and severity of accidents, as an increase in traffic congestion affects the ability of drivers to safely maneuver in the traffic stream.

[138] DOT&PF. 2015. Annual Traffic Volume Report, 2013-2015.

5 MAINTENANCE AND OPERATIONS

Section Highlights

Rehabilitation and Maintenance

- The Yukon River Bridge requires more frequent rehabilitation and retrofit than most conventional highway structures. A number of factors contribute to this, including the harsh climate, heavy-loaded vehicles, wintertime chain usage, and the wearing down of the timber running planks and timber deck.
  - The bridge's timber running planks require replacement every 6-7 years.
  - Timber deck requires replacement every 12-14 years.
- Ice loading on the piers has resulted in several rehabilitation projects.
- Modifications have been made to the bridge rail since it was installed, though the rail in its current configuration has not been tested in accordance with industry requirements.
- A Phase I seismic retrofit was performed on the bridge in 2011.
- Near term needs will likely include a Phase II seismic retrofit project and full bridge painting.

Upcoming needs

- Redecking: Assuming "partial redecking" every 7 years, the average cost required to maintain the bridge deck is approximately $350,000 per year (in 2016 dollars).
- Repainting: The bridge paint is in good condition, but is showing early signs of deterioration. A full repainting is anticipated in 10 to 20 years. Approximate cost is $10 million.
- Phase II Seismic Retrofit: A Phase II seismic retrofit may need to be conducted in the future, depending on the magnitude and uncertainty of the seismic demands. Approximate cost is between $10 and $20 million.
- Fatigue Analysis/Evaluation: Currently not anticipated to be a problem, though orthotropic steel bridges are more susceptible to fatigue-related problems than conventional highway bridges.
- Accommodation of oil and gas pipelines/ strengthening the bridge: Should another pipeline be located on the bridge, the need to strengthen the bridge is not anticipated (though this is dependent on other factors). Strengthening the bridge would be impractical for a number of reasons.

5.1 Bridge Rehabilitation and Other Maintenance Work Completed to Date

The Yukon River Bridge has required more frequent rehabilitation and retrofit than most conventional highway structures. Due primarily to the bridge's size and location, the cost of each project is high compared to other structures on the highway system. Timber running planks require replacement on a 6- to 7-year cycle, and the entire timber deck requires replacement on a 12- to 14-year cycle. Ice loading on the piers has resulted in 3 pier armoring rehabilitation projects. A partial list of the most noteworthy bridge projects is discussed in this section.

5.1.1 Replacement of Timber Running Planks and Deck

Due to the harsh environment, heavy loads, wintertime chain usage, and other factors, the timber running planks and deck require relatively frequent repairs and replacement. As noted in the history below, the timber members require replacement about every six to seven years.

- 1975: Timber deck and running planks installed
- 1981: Timber running planks replaced
- 1992: Timber running planks and deck replaced, steel deck repainted
- 1998: Timber running planks replaced
- 2005: Partial deck replacement
- 2007: Timber deck replaced

5.1.2 Pier Nosing Repairs

The leading edge of the concrete piers has been hardened with steel nosing armor. The nosing armor on Pier 4 and Pier 5 have been damaged as a result of ice loads. Damage and repairs occurred as follows:

- 1985: Pier 5 nosing armor damaged due to ice; repairs executed in 1986
- 1997: Pier 4 nosing armor damaged
- 1999: Pier 4 nosing armor repaired

5.1.3 Bridge Rail Retrofit

The bridge was originally designed and constructed with a side-mounted, two-tube metal rail. When the oil pipeline was added in 1976, the two-tube railing was replaced with a three-tube railing to address concerns that errant vehicles may penetrate the rail and contact the pipeline. In 2011, the railing was rehabilitated and strengthened.

The current bridge rail has not been crash tested in accordance with either the National Cooperative Highway Research Program (NCHRP) Report 350 or AASHTO *Manual for Assessing Safety Hardware* (MASH) requirements. Current design practice requires the use of bridge railings and guardrail transitions that have been tested to these standards to ensure vehicular safety.

5.1.4 Phase I Seismic Retrofit

The seismic retrofit of bridges has been classified under two phases. Phase I seismic retrofits address the most vulnerable failure mechanisms, such as unseating of girder supports, the need for transverse and longitudinal restraint, and the replacement of tall rocker bearings. Phase II seismic retrofits address column and footing vulnerabilities, foundation capacity, and liquefiable soils. Phase I seismic retrofits are relatively inexpensive compared to Phase II seismic retrofits, which can be an order of magnitude or greater in cost. Phase I is addressed below and Phase II is addressed in Section 5.2.3.

In 2011, a Phase I seismic retrofit was performed on the bridge. The seismic retrofit included the addition of transverse shear keys at the abutments, timber blocking between the end of the box girders and the abutment backwall at the north abutment (Abutment 1), and strengthening of the ends of the box beams to accommodate longitudinal loading at the backwall-girder interface.

5.2 Anticipated Future Bridge Maintenance Requirements

Future maintenance needs for the Yukon River Bridge are expected to include continued redecking and deck repainting at a cost of approximately $350,000 per year (2016 dollars). Near term needs will likely include a Phase II seismic retrofit project and full bridge painting. Other significant structural rehabilitation in the near term is not anticipated based on the current condition of the bridge. The ability to complete significant structural rehabilitation (versus total replacement) is also limited due to the construction of the current structure.

5.2.1 Redecking

Based on past performance, it is anticipated that the timber running planks (partial redecking) will be replaced on a 5- to 10-year schedule. The underlying timber deck (full redecking) will continue to be replaced with every other running plank replacement project. When the running planks and deck are replaced, the steel deck will be cleaned and repainted to prevent section loss associated with abrasion and corrosion. In 2016 dollars, the construction bid cost of each "partial redecking" project is about $1.5 million, and the cost of each "full redecking" project is about $3 million.

Assuming "partial redecking" every seven years, the average annual cost required to maintain the bridge deck is approximately $350,000 per year (in 2016 dollars).

5.2.2 Repainting

The bridge's paint coating is in good condition, but is showing early signs of deterioration. For example, rust stains at the bolted connections and floor beam openings have been noted in the most recent bridge inspection report. At the current rate of deterioration, it is anticipated that the bridge will need to be repainted in approximately 10 to 20 years.

The bridge is not coated in a lead-based paint or primer. Consequently, a full pressurized containment structure should not be required. On the other hand, the size, location, and height of the bridge above the water may complicate repainting operations.

In 2016 dollars, the anticipated construction bid cost to repaint the bridge superstructure and substructure (excluding painting of the steel deck below the timber wearing members) is approximately $10 million. It is anticipated that the life expectancy of the repainted bridge would be about 50 years.

5.2.3 Phase II Seismic Retrofit

In 2011, the Yukon River Bridge received a Phase I seismic retrofit (refer to Section 5.1.4). The pier legs are not capable of accommodating large, inelastic deformation. Provided that the seismic demands are sufficiently small, tower legs are not anticipated to result in inelastic deformations. Because there is a great amount of uncertainty in earthquake loading, a Phase II retrofit of the bridge may be required. For example, if the seismic deformation demands result in stress greater than yield, the towers may require stiffening to prevent local plate buckling (buckling may result in pier instability and collapse).

Phase II retrofit of the tower legs is complicated. Limited access to the interior of the tower legs and the use of closed stiffeners make the addition of stiffeners impractical. Likewise, filling the tower legs with concrete would not stiffen the areas behind the trapezoidal stiffeners and would add significant weight to the piers. The addition of external cover plates may be feasible, but will be complicated by the cross frames, bolted connections, and other geometric features on the exterior surfaces of the towers.

The construction cost of a Phase II seismic retrofit of the Yukon River Bridge is difficult to estimate without a refined structural analysis. Based upon the Phase II seismic retrofit of other large bridges in Alaska (e.g., the Sitka Harbor Bridge and the Million Dollar Bridge), the anticipated construction cost of a Phase II retrofit of the Yukon River Bridge would be between $10 and $20 million.

5.2.4 Fatigue Analysis and Evaluation

Based upon the magnitude and frequency of live loads, fatigue is not anticipated to be a problem unless cracks initiate, at which point it could quickly become a significant problem. Orthotropic steel bridges are more susceptible to fatigue-related problems than are conventional highway bridges. An inspection of fracture critical elements on a 24-month cycle will be required for the life of the bridge (see Section 3.2.1 for more discussion on life expectancy).

5.2.5 Difficulty in Strengthening the Bridge

The Yukon River Bridge (super and substructure, and foundation) is designed to accommodate two oil pipelines. With the addition of a second oil pipeline, the live load capacity of the bridge is expected to remain above the HS-20 design live load. Consequently, strengthening of the bridge is not anticipated.

The above notwithstanding, strengthening of the bridge may be required if cracks are found, the steel members are damaged, measureable corrosion occurs, or heavy future dead loads (e.g., wearing surface overlay or third pipeline) are added. Strengthening the bridge would be difficult due to the numerous stiffeners, bolted connections, splice plates, harsh environment, and limited access. Further, field welding to the existing steel would be complicated due to the unusual type of steel used in the girders, irregular geometry, limited access, cold temperatures, and introduction of additional fatigue-prone features. Strengthening the existing bridge would be both technically and economically impractical.

The current load rating is based upon as-is condition. Future load ratings will be reduced by the addition of dead load(s) (e.g. a gas pipeline, heavier wearing surface, etc.) and future deterioration of structural components (if not repaired). At least twice in the past, developers have considered the addition of a gas pipeline. Should another pipeline (natural gas) be added, likely on the downstream side of the bridge, it was calculated that the live load rating would be decreased by about 5 percent with its addition. A reduction in operating rating (the maximum load allowed on the bridge) would occur, but less so than for the inventory condition (the regular day to day loads allowed for the bridge).

Orthotropic Deck

Covering the deck with timber distributes the loads over a greater area, thereby decreasing the local deck stresses. Retaining the timber surface may help ensure that the deck does not become a strength or fatigue problem. On the other hand, the trapezoidal stiffeners below the deck and the timber wearing surface above the deck obstruct visual inspection. When the timber deck was fully replaced previously, the steel deck was exposed and inspected. Some section loss (e.g., pitting due to abrasion between timber and steel decking) of the deck has been observed and would be anticipated to continue until a satisfactory substitute for the timber wearing surface is installed. At this time, the section loss in the steel deck plate does not result in a reduction of bridge strength, but as the thickness of the steel deck plates is reduced, the deck will have less strength and stiffness, leading to a reduction in bridge strength.

Trapezoidal Stiffeners Covering Flanges at High-Stress Locations

External cover plates bolted to the bottom flange may be a feasible means of strengthening the bridge in some locations. If needed, strengthening of the bottom flange would be relatively easy near mid-span, as there are no stiffeners interfering with potential bolt locations. On the other hand, strengthening the bottom flanges near the piers would be very difficult due to the presence of the stiffeners, bearings, diaphragms, and other obstructions.

The trapezoidal stiffeners below the deck are provided with bolt and inspection access holes. These access holes have attracted birds that are nesting in the stiffeners. Bird droppings and water leakage through the bolted deck joints are resulting in corrosion of the top flange plate, trapezoidal stiffeners, and floor beams. Figure 5-1 shows an example of debris on the top flange and stiffener.

Figure 5-1. Debris on Top Flange and Stiffeners on the Yukon River Bridge

Bridge No.	**0271**	Br. Name	**Yukon River**	Date	**07/23/16**
		Inspector	**Arndt / Huse**	Frame	**14**

Leak at FB 19

Source: DOT&PF.

5.3 Dalton Highway Operations and Maintenance Synopsis

The Alaska State Legislature Senate Transportation Standing Committee held an informational hearing on the Dalton Highway on February 26, 2015, that consisted of valuable background information pertaining to operations and maintenance of the Dalton Highway. As of 2015, nearly $800 million of capital work has been completed or will be completed on the Dalton Highway within the next decade.[139] This is indicative of the State's commitment to maintaining access to the North Slope. At the 2015 committee meeting, it was reported the average annual maintenance and operations budget for the highway is between $15 and $20 million.

[139] Alaska State Legislature Senate Transportation Standing Committee. February 26, 2015 meeting minutes. http://www.legis.state.ak.us/basis/get_single_minute.asp?house=S&session=29&comm=TRA&date=20150226&time=1301, accessed August 28, 2017.

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6 BRIDGE FAILURE SCENARIOS, CONSEQUENCES, AND ALTERNATIVES IN EVENT OF FAILURE

Section Highlights

Bridge Failure Consequences

- The consequences of bridge failure would include limited to loss of surface connection access to the North Slope.
- Bridge failure could lead to immediate and severe consequences to the State's economy as a result of loss in oil and gas revenue.
- Failure of the bridge would require an alternative emergency access option.
- In the event of bridge failure, the bridge would be irreparable, as replacing a single span is not feasible for this type of bridge structure.

6.1 Consequence of Failure

The consequences of bridge failure include limited to no surface connection access to the North Slope. This loss of access could have immediate and severe consequences to the State's economy due to the possible loss of oil and gas production, which impacts a variety of taxes, royalties, and revenue. Furthermore, should the North Slope oil field production shut down due to the consequences of pipeline failure at the bridge crossing, the implications would be felt nationally. Based on the amount of oil production loss and the price of oil at the time, a shutdown would cost the State of Alaska millions of dollars per day. A rare shutdown of TAPS in 2011 cost the State of Alaska $18.1 million in oil royalties and taxes daily.[140]Additional consequences may result due to the fact that oil wells that are restarted after shutdown may have poorer performance and production yields.

A risk analysis prepared six years after the bridge opened anticipated other macro-level consequences such as "national energy problems and defense needs."[141] The Peratrovich & Nottingham, Inc. 1981 risk analysis criteria development report cited the Yukon River Bridge crossing as one of the most difficult links to repair if critically damaged.

Failure of a pier tower leg (or both legs) is expected to result in the collapse of the bridge, rendering it unusable. In the event of failure, the bridge would not likely be repairable as replacing a single span is not feasible for this type of structure. Furthermore, the span lengths exceed that of modular truss bridge capability. Failure of the bridge would require an alternative means of crossing the river. Section 6.4 discusses several alternative emergency access options.

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[140] Anchorage Daily News. 2016. *Oil Pipeline shutdown among longest ever*. Published January 10, 2011, updated September 29, 2017. https://www.adn.com/economy/article/oil-pipeline-shutdown-among-longest-ever/2011/01/10/, accessed March 1, 2018.
[141] Peratrovich & Nottingham, Inc. 1981. Yukon River Bridge Use Risk Analysis Criteria Development. Prepared for DOT&PF Division of Planning and Programming, Research Section, Fairbanks, Alaska.

Section Highlights

Bridge Vulnerability

- Fracture Critical Elements: As a fracture critical bridge, failure of the Yukon River Bridge could be sudden and catastrophic without noticeable warning signs. However, the bridge was designed so that one box girder could carry the weight of the entire bridge without collapse. The intent of this design was to provide sufficient reserve strength to prevent sudden failure.
- Fatigue: Fatigue is not anticipated to be an issue.
- Routine maintenance mishaps: Bolt heads located at the deck level could be inadvertently sheared off by snow plows during maintenance events. Therefore, covers over bolt heads are an important component in the selection of surface materials.
- Extreme climate conditions: The bridge is constructed with high-strength steel that is more brittle than other types. Overall, steel is susceptible to increased brittleness under cold temperatures. To address this, a high crack-resistant parameter was specified for the bridge.

6.2 Vulnerabilities

This section identifies and summarizes potential bridge vulnerabilities, including fracture critical elements, fatigue, bolt heads at deck level, and brittle fracture due to the extremely cold climate.

6.2.1 Fracture Critical Elements

Fracture critical bridges are subject to sudden failure without significant "early warning signs" such as large deformations. One such example is the I-35W Mississippi River Bridge in Minneapolis, which was designated a fracture critical bridge. In August 2007, the failure of a single steel gusset plate resulted in the collapse of the bridge. Figure 6-1 shows the I-35W bridge failure. The failure was not preceded by large deformations or other indications of impending failure that would have alerted motorists of the need to evacuate the bridge prior to collapse. Thirteen people were killed and 145 were injured as a result of this failure.

Figure 6-1. Fracture Critical Bridge Failure in Minneapolis

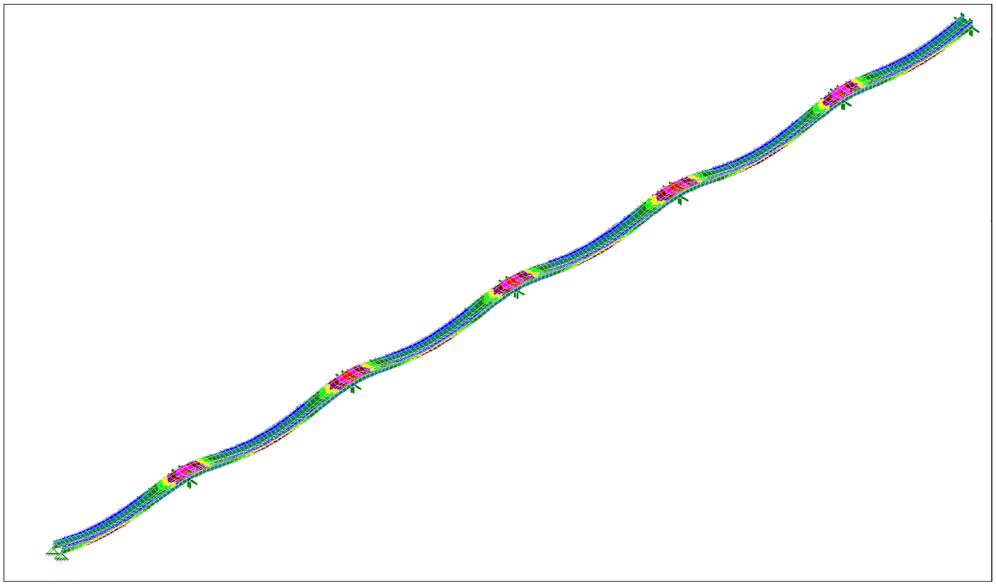
Image provided by DOT&PF.

Like the I-35W fracture critical bridge in Minneapolis, the Yukon River Bridge is classified as a fracture critical bridge. As such, failure could be sudden and catastrophic without noticeable warning signs. Specifically, it is assumed that if one of the two steel box girders was to fracture, the entire Yukon River Bridge would collapse. However, according to the 1972 report, *Designing the Yukon River Bridge*, the bridge was designed so that one box girder can carry the weight of the entire bridge without collapse.

Yukon River Bridge Modeling Results for a Fracture Critical Bridge Failure

Numerical computer models are often created and used to predict stresses and deformations in complex structures. Computer software may be used to model a structure with varying degrees of sophistication, but at the expense of greater modeling effort and computer run time. To examine the design assertion that one box girder would have sufficient capacity to accommodate the full weight of the bridge without collapse, a relatively large but somewhat idealized three-dimensional elastic model of the structure was generated. The computer model, as depicted in Figure 6-2, was comprised of about 3,700 shell elements to model the girders and another 3,700 beam elements to model cross frames, floor beams, and struts. The dead load deflections generated by the model were found to be in good agreement with the contract drawings camber values (i.e., good agreement with stiffness suggests good agreement with stresses).

Figure 6-2. Yukon River Bridge 3-dimensional Elastic Shell Model

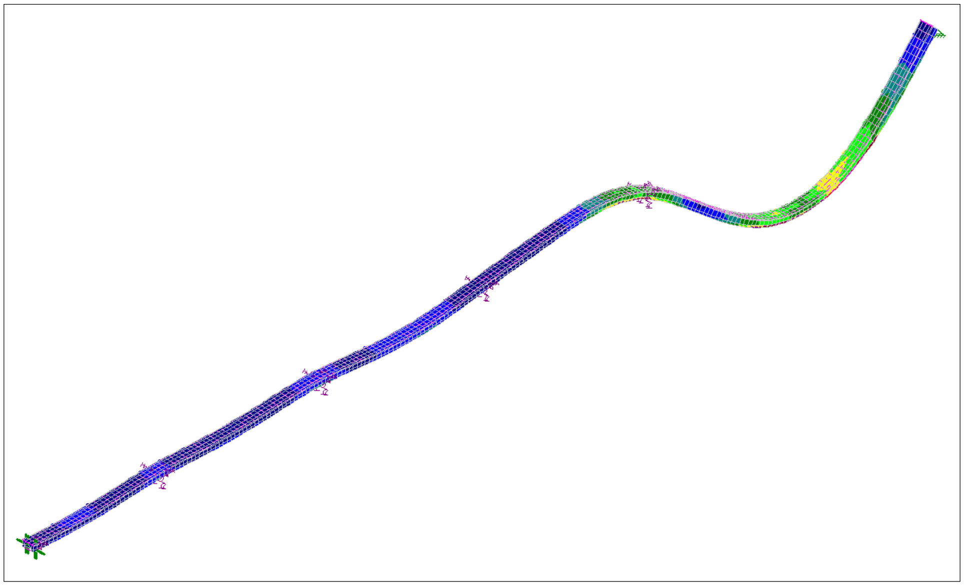


Note: In the 3D model, the dead load deformations were exaggerated 40 times.

Single box girder failure scenario. A 10-foot length of a single box girder (i.e., bottom flange, top flange, and two webs) was removed at high-stress locations. The removal of these segments of a box beam is intended to represent failure (e.g., fracture of the tension flange) of a single box girder. Both scenarios of the current single pipeline and future double pipeline configurations were considered in the model. Segments were removed near mid-span and over intermediate supports at several locations along the length of the bridge. The analysis indicated that the structure remained stable when one box girder was fractured.

Single pier failure scenario. In addition to the failure of a single box girder, the failure of a single pier was examined. Two scenarios were considered. Specifically, (1) the removal of one tower leg, assuming that the remaining leg remained stable, and (2) the removal of an entire pier (i.e., both tower legs). In the first scenario, the removal of a single tower leg support was examined, and the bridge appeared to remain stable. On the other hand, it is unlikely that only one tower leg would fail without overloading the remaining leg. In the second scenario, when both tower legs have failed, bridge collapse was predicted, as illustrated by the exaggerated deformation shown in Figure 6-3. Based on the numerical model, bridge failure is anticipated if one or more pier towers fail.

Figure 6-3. Yukon River Bridge 3-dimensional Model Depicting Bridge Pier Failure



Source: DOT&PF.

6.2.2 Fatigue

Fatigue was described previously in Section 3. Unless Annual Average Daily Truck Traffic increases dramatically (i.e., an order of magnitude increase in truck traffic) as part of future oil or gas production or other industrial development associated with large mine development or similar, fatigue is not anticipated to be a problem or to reduce the bridge's design life. A dramatic increase in traffic as a result of future development plans, as described earlier, is not anticipated.

6.2.3 Bolt Heads at Deck Level

Exposure at the steel deck could be a hazard if a thin overlay were used. For example, snow plow blades may inadvertently shear off the heads of the bolts, thereby disconnecting the bridge segments and possibly leading to catastrophic failure. Consequently, cover over the bolt heads must be considered when wearing surface materials are selected. See Figure 6-4.

Figure 6-4. Splice Plates and Bolts below Timber Wearing Surface

Image from DOT&PF.

6.2.4 Brittle Fracture Due to Extreme Cold Climate

The bridge incorporates high-strength steel (i.e., yield stress of 100,000 pounds per square inch at high stress locations) that is more brittle than milder steels. Furthermore, steel is susceptible to increased brittleness when subjected to cold temperatures. In order to address these issues, a high crack-resistant parameter (i.e., Charpy V-Notch Toughness) was specified for this bridge. Figure 6-5 depicts the V-Notch Toughness requirements.

Figure 6-5. Yukon River Bridge V-notch Toughness Requirements

ASTM Base Metal Designation	Stress in Member	Plate Thickness Range (Inches)	Minimum Charpy V-notch Values @ -50°F. (in Ft.-Lbs.)*	
			Minimum for 1 specimen	Average of 3 Specifmens
A514	Tension	5/16 ≤ 1/2	25	30
		> 1/2 ≤ 1	36	45
		> 1 ≤ 1-1/4	48	60
	Compression	5/16 to 1-1/4	20	--
A537 Grade A	Tension or Compression	1/2 to 1-1/2	28	35

Source: Excerpted from the Yukon River Bridge original construction contract (Special Provisions, p. 64). DOT&PF.

The steel used for this bridge has a higher toughness measure than that required by the current design code. For example, the primary tension elements of the bridge were required to have a Charpy V-Notch Impact Toughness of 60 foot-pounds (ft-lbs) at a temperature of -50ºF, whereas current code requirements are for 35 ft-lbs at -35ºF. Nonetheless, due to the type of bridge and extremely cold climate at the site, brittle fracture is assumed to be a moderate hazard for this bridge.

Figure 6-6. 2016 AASHTO V-notch Toughness Requirements for Fracture Critical Components

TABLE 10 Fracture Critical Tension Component Impact Test Requirements

Grade	Thickness, in. [mm]	Minimum Test Value Energy,[A] ft-lbf [J]	Minimum Average Energy,[A] ft-lbf [J]		
			Zone 1	Zone 2	Zone 3
36F [250F]	to 4 [100], incl	20 [27]	25 [34] at 70°F [21°C]	25 [34] at 40°F [4°C]	25 [34] at 10°F [−12°C]
50F [345F][B], 50SF [345SF][B] 50WF [345WF][B]	to 2 [50], incl over 2 to 4 [50 to 100], incl	20 [27] 24 [33]	25 [34] at 70°F [21°C] 30 [41] at 70°F [21°C]	25 [34] at 40°F [4°C] 30 [41] at 40°F [4°C]	25 [34] at 10°F [−12°C] 30 [41] at 10°F [−12°C]
HPS 50WF [HPS 345WF][B]	to 4 [100], incl	24 [33]	30 [41] at 10°F [−12°C]	30 [41] at 10°F [−12°C]	30 [41] at 10°F [−12°C]
HPS 70WF [HPS 485WF][C]	to 4 [100], incl	28 [38]	35 [48] at −10°F [−23°C]	35 [48] at −10°F [−23°C]	35 [48] at −10°F [−23°C]
HPS 100WF [HPS 690WF]	to 2½ [65], incl over 2½ to 4 [65 to 100], incl	28 [38] [D]	35 [48] at −30°F [−34°C] Not permitted	35 [48] at −30°F [−34°C] Not permitted	35 [48] at −30°F [−34°C] Not permitted

[A] The CVN-impact testing shall be at "P" frequency in accordance with Specification A673/A673M except for plates, for which the sampling shall be as follows:
(1) As-rolled (including control-rolled and TMCP) plates shall be sampled at each end of each plate-as-rolled.
(2) Normalized plates shall be sampled at one end of each plate, as heat treated.
(3) Quenched and tempered plates shall be sampled at each end of each plate, as heat treated.
[B] If the yield point of the structural product exceeds 65 ksi [450 MPa], the testing temperature for the minimum average energy and minimum test value energy required shall be reduced by 15°F [8°C] for each increment of 10 ksi [70 MPa] above 65 ksi [450 MPa]. The yield point is the value given in the test report.
[C] If the yield strength of the structural product exceeds 85 ksi [585 MPa], the testing temperature for the minimum average energy and minimum test value energy required shall be reduced by 15°F [8°C] for each increment of 10 ksi [70 MPa] above 85 ksi [585 MPa]. The yield strength is the value given in the test report.
[D] Not applicable.

Source: AASHTO, ASTM A709/ A709M – 16a, Standard Specification for Structural Steel for Bridges, ASTM International 16.

Section Highlights

Threats and Hazards

- Geotechnical: Geotechnical hazards exist in the vicinity of the bridge. In September 2012, a sizeable landslide occurred approximately 400 feet downstream of the bridge's south abutment. Subsequently, a number of geotechnical studies were conducted.
- Oil Pipeline Rupture: Failure of the oil pipeline would not likely have direct structural consequences to the structural integrity of the bridge, but indirect consequences could lead to catastrophic failure.
- Seismic Ground Motion: The bridge is in varying degrees of compliance with standards. Some of the structural details used in the bridge do not comply with current standards (e.g., thickness of steel plates in the bridge tower legs), whereas other components (e.g., seismic loads used to design the bridge) were greater than current design specifications. Significant damage to the bridge is anticipated as a result of the design seismic event.
- Hydraulic, Ice, and Vessel Collision: The main concern has been ice damage to the nosing armor of the bridge piers.
- Terrorist attack: Attacks on the TAPS have occurred over time and is a threat to be aware of considering that the pipeline is located on the bridge.

6.3 Threats and Hazards

This section identifies and summarizes threats and hazards that could affect the bridge, including geotechnical hazards; oil pipeline rupture; seismic ground motion; hydraulic, ice and vessel collision; and terrorist attack.

6.3.1 Geotechnical

Geotechnical hazards exist in the vicinity of the Yukon River Bridge, as evidenced by a landslide that occurred in September 2012, approximately 400 feet downstream of the south abutment. The 2012 slide was the first landslide of this type since the construction of the bridge in 1974 and 1975.[142] Figure 6-7 depicts the 2012 landslide. The slide did not damage the bridge foundation; however, it prompted multiple geotechnical studies and a recommendation for a monitoring program.[143] A 2013 Preliminary Interpretive Report stated that while not completely understood, a number of factors may have initiated the slide and slope failure, including an underlying highly weathered, weak bedrock and the influence of surface hydrology.

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142 DNR, Division of Geologic and Geotechnical Surveys. 2013. Yukon River Bridge Landslide: Preliminary Geologic and Geotechnical Evaluation. Preliminary Interpretive Report 2013-6. October 2013.
143 DNR, Division of Geologic and Geotechnical Surveys. 2013. Yukon River Bridge Landslide: Preliminary Geologic and Geotechnical Evaluation. Preliminary Interpretive Report 2013-6. October 2013.

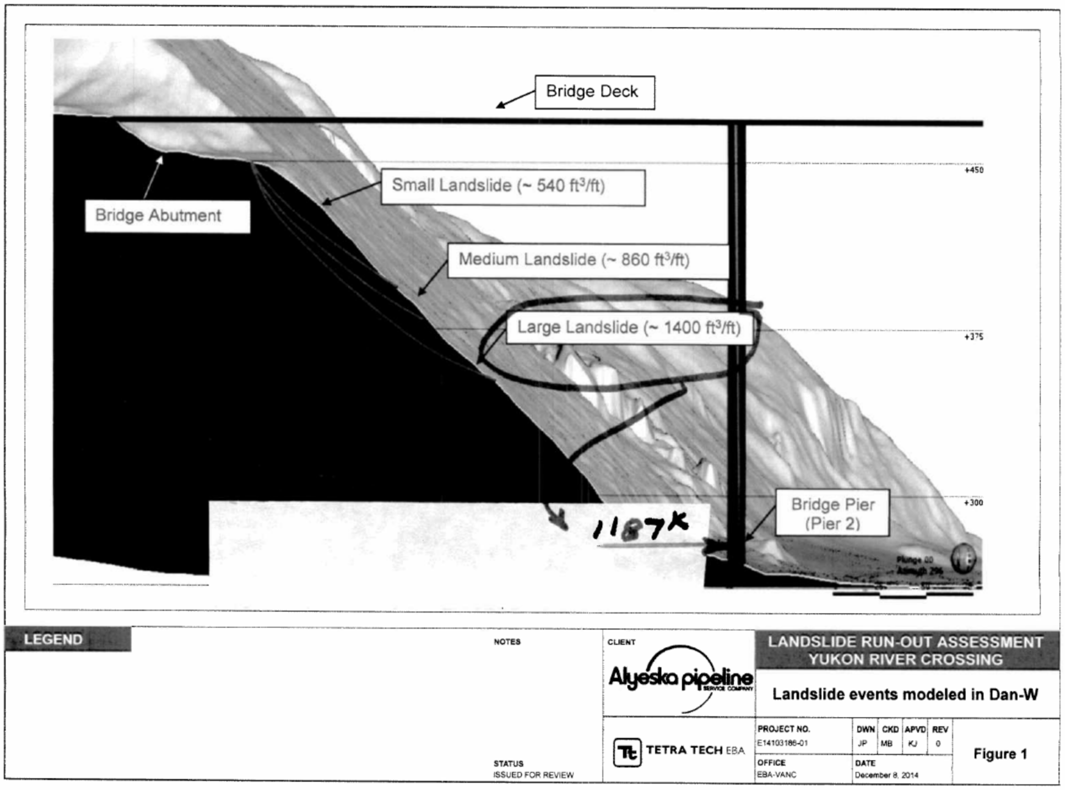
Figure 6-7. 2012 Landslide Located 400 Feet Downstream of the Yukon River Bridge South Abutment

Image from DOT&PF.

The threat of a similar slide under the south abutment, with soil loads impacting Pier 2, was considered. Soil loads acting on the concrete pier wall were calculated by Tetra Tech (under contract with Alyeska) to be approximately 1,187 kilopounds. Figure 6-8 depicts the landslide run-out event modeled in the 2014 report prepared for Alyeska. The factored nominal moment capacity of the as-built concrete pier section exceeds that of the predicted soil loading, indicating that the estimated landslide would not cause failure.

The above conclusion notwithstanding, if the pier were to fail (e.g., load greater than predicted or failure of the steel tower legs), it is anticipated that the entire bridge would fail, as noted in Section 6.2.1 and shown in Figure 6-3.

Figure 6-8. Landslide Model below the Yukon River Bridge South Abutment



6.3.2 Oil Pipeline Rupture

Minimal structural consequences associated with the rupture of the oil pipeline are foreseen. Secondary consequences such as ignition of the oil and environmental contamination of the Yukon River would likely be more significant.

Failure of the oil pipeline would not likely have direct structural consequences to the structural integrity of the bridge, but indirect consequences could lead to catastrophic failure. For example, the heat generated by ignited oil would greatly reduce the strength and stiffness of the steel bridge elements and likely lead to collapse (similar to the collapse of the World Trade Center towers when subjected to the prolonged heat of the fire caused by the burning jet fuel). Additionally, the environmental contamination of the Yukon River resulting from a large oil spill would likely be of great significance.

6.3.3 Seismic Ground Motion

The seismic loads used to design the bridge in 1971 are somewhat greater than those of the current design specifications. However, some of the structural details used in the bridge do not comply with the current standards.

The steel plates used to construct the steel pier towers and box girders are relatively thin and prone to buckling when subjected to large stresses. Stiffeners are added to counteract the buckling tendency of the plates. The stiffeners allow the steel plates to accommodate larger stresses prior to buckling, but when subjected to very large demands, such as those generated by earthquakes, the plates are still prone to buckle.

The thickness of the steel plates used to construct the tower legs is thinner than that permitted under current seismic design provisions. The plates may buckle when subjected to seismic loading. Further, the cyclic nature of seismic loading may result in weld failures that "unzip" the tower leg plates.

Finally, the variability in seismic demands can be significant. Modern structures are designed to accommodate large deformations as a means of addressing the uncertainty in the seismic loads. The tower legs of the Yukon River Bridge were not designed to accommodate significant inelastic demands. Significant damage to the bridge, possibly even collapse, is anticipated as a result of the design seismic event, depending upon the earthquake's magnitude, location, depth, duration, and similar parameters.

6.3.4 Hydraulic, Ice, and Vessel Collision

The bridge piers have performed well, with the exception of the ice damage to the nosing armor. No large maritime vessels currently use the river and even if they did, the applied load is likely less than that of the design ice force.

Figure 6-9 shows ice damage to the steel pier nosing.

Figure 6-9. Ice Damage to the Yukon River Bridge Steel Pier Nosing

Image provided by DOT&PF.

6.3.5 Terrorist Attack

Terrorist threats to bridges can entail a number of activities, including fire, impact, mechanical cutting devices, corrosive chemicals, and blast or explosion.[144]

[144] FHWA. 2006. Multiyear Plan for Bridge and Tunnel Security Research, Development, and Deployment. March 2016. https://www.fhwa.dot.gov/publications/research/infrastructure/structures/06072/06072.pdf, accessed September 29, 2017.

A classified report was prepared for DOT&PF for consideration of a terrorist attack of the TAPS and implications for the Yukon River Bridge. Increasing the setback distance from the threat would be the best solution (as blast forces decrease inversely with the cube of the distance). A Congressional Research Service report (2013) titled *Keeping America's Pipelines Safe and Secure: Key Issues for Congress* discussed the TAPS as one of the country's pipelines of particular concern with regard to its history of terrorist and vandal activity. The report cited a number of potential and actual vandal attacks on the pipeline, including the 2001 high-powered rifle attack on the pipeline that led to a two-day shutdown, which resulted in extensive economic and ecological damage.[145] Also, the option to add a proposed LNG pipeline to the existing Yukon River Bridge would make it an even bigger target for terrorism.

In 2009, the Transportation Security Administration (TSA) commissioned through an Interagency Agreement with the USACE to conduct comprehensive structural and operational vulnerability assessments on significant highway structures.[146] As part of that initiative, this report documents the USACE findings of the potential vulnerabilities of the Yukon River Bridge to terrorist acts intended to cause structural failure and/or substantially disrupt commerce. The report also presents conceptual mitigation strategies and associated costs to mitigate the vulnerabilities identified. The site survey was conducted in July 2012. The report suggested strengthening several areas of the bridge including the piers, steel frames, box girders, steel deck and ribs and frame bearings to further protect against a vehicle or vessel-borne improvised explosive device.

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[145] Congressional Research Service. 2013. *Keeping America's Pipelines Safe and Secure: Key Issues for Congress*. Prepared by Specialist in Energy and Infrastructure Policy Paul W. Parfomak. January 9, 2013.
[146] USACE. 2012. TSA Security Assessment of the Yukon River Bridge.

Section Highlights

Emergency Alternatives

Several alternatives to the bridge crossing in emergency situations exist, including an ice bridge; ferry, barge, or hovercraft; temporary bridge; pontoon or floating bridge; and aircraft.

- Ice bridge. This is the most feasible alternative for crossing the Yukon River in the winter. Duration from bridge collapse to when emergency alternative is open to traffic: one to three months.
- Ferry, barge, or hovercraft. This is alternative is limited to the summer. Duration from bridge collapse to when emergency alternative is open to traffic: two weeks to two months.
- Floating bridge or pontoon. This is a summer-only alternative. Duration from bridge collapse to when emergency alternative is open to traffic: two to four months.
- Temporary bridge. This alternative could be implemented year-round. Duration from bridge collapse to when emergency alternative is open to traffic: three to six months.
- Aircraft. This alternative could be implemented year-round but the amount of freight and personnel to be moved under this emergency alternative would be fairly restrictive. Duration from bridge collapse to when emergency alternative is open to traffic: two weeks to two months.

6.4 Emergency Alternatives

Several alternatives for bridge crossing in emergency situations exist, including an ice bridge; ferry, barge, or hovercraft; temporary bridge; pontoon or floating bridge; and aircraft. Most of these emergency alternatives would take several months to construct before being open to traffic. The ferry/barge/hovercraft or aircraft options could possibly be constructed or implemented as emergency alternatives in a shorter timeframe (e.g., a minimum of two weeks); however, the exact amount of time it would take to construct or implement these alternatives is difficult to predict.

The draft DOT&PF *Highway Bridge Incident Management Plan* (2003) lists the Yukon River Bridge as one of 10 statewide critical bridges. Emergency access options are listed for each identified critical bridge. For the Yukon River Bridge, the report stated that both DOT&PF and Alyeska "are in agreement that emergency access for this bridge is best provided by utilizing methods that were employed prior to the bridge being in place." The report lists the following methods for emergency access alternatives: barge, landing crafts, and/or hovercrafts providing ferry service during the summer or an ice bridge for access during the winter.

6.4.1 Ice Bridge

The Yukon River is typically frozen from late October to mid-April (although the recent trend is for a later buildup and an earlier breakup). In order to accommodate legal highway truck loads and vehicular traffic (i.e., up to about 90,000 pounds over a 65-foot wheel base), the ice must be at least 2 feet thick. In order to accommodate loads of more than about 200,000 pounds, the ice must be at least 3 feet thick. If necessary, the thickness of the ice can be increased by pumping water from below the ice to the surface, where it will freeze and thicken the driving surface.

It is assumed that an ice bridge, located within several hundred feet of the existing bridge, would be the most feasible alternative for crossing the river in winter. In an emergency scenario, it could take between one and three months to construct an ice bridge, depending upon the existing conditions at the time.

6.4.2 Ferry, Barge, or Hovercraft

A flexi-float (i.e., a modular steel barge) or lightering barge capable of supporting vehicle loads in excess of 400,000 pounds would be feasible, but may not be immediately available for deployment. Dawson City in the Yukon Territory, for example, uses a barge when the river is not frozen. Figure 6-10 shows an example of a vehicular barge option. A hovercraft may be a more versatile option because it would be able to accommodate traffic in both winter and summer.

Figure 6-10. Alternative Emergency Access Option: "Flexifloat" Vehicular Barge Example

Image provided by DOT&PF.

An estimated two weeks to two months would be required to mobilize and assemble a modular steel barge at the existing bridge location. During this time, earthwork and mooring facilities would be constructed to accommodate barge landing areas.

6.4.3 Temporary Bridge

Constructing a temporary bridge is another option that could be deployed under an emergency scenario, though it is likely this option would take longer to construct and implement than the other emergency access alternatives. While difficult to predict, it would likely take between three and six months from when the existing bridge collapsed to when the temporary bridge would be open to traffic.

Acrow Bridge designs and manufactures customizable modular steel bridges. An Acrow modular bridge similar to those used in the Hurricane Katrina response could be utilized. However, it would require substantial, heavy piers to accommodate ice demands in the winter. The water depth and span limitations would make a temporary trestle (i.e., a structure built span by span) not feasible. It is likely that a crane barge or similar vessel would be required to build a temporary or permanent bridge.

6.4.4 Pontoon or Floating Bridge

While technically feasible in summer, floating bridges are not practical due to ice in winter and problematic due to floating debris (trees) in summer. Furthermore, if it takes approximately two to four months to deploy a floating bridge or pontoon, a short summer (open-water) season would severely limit the amount of time for which these emergency access options could actually be used. Figure 6-11 shows an example of a temporary floating bridge.

Figure 6-11. Temporary Floating Bridge Example

Image provided by DOT&PF.

6.4.5 Access by Aircraft

Aircraft is one method of evacuating and transporting people and light freight, if needed. Transportation by aircraft is impractical for the heavy commerce required for oil production facilities. Some freight loads can exceed 410,000 pounds, whereas common transport aircraft (e.g., Hercules or C-133) are limited in both size and weight of cargo capacity. For example, the cargo hold of the Hercules aircraft is about 8 feet by 8 feet by 45 feet and is limited to 43,000 pounds; the C-133 aircraft has a cargo area which measures 11 feet by 11 feet by 88 feet and is limited to 70,000 pounds.

The nearest airport is at Five Mile, which is located about 5 miles north of the Yukon River Bridge. The landing strip is about 2,700 feet long. This airport would not be able to accommodate aircraft delivery of construction materials.

The nearest airport capable of accommodating a C-130 aircraft (i.e., for construction materials) is located at Prospect Creek (MP 135), approximately 64 miles north of the Yukon River Bridge, as shown on Figure 6-12. The landing strip is about 5,000 feet long. Figure 6-12 also shows the configuration of the Prospect Creek Airport.

Should the existing bridge collapse, implementing this alternative as the primary way to provide emergency access could take between a few weeks and a few months.

Figure 6-12. Prospect Creek Airport Location and Configuration

7 ECONOMIC, ENVIRONMENTAL, AND SOCIAL CONSIDERATIONS

Section Highlights

Economic, Environmental, and Social Considerations

- A Yukon River Bridge crossing provides access for a number of stakeholders, including the oil and gas industry, local native allotment holders, and other users of the area such as those accessing the river for fishing or hunting.
- As the sole surface connection to the North Slope, this means the bridge and highway provide a critical link to the State's oil and gas field operations. This has particular economic importance for the State as well as national implications on U.S. oil production.
- Any changes to the Yukon River bridge vicinity should take into consideration subsistence, which is an important activity in the surrounding area.
- Climate change has the potential to alter the physical and biological environment.

7.1 Socioeconomic and Environmental Considerations Overview

Relevant socioeconomic and environmental data was collected based on existing public databases, State and federal agency planning documents, and industry/area knowledge. DOT&PF reached out to Dalton Highway tourism businesses and oil industry transport companies to better understand, from a high level perspective, the economic value of the Yukon River Bridge and develop an understanding of stakeholder needs. DOT&PF also reached out to tribal organizations and Native allotment owners to understand their needs concerning the bridge crossing. DOT&PF distributed questionnaires to these stakeholders as discussed in Section 2.5. Copies of these outreach efforts and returned survey questionnaire responses are included in Appendix C.

The following sections inventory relevant economic, environmental and social considerations for determining the recommended improvements for the Yukon River crossing. This section addresses:

- Land ownership and land use
- Socioeconomics
- Subsistence and cultural resources
- Wetlands, water bodies, fish, and wildlife resources
- Climate change

An initial overview of environmental resources, such as subsistence, cultural resources and features such as wetlands, is often conducted to help in the identification and analysis of alternatives. While there may not be needs associated with these resources, identifying them helps to establish the environmental setting.

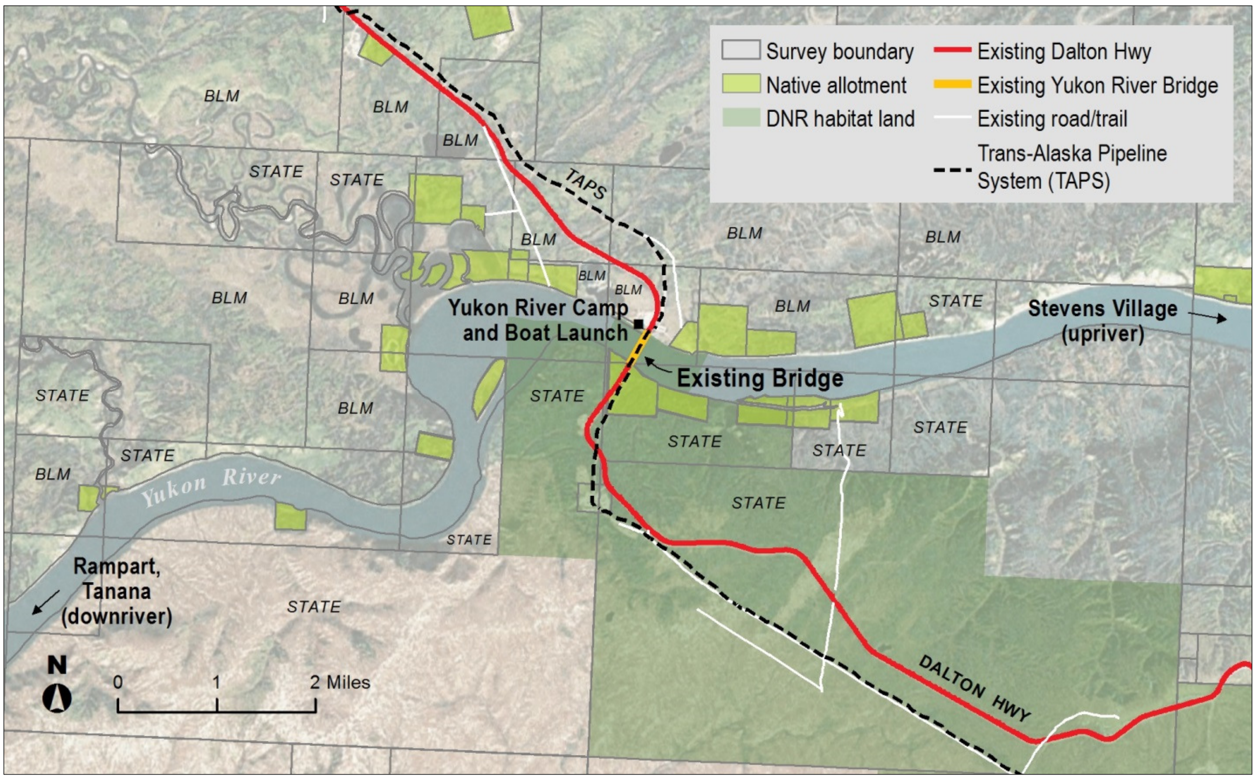
7.2 Land Ownership and Land Use

Outside the existing Dalton Highway right-of-way, the highway traverses State/habitat lands immediately south of the Yukon River, and federal (BLM) lands north of the Yukon River.

Figure 7-1 depicts land ownership near the bridge. Native and Alaska Native Claims Settlement Act (ANCSA) lands are adjacent to the Yukon River near the existing crossing. Corners of the Yukon Flats National Wildlife Refuge, managed by the USFWS, come to about 5 miles east of the bridge crossing.

The BLM Central Yukon Field Office manages lands both upstream and downstream of the current bridge. On their lands on the north side of the river near the crossing, BLM has some infrastructure and a lease to the business on the north side of the bridge that could be affected to some degree if the bridge were moved and/or during construction.[147]

Figure 7-1. Land Ownership near the Yukon River Bridge



Sources: BLM Native Allotments, 2013; DNR General Land Status, 2017; DNR Habitat Land, 2006.

Twenty-nine Native allotment parcels are located in the vicinity of the Yukon River crossing, as identified on Figure 7-1. The highway provides access to nearby communities, recreational lands, local game units, private/Native allotment/ANCSA-selected lands, and subsistence resources on both sides of the river crossing. Maintaining access to these lands for varying stakeholders is important. Tribes and landowners will have acquisition and access concerns and will expect to play a strong role in project development. Should an alternative Yukon River crossing be located, land acquisition would be required for the portion of the relocated road ROW.

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[147] Ethun, Chel. 2018. E-mail correspondence between BLM Central Yukon Resource Management Plan Project Manager Chel Ethun and DOT&PF Project Manager Lauren Little. February 1, 2018.

The Dalton Highway Corridor Management Area prohibits sport hunting with firearms within 5 miles on either side of the highway from the Yukon River north to the Arctic Ocean. Off-highway motor vehicle use is also limited to snow machines used only to transport hunters from the highway across the management area.[148] Refer to Section 2.2 for more details about use along the highway and at the bridge crossing.

7.3 Socioeconomics

The Dalton Highway and the Yukon River Bridge is the only north-south road crossing in Interior Alaska. As the sole surface connection to the North Slope, this means the bridge and highway provide a critical link to the State's oil and gas field operations. For economic context, the oil and gas industry funds the majority of the State's operating budget: 92 percent of the State's unrestricted revenue in FY 2013.[149] Furthermore, the State's crude oil production represents approximately 6 percent of the total U.S. production in 2016 and 0.6 percent of the total global production in 2015. The economic value the bridge provides is significant as it facilitates access to and production of these resources and is economically important on a state and national level.

While the highway does not directly serve any local communities near the bridge, the crossing and boat launch provide people and freight access to and from communities that otherwise could be accessed only by air, specifically Stevens Village, Rampart, and Tanana. The Yukon River Camp, located near the north end of the bridge on the west side, provides summer seasonal lodging, camping services, food, and fuel for travelers.

Socioeconomic data for many of the communities in the project vicinity are presented in Table 7-1. Each of these communities has a recognized tribal government and tribal populations. Understanding the social and economic benefits and impacts of the existing bridge to these communities is an important component of understanding how corridor or crossing changes would impact these populations.

Table 7-1. Socioeconomic Characteristics of Communities in the Yukon River Bridge Vicinity

Community	2010 Population	% Native Pop.	% Pop. Below Poverty Level	Federally Recognized Tribal Government	Highway Access
Beaver	84	97.6%	34.7%	Beaver Village	None
Fort Yukon	583	89.1%	21.1%	Native Village of Fort Yukon	None
Rampart	24	95.9%	17.9% *	Rampart Village Council	None
Stevens Village	78	85.5%	86.4%	Stevens Village Indian Reorganization Act Council	None
Tanana	246	86.6%	12.0%	Native Village of Tanana	None

Source: 2010 U.S. Census and U.S. Census Bureau 2009-2013 American Community Survey 5-Year Estimates
* Census margin of error exceeded 50 percent; data from the IATP (November, 2010)

148 Alaska Department of Fish and Game (ADF&G). No date. Management Areas: Dalton Highway Corridor Management Area. http://www.adfg.alaska.gov/index.cfm?adfg=huntingmaps.managementareas&area=MA_daltonhwy, accessed March 27, 2017.

149 AOGA. 2018. State Revenue webpage. https://www.aoga.org/facts-and-figures/state-revenue, accessed March 1, 2018.

The highway and bridge crossing are the primary facilitators of commerce in the project area. While the Yukon River Camp is the only commercial facility in the project area, the presence and operation of the highway and Yukon River Bridge facilities are the basis for business throughout the area. Most recreation (including hunting), freight transport to the North Slope oil and gas industry, road access for northern communities, tourism, and subsistence activities are dependent on the river crossing. To assess the business and economic component, DOT&PF sent surveys to oil and gas industry users, tourism companies, and Native allotment stakeholders to identify key issues and concerns regarding the existing bridge. See Section 2.5 for a synopsis of stakeholder survey responses. Every respondent identified that their business depended on vehicular access across the Yukon River, and could tolerate bridge closures only of a short-term nature (days or weeks) before their business would suffer.

7.4 Subsistence

Subsistence is an integral part of life in Alaska. As defined in Title VIII of the Alaska National Interest Lands Conservation Act, subsistence is defined as the customary and traditional use by rural residents of wild, renewable resources for direct personal or family consumption as food, shelter, fuel, clothing, tools, or transportation; for the making and selling of handicraft articles out of non-edible byproducts of fish and wildlife resources taken for family or personal consumption; for barter, or sharing for personal or family consumption; and for customary trade.

Subsistence is an important activity within the study area, and changes to the Yukon River Bridge and surrounding area could impact subsistence use and harvest. Any in-stream construction would need to take into account subsistence fishing site locations and the run timing of salmon species. This is especially important, as recent years with low fish return are a cause for concern among Interior tribes. The U.S.-Canada Yukon River Salmon Agreement (2002) set up the binational Yukon River Panel and Yukon River Joint Technical Committee to coordinate management. Additionally, any infrastructure development crossing the Yukon River may be highly scrutinized and could garner cross-border attention.

A review of existing available data for the nearby communities of Rampart, Livengood, and Stevens Village, as well as outlying communities (including Tanana, Beaver, Coldfoot, Wiseman, Bettles, Minto, and Manley Hot Springs) indicate that those with documented subsistence use in and around the analysis area are Rampart[150] (migratory birds only), Stevens Village[151], Beaver[152], and Manley Hot Springs.[153] No data are available for the community of Livengood. Preliminary review of the available data indicates that resources harvested in and around the analysis area include salmon and non-salmon fish species, migratory birds and eggs, moose, bear, furbearers, and berries. Data also indicate that

[150] ADF&G. 2001. The 2000 Harvest of Migratory Birds in Ten Upper Yukon River Communities, Alaska; Technical Paper 268. Final Report No.1 to USFWS Under Cooperative Agreement No. 701810J252. Authored by D.B. Anderson and Gretchen Jennings, Division of Subsistence, Anchorage.

[151] ADF&G. 1988. Land and Resource Use Patterns in Stevens Village, Alaska; Technical Paper 129. Authored by Valerie Sumida, Division of Subsistence, Fairbanks.

[152] ADF&G. 2012. Subsistence Harvests and Uses of Wild Resources by Communities in the Eastern Interior of Alaska, 2011; Technical Paper 372. Edited by Davin Holen, Sarah M. Hazell, and David S. Koster, Division of Subsistence, Anchorage.

[153] ADF&G. 2014. Wild Resource Harvests and Uses, Land Use Patterns, and Subsistence Economies in Manley Hot Springs and Minot, Alaska, 2012; Technical Paper No. 400. Authored by Caroline L. Brown, Lisa J. Slayton, Alida Trainor, David S. Koster, and Marylynne L. Kostick, Division of Subsistence, Fairbanks.

important subsistence resources that migrate through the analysis area, but that are harvested elsewhere, include moose and salmon.

The existing bridge facilitates access to the Yukon River and the boat launch. The Yukon River itself is an important access corridor for numerous communities that harvest resources along the river. Changes to boat and vehicle access to the river at the Yukon River Bridge may result in changes to subsistence users' ability to access the river corridor and the resources that are harvested in the analysis area and elsewhere. Restrictions to river access are likely to result in restrictions to subsistence; however, improvements to access may also result in actual or perceived restrictions to subsistence. The notable potential challenge to research, if access is improved, is the increased use of the Yukon River and analysis area by non-local and non-rural users. Increased access to local game units, such as Game Units 20F and 25D (Yukon Flats National Wildlife Refuge), may impact local food sources. This may result in user conflicts between local subsistence, non-local subsistence, and non-rural and/or sport users.

7.4.1 Cultural Resources

Preliminary review of the Alaska Heritage Resources Survey (AHRS) indicates that the analysis area includes at least 11 documented cultural resources; only two of which have been evaluated or considered for eligibility for listing in the National Register of Historic Places (NRHP). These evaluated resources are (1) the Yukon River Bridge itself, which has been determined to be eligible for the NRHP and is excepted from review under the Program Comment for common post-1945 concrete bridge structures, and (2) the Dalton Highway, which has not received a formal evaluation, but is considered a "treated as eligible" road under the Alaska Roads Programmatic Agreement. An additional nine cultural resources are documented within a 5-mile radius of the existing bridge. AHRS records and other documentation (e.g., reports) for these nine remaining sites provide insufficient data for evaluating NRHP eligibility.

Areas in the immediate vicinity of the existing bridge and Dalton Highway have been surveyed in recent years for proposed gas line projects.[154,155,156] Restrictions on viewing the exact locations of previous surveys due to the proprietary nature of the gas line projects limit understanding of the breadth of previous survey efforts, but it is presumed that gas-line-related survey has been focused within 1 mile of either side of the Dalton Highway corridor in this area. No other surveys are known to have been conducted recently (within the last 10 years) in the areas outside the 1-mile Dalton Highway corridor and presumed area of gas line survey coverage.

To identify the historic properties that may be affected by the construction of a new bridge, additional field and literature investigation to determine the NRHP eligibility of documented, unevaluated cultural resources will likely be needed. Additionally, analysis alternatives located outside of areas previously surveyed for gas line projects may need cultural resources field survey, to identify and document previously unidentified historic properties.

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[154] Northern Land Use Research (NLUR). 2012. *Phase I Cultural Resources Overview and Survey Report for the Alaska Pipeline Project, Prudhoe Bay to the Alaska, United States-Canada Border, 2010-2011* USAG-US-SRZZZ-000030. Report on file with the Alaska Office of History and Archaeology (OHA).
[155] NLUR. 2014. *Alaska LNG, 2013 Phase I Cultural Resource Report: Archaeological Survey and Site Documentation*, USAKE-UR-SRZZZ-00-0021. Report on file with the Alaska OHA.
[156] Radonich, Marko. 2012. Letter from Marko Radonich to Earle Williams re: Section 106 Review of the Yukon River Bridge Geotechnical Testing Project. Report on file with the Alaska OHA. October 12, 2012.

7.5 Affected Biological Environment

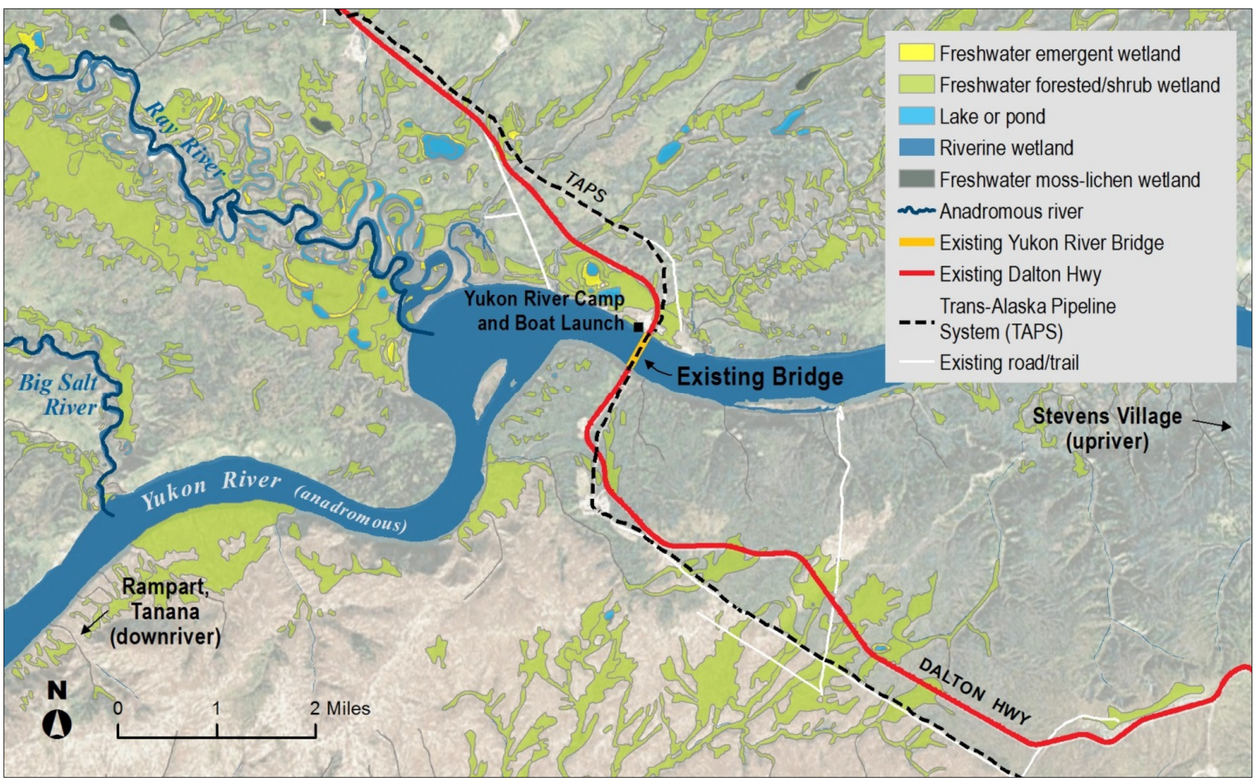
7.5.1 Wetlands and Water Bodies

Figure 7-2 identifies wetlands and water bodies in the area and vicinity of the Yukon River Bridge, as mapped as part of the USFWS National Wetlands Inventory (NWI). Any design change or action to the bridge and road approaches would likely impact wetlands regulated by the U.S. Army Corps of Engineers. Construction would require a permit under authority of Section 404 of the Clean Water Act or Section 10 of the Rivers and Harbors Act of 1899.

Wetland impacts will vary in acreage and function depending on the alternative. Alignments downstream of the existing bridge would require crossing higher value wetlands and additional water bodies. Upstream crossing locations would incur geotechnical and topographic difficulties, as well as impacts to other resources, such as private property. The existing NWI mapping is based on aerial photographic interpretation with limited ground verification and smaller wetlands not included in the mapping. During planning and alternative screening stages, existing mapping data is sufficient, but may not be suitable for a Section 404 permit application.

The Yukon River is utilized for interstate commerce and would therefore be subject to the U.S. Coast Guard bridge permitting process. It is also a Traditionally Navigable Water (TNW) subject to USACE Section 10 permitting.

Figure 7-2. Wetlands and Water Bodies near the Yukon River Bridge



Source: USFWS Alaska Statewide National Wetlands Inventory, 2016; ADF&G Anadromous Fish Atlas, 2016

7.5.2 Fish Habitat and Wildlife

The Yukon River is documented habitat for anadromous and resident fish, including all five species of Pacific salmon, sheefish, and whitefish.[157] The Ray River, which is a tributary of the Yukon River just downstream of the bridge crossing, is habitat to chum and king salmon, and farther downstream, the Big Salt River is habitat to chum, coho, and king salmon.[158] The Yukon River and many of its tributaries have consistently experienced under-performing runs of chum and king salmon over the last several years. Alaska has a harvest-sharing commitment for salmon under the U.S.-Canada Yukon River Salmon Agreement,[159] which may bring a heightened level of awareness and scrutiny to a bridge project regarding potential impacts to fish. The arctic lamprey is another species found in the Yukon River; it has traditionally been an important food source and harvested in the winter.[160]

The boreal forest habitat that surrounds the Yukon River Bridge crossing offers few opportunities to see wildlife unless they cross the road. The surrounding lands provide habitat for moose, wolf, fox, bear, snowshoe hare, lynx, and songbirds. Beaver, muskrat, mink, and migratory birds such as ducks, geese, and loons may be found in area streams and ponds.[161] Adjacent State game management units (20F and 25D) have legal annual hunts for black bear, grizzly bear, caribou, wolverine, and wolf (although various seasonal and residency restrictions apply).[162]

7.5.3 Climate Change

Climate change has the potential to alter the physical and biological environment. The USGS partnered with the Yukon River Inter-Tribal Watershed Council more than a decade ago to look at the Yukon River and its relation to climate. Climate changes have the potential to "affect traditional ways of life and the availability of future resources."[163] The thawing of permafrost could change groundwater flows and affect the quantity of water in the Yukon River, which could also affect fish and wildlife. All these considerations should be taken into account as factors related to the bridge crossing of the Yukon River.

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157 ADF&G. 2016. *Anadromous Waters Catalog and Atlas.* Data accessed using the Interactive Fish Mapper.http://extra.sf.adfg.state.ak.us/FishResourceMonitor/?mode=awc, accessed March 6, 2017.
158 ADF&G. 2016. *Anadromous Waters Catalog and Atlas*
159 Yukon River Salmon Agreement, 2001. Pacific Salmon Treaty: Attachment B, Annex IV, Chapter 8. http://yukonriverpanel.com/salmon/about/yukon-river-salmon-agreement, accessed March 27, 2017.
160 ADF&G. 2007. *Alaska's Lampreys: Mysterious and Tasty.* Alaska Fish & Wildlife News. By Erik Anderson. http://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=278, accessed March 1, 2018
161 BLM. 2016. *The Dalton Highway: Visitor Guide.* Produced in association with Alaska Geographic. http://akgeo.org/wp-content/uploads/2016/06/Dalton-Highway-2016.pdf, accessed March 1, 2017.
162 ADF&G. No date. Hunting Maps by Game Management Units. http://www.adfg.alaska.gov/index.cfm?adfg=huntingmaps.bygmu, accessed March 27, 2017.
163 Schuster, Paul F., and Karonhiakta'tie Bryan Maracle. Studies of Climate Change in the Yukon River Basin—Connecting Community and Science Through a Unique Partnership. Fact Sheet. US Geological Survey, 2010. http://pubs.usgs.gov/fs/2010/3020/

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8 LIFE-CYCLE COST ANALYSIS

Section Highlights

Life-Cycle Cost Analysis

- The following three bridge scenarios were analyzed in a Life-Cycle Cost Analysis (LCCA).
    - Scenario 1: Utilize the existing bridge ("do nothing" base case)
    - Scenario 2: Replace the existing bridge in or near the same location
    - Scenario 3: Construct a redundant bridge upstream and retain the existing bridge
- The LCCA period of analysis is 75 years, beginning 2020 and projected out to 2095.
- The present value results for the 75-year analysis period includes maintenance costs, capital costs, and residual value, as expressed in totals (rounded) below.
    - Scenario 1: $65 million
    - Scenario 2: $200 million
    - Scenario 3: $280 million

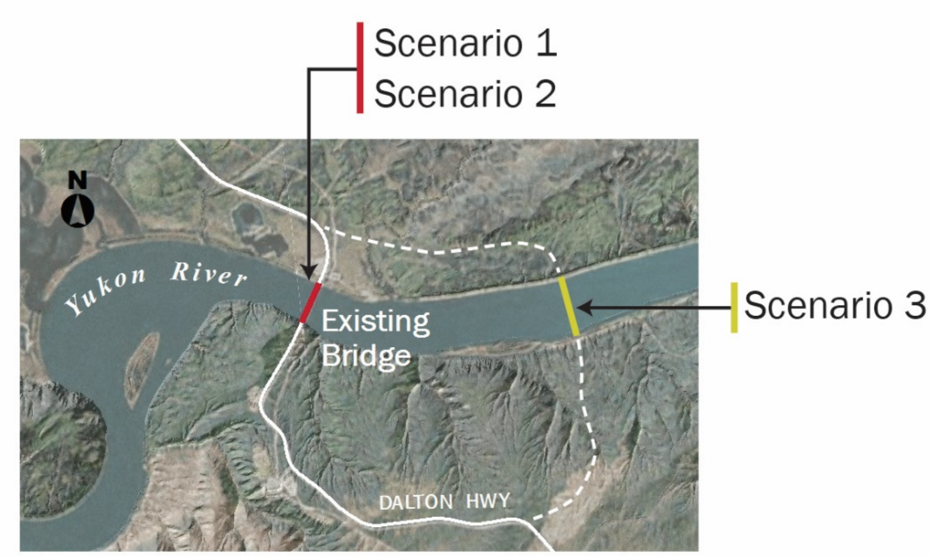
8.1 Introduction

A Life-Cycle Cost Analysis (LCCA) is an important economic analysis tool used to calculate the overall estimated cost over the life of a project or a given project. An LCCA includes a comparison of the total costs of competing alternatives to determine the most cost-effective means to accomplish a project's objectives. For this Study, an LCCA was prepared to compare the total costs of three future bridge scenarios to aid decision makers with future investment decisions relative to the Yukon River Bridge. The complete LCCA is included in Appendix E and summarized in this chapter.

Three bridge development scenarios evaluated, as described below and depicted on Figure 8-1.

- **Scenario 1 synopsis ("do nothing" base case with the existing bridge):** The first scenario represents the "do nothing" case, and looks at the life-cycle cost for utilizing and maintaining the existing Yukon River Bridge (#271). This LCCA is the basis of comparison for the other two scenarios.
- **Scenario 2 synopsis (replace existing bridge):** The second scenario looks at the life-cycle costs for a complete replacement bridge to be constructed at or near the location of the existing bridge. This scenario includes relocation of all existing utilities (including TAPS) onto the replacement bridge.
- **Scenario 3 synopsis (add redundant bridge):** The third scenario looks at the life-cycle costs for adding a new bridge across the Yukon River approximately 2 to 3 miles upstream from the existing bridge. The new bridge would accommodate vehicular traffic via a new alignment of the Dalton Highway. The existing bridge would serve as a support crossing for existing utilities (including TAPS). Under this scenario, the existing bridge would be maintained to serve as a redundant vehicle crossing on the existing Dalton Highway alignment (e.g., as a temporary detour or secondary crossing to the new bridge's primary crossing).

Figure 8-1. Three Bridge Scenarios Analyzed in the Life-Cycle Cost Analysis



Over their service lives, bridges require a long-term, multi-year public investment in ongoing inspection, maintenance, and repair after their construction. In accordance with current design standards, bridges are designed to have a 75-year design life, though they may last substantially longer, depending upon a number of factors, or may have shorter lifespans due to extreme events or functional obsolescence brought about by unexpected growth in traffic.

8.2 Analysis Process

The LCCA was prepared using a "net present value" metric that was applied to bridge costs. For the "net present value" analysis, past and future expenditures are tabulated, converted, and incurred at an equivalent present value. What this means is that all projected costs are converted into present dollars to produce a net present value. This technique is known as "discounting" and results in future costs being "discounted" to their net present value. The premise behind this is that the same dollar today is worth less in the future or more in the past, and using net present value takes this into account. Expenditures for any given year are summed and applied at the end of that year.

The period of analysis used in the LCCA is 75 years. Beginning 2020, the costs for each scenario are projected out to the year 2095.

A number of caveats and assumptions were included in the LCCA, such as no major socioeconomic factors that would substantially alter the long-term traffic demands on the bridge or changes to standards requiring immediate retrofits. These are further detailed in the LCCA in Appendix E.

Maintenance and capital costs were the two primary cost categories included in the LCCA. Maintenance costs include base maintenance and a variety of inspection types (routine, fracture critical, and underwater). Capital costs include design, rehabilitation, and salvage. For the two build scenarios (Scenarios 2 and 3), capital costs may also include design, construction, and demolition.

8.3 Results

Table 8-1 summarizes the present value results of all three scenarios for the 75-year analysis period between 2020 and 2095.

Table 8-1. Life-Cycle Costs Comparison of Three Bridge Scenarios (Million $s, in 2016 dollars)

Cost Category	Scenario 1 (Utilize Existing Bridge)	Scenario 2 (Replace Existing Bridge)	Scenario 3 (Add Redundant Bridge)
Maintenance Costs	$4	$1	$3
Capital Costs	$60	$215	$296
Residual Value	$0	($17)	($17)
Grand Total Present Value Life-Cycle Costs	**$65**	**$200**	**$280**

Values in this table represent present value discounted costs.
Due to rounding, the sum of these values may not match up completely in this table. Refer to the LCCA appendix for actual values.
Assumes maintenance costs and capital costs come from state and federal funding, respectively.

As summarized in the table, Scenario 1 (base case with the existing bridge) has the lowest present value life-cycle costs of all three scenarios over the analysis period between 2020 and 2095. This is largely due to the lower capital cost expenditures necessary to maintain only the current bridge rather than to construct new bridges as in Scenarios 2 and 3. On the other hand, Scenario 1 has the highest maintenance costs of all three scenarios due to the added cost of keeping the older existing bridge in proper working order.

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9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Key Topic Areas

The results of this Study reinforce that maintaining access across the Yukon River Bridge is critically important for multiple user groups, industries, the State, the nation, residents, and non-residents, both now and in the future.

For this Study, readily available information was obtained and reviewed to present the history of the bridge, existing conditions, and future needs. To supplement the data collected, DOT&PF distributed a questionnaire (refer to Section 2.5 and Appendix C) to a number of stakeholder groups, soliciting feedback to better understand needs and uses of the bridge and transportation corridor.

The main topics investigated in this Study included:

- historical, current, and future use of the Yukon River Bridge and highway corridor;
- future development plans in the corridor;
- existing transportation plans in the vicinity;
- existing and future conditions of the bridge;
- traffic safety and LOS;
- existing and future maintenance and operation needs of the bridge;
- bridge failure scenarios;
- emergency access alternatives;
- socioeconomic and environmental considerations; and
- likely LCCA scenarios.

The State Legislature was the primary driver for initiating this Study. Specifically, the State Legislature's intent was to evaluate the design and construction of a new, separate bridge across the Yukon River that would accommodate both vehicular traffic and infrastructure related to a future development, specifically in support of gas pipelines proposed either for the ASAP or AKLNG projects.

In general, the key topic areas included in this Study, and listed above, provide information to support a future determination as to the need for a new bridge or replacement of the existing bridge. Identification of these existing conditions and needs establishes a snapshot for decision makers to inform the necessity and timing of any future bridge project. The information included in this Study serves as a foundation for additional project development should the consideration and concept of a new, separate Yukon River Bridge move forward.

9.2 Study and Project Purpose

The original purpose for this Study is to identify alternative Yukon River crossing locations that will (1) enhance safety, (2) reduce maintenance and operational costs to the State and user groups, and (3) provide Yukon River crossing redundancy for this critical NHS route.

As development of this Study moved forward, it was determined that it was important to identify the transportation needs associated with the Yukon River Bridge crossing. These are summarized in the next section.

The overarching project purpose is to **ensure bridge access is maintained across the Yukon River.**

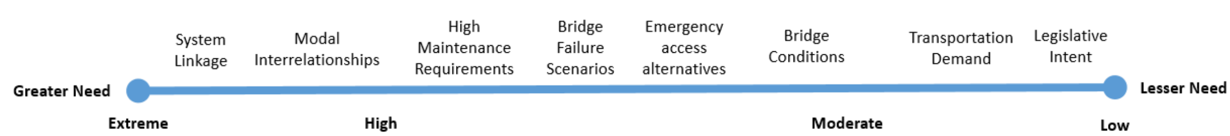
9.3 Summary of Conditions and Needs

The summary of the conditions and needs identified in this Study are presented below, generally in the order of the key topics addressed in this document. The intent of this summary is to provide information to help inform decision makers of the scale of the need, which may influence the level of effort and composition of future work. Each item or need was given a "scale of need" rating based on how soon it might warrant action and the severity of the consequences of not addressing the need. Refer to Figure 9-1.

For each item, the scale of need is described as follows:

- **Low:** No immediate action is required
- **Moderate:** Is a concern; however, may not need immediate attention
- **High:** Has severe consequences and must be planned for in the foreseeable future
- **Extreme:** Has severe consequences and warrants immediate attention

Figure 9-1. Scale of Need



A vulnerability risk assessment might be a good next step to determine the likelihood of some of the risks associated with the identified conditions and needs.

9.3.1 Legislative Intent

Legislative Intent. The initial need driving this Study was a legislative mandate. SB 138 was signed in 2014 and would require DOT&PF to evaluate the design and construction of a new, separate bridge across the Yukon River that would accommodate both vehicular traffic and infrastructure related to an AKLNG project. Since the bill was issued and as the AKLNG project has advanced forward, installation of the gas pipeline on a highway structure was determined infeasible due to cost and safety concerns. Therefore, since any future vehicular bridge likely would not be combined with a gas pipeline, there is no longer a legislative need to evaluate a joint vehicular-pipeline bridge across the Yukon River.

Need Scale: low

9.3.2 Use of the Yukon River Bridge and transportation corridor

System Linkage. System linkage is one of nine factors the FHWA Technical Advisory T 6640.8A lists[164] for establishing the need for a proposed transportation action. The Yukon River Bridge is a

[164] While not an exhaustive list, the FHWA Technical Advisory T 6640.8A lists nine items that assist in helping to identify the purpose and need for a proposed transportation action. These include: project status, system linkage, capacity, transportation demand, legislation, social demands or economic development, modal interrelationships, safety,

critical "connecting link" between the North Slope and the rest of Alaska as it is the sole permanent, year-round overland link. Furthermore, the bridge provides the only permanent, year-round overland access across the Yukon River at the Dalton Highway for emergency services, subsistence users, recreational hunters, tourists, and other recreational users. Access would be much more difficult and expensive, if not impossible, without the current bridge.

The Dalton Highway's multiple designations, including a State Scenic Byway designation and a High Priority Corridor of the NHS as designated by Congress is further indicative of the importance of the transportation link the highway and bridge provides. Maintaining the system linkage_provided by a bridge of the Dalton Highway over the Yukon River is a critical need. As the sole link, the lack of redundancy is a significant concern with regard to maintaining access should the bridge fail.

Need Scale: extreme

Modal Interrelationships. The area in the immediate vicinity of the Yukon River Bridge is a jumping off point for many locals since the boat launch is located just downstream of the bridge on the northern side of the river. Residents from nearby villages, such as Stevens Village, use their snowmachines to travel from their communities to the boat launch. Seasonal tug or barge service also occurs along the Yukon River in the summer, delivering freight and fuel to communities. The bridge also enables hunters and people with boat trailers who are driving from the south to cross the bridge and access the Yukon River from the north. The Yukon River Bridge is needed to provide access to the boat launch where locals and non-locals depart using other transportation. The Yukon River Bridge complements and interfaces with these other transportation modes.

Need Scale: high

9.3.3 Future Development Plans and Needs in the Corridor

Transportation Demand. Transportation Demand is one of nine factors the FHWA Technical Advisory T 6640.8A lists for establishing the need for a proposed transportation action. Typically, this item is related to statewide transportation planning processes and traffic forecasts.

Traffic forecasts for the Dalton Highway can be gleaned from future development plans in the corridor. Underlying the importance of system linkage, the Yukon River Bridge and Dalton Highway provide the only hard surface links connecting Interior Alaska to resources north of the Yukon River. These include mining resources and potential future oil and gas developments accessed from the highway and on the North Slope. Several "roads to resources" branching from the Dalton Highway have the potential to increase vehicular traffic over the Yukon River. The construction and operations of two proposed LNG projects would also generate additional traffic. However, based on the information obtained from these future development plans, the current AADT count (of 294 vehicles in 2015) would have to increase nearly six-fold (to more than 1,700 passenger cars per hour) to have a significant effect on the roadway LOS. Therefore, there is not a need to improve or add to the roadway or bridge capacity because the existing and future traffic volumes along the Dalton Highway and on the bridge operate under a reasonable LOS at this time and for the foreseeable future. As future development plans progress and more project details are known, it is possible there would be a need to revisit the implications to the existing transportation infrastructure.

Need Scale: moderate to low

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and roadway deficiencies. Some but not all of these items relate to needs associated with maintaining bridge access across the Yukon River.

9.3.4 Existing and Future Conditions of the Bridge

Bridge Conditions. The Yukon River Bridge is not classified as structurally deficient. The current sufficiency rating has remained relatively unchanged over the past decade; the condition rating values are indicative that the bridge is serving its purpose well. The bridge superstructure is in good condition, and the substructure is in satisfactory condition. This implies a lower need for immediate replacement.

The remaining life expectancy of the bridge is difficult to accurately predict. The bridge has a finite life span and at some point in the future will need to be replaced. Completed in 1975, the Yukon River Bridge was designed with a 50-year design life. Based on a number of methodologies, including previous condition factors and remaining fatigue life, the bridge is expected to become structurally deficient between 2035 and 2050. This is nearly 20 years from now, when the bridge would be between 60 and 75 years old. The bridge would be very difficult to retrofit or rehabilitate due to complicated structural details and materials used.

Additional analysis to assess bridge vulnerability to seismic events is recommended based on the structural details of the bridge.

Need Scale: moderate

9.3.5 Maintenance and Operations Needs of the Bridge

High Maintenance Requirements. One of several needs initially driving this Study was the need to reduce maintenance and operational costs. The Yukon River Bridge requires more frequent rehabilitation and retrofit than most conventional highway structures. A number of factors contribute to this, including the harsh climate, heavy-loaded vehicles, wintertime chain usage, and the wearing down of the timber running planks and timber deck.

The Yukon River Bridge's current timber deck requires frequent replacement. The deck running timbers must be replaced every 6 to 7 years and the underlying timber deck must be replaced every 12 to 14 years. This indicates a continued need for substantial annual maintenance costs. However, after the replacement work is done, the deck is brought up to a "good" condition classification. The bridge can drop to an unacceptable condition within 5 to 10 years. When not in "good" condition, the deck presents hazards to vehicles crossing the bridge. As the deck condition degrades, in addition to increased exposure of previously protected structural elements, hazards are presented for vehicles crossing the bridge. These hazards include an uneven surface on a steep grade, slippery surface, and exposed spikes/screws that may puncture tires or snag plow blades.

The "fracture critical" classification requires more stringent inspection and maintenance than for other types of bridges. If the steel bridge elements are subjected to tension and fail, it may lead to catastrophic failure of the bridge. This indicates that the condition of this decades-old bridge must be closely monitored and maintained to avoid total loss of access to the North Slope.

As the bridge ages, more maintenance needs will develop. While a Phase I seismic retrofit addressed the most vulnerable failure mechanisms (e.g., unseating of girder supports), more expensive Phase II seismic retrofitting (e.g., structural modifications to the piers) may be required to address larger seismic events.

Need Scale: moderate to high

9.3.6 Bridge Failure Scenarios

A bridge failure would have devastating effects on the State's economy. The lack of system redundancy should the bridge fail is a significant concern. This ties back to the issue of a resultant missing critical link in the transportation network. System redundancy would ensure access is maintained.

The extremely cold temperatures encountered at this fracture critical bridge raise this concern to a moderate rating. This can be largely addressed through increased inspection or construction of a redundant bridge.

Failure of the bridge due to landslide and ground motion are relevant issues that need to be considered, especially considering the September 2012 landslide that occurred 400 feet downstream from the south abutment. A similar slide that would impact a bridge pier had been modeled under the south abutment. The results of that limited scenario were that the bridge would have survived that type of event, but would likely have required some level of repair and associated closures; however, larger events could take place. Failure of the bridge can be mitigated by providing for a redundant structure built to higher modern seismic criteria.

Terrorism associated with the oil pipeline is a relevant threat to the bridge. A classified report prepared for DOT&PF noted that increasing the setback distance from the threat would be the best solution.

Need Scale: moderate

9.3.7 Emergency Access Alternatives

In the event that the Yukon River Bridge is not usable, emergency access alternatives would need to be deployed to maintain system linkage and connectivity between Interior Alaska and the North Slope. In warmer periods of the year, ferries, barges, and hovercraft could be utilized. These would provide less traffic capacity and result in higher costs. During the winter, an ice bridge could be constructed. Various types of temporary bridges can be considered; however, components would not be immediately available, and the span and characteristics of this location make these bridge options problematic, if not impractical. At times, air transport would be the only available access type until a new bridge could be constructed. However, this method of access would not support the heavier loads accommodated by a bridge. A bridge failure would likely result in an emergency order issued by the Governor, as was the case when the Dalton Highway was closed for weeks during a spring thaw event.[165]

Need Scale: moderate to high

9.3.8 Socioeconomic and Environmental Considerations

The immediate area of the highway and bridge traverses State/habitat lands, federal lands, ANCSA lands, and Native allotments. The highway provides access to subsistence resources on both sides of the river. Maintaining access to land for Native uses and subsistence is important.

Need Scale: moderate

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[165] On April 8, 2015, and again on May 22, 2015, Alaska Governor Bill Walker declared a state disaster in response to flooding that made the Dalton Highway impassable. (Sources: https://gov.alaska.gov/newsroom/2015/04/disaster-declared-for-dalton-highway-flooding/ and https://gov.alaska.gov/newsroom/2015/05/disaster-declared-for-dalton-highway-flooding-2/)

9.3.9 LCCA Scenarios

An LCCA was prepared under three scenarios: (1) "do nothing," as in maintain the existing bridge, (2) construct a new replacement bridge at or near the existing bridge, or (3) construct a new redundant bridge several miles upstream. The LCCA used a "net present value" metric and looked at the scenarios over a 75-year period, from 2020 through 2095. The cost associated with Scenarios 1, 2, and 3 are $65 million, $200 million, and $280 million, respectively. These costs represent a significant range and investment, especially at a time when the economic climate of the State is constrained. One of several needs initially driving this Study was the need to reduce maintenance and operational costs. The construction of a new bridge would lead to reduced maintenance and operational costs, but would require significant capital costs upfront. Decision makers need to weigh the risks and costs associated with maintaining the condition of the existing bridge versus making the capital expenditure to construct a new bridge.

Need Scale: moderate

9.3.10 Preliminary Purpose and Need Statement

Based on the preponderance and scale of the needs, the major need for the project is to provide continued access to the economic drivers for the State and to maintain that access into the future. Inherent in those needs is that this is a single point of access that has no redundancies. In other words, the existing condition consists of a fracture-critical, structurally non-redundant bridge that is located on a non-redundant route. The redundancy is especially important since alternate access such as hovercrafts or ice roads are only stop gaps, and a replacement bridge would take years to construct. In addition, the structural details of the bridge would make rehabilitation difficult to impossible, potentially necessitating a new structure that would have to be installed rapidly.

The purpose and need could be summarized as:

> *The Yukon River Bridge and Dalton Highway provide critical support to existing and future economic development and transportation needs of the Interior and North Slope of Alaska. The overarching project purpose is to ensure bridge access is maintained across the Yukon River.*

9.4 Conclusions and Recommendations

The Yukon River Bridge is exceptionally important for a number of reasons. It is important to multiple industries and user groups who have a common need—access across the Yukon River. As discussed in this conditions and initial needs assessment, a bridge is required to meet a preponderance of those needs. While there are emergency access options that could be utilized, a bridge is key to the continued prosperity of one of the State's top economic drivers.

The primary issue is the consequences of bridge failure and associated potentially severe economic impacts on the State budget. The LCCA gives a measurement of the relative costs to replace the bridge or construct a redundant bridge.

It is likely a policy matter to determine how costs associated with the various scenarios reflect on the State's risk tolerance of losing the existing bridge.

This report uses existing information to quantify costs and does not summarize bridge crossing options that could be further defined.

It is prudent to examine bridge and crossing options to better refine costs and plans for both bridge replacement as well as a redundant bridge to better assist decision makers. This work will be the next component of the Study.