Memorandum

Date: November 21, 2018

To: ADOT&PF

From: Patrick Burden and Leah Cuyno

Re: Benefit-Cost Analysis of Northern Region Bridge Rehabilitation and Replacement

This memorandum is provided in support of the Alaska Department of Transportation and Public Facilities (ADOT&PF) Bridge Section's application for grant funding for the FHWA's Competitive Highway Bridge Program for Fiscal Year 2018.

This memorandum describes the benefit-cost analysis (BCA) conducted for the proposed bridge rehabilitation projects in ADOT&PF's Northern Region. A BCA spreadsheet model was developed to determine the net present value of the expected benefits of three proposed bridge projects in the Northern Region. The analysis also considered the cost effectiveness of bundling the projects during construction to generate cost savings.

Net Present Value (NPV) and Benefit-Cost (B/C) Ratio

The following table summarizes the expected outcomes with respect to benefits and costs of the three proposed bridge projects in the ADOT&PF Northern Region. Constructing the three bridge rehabilitation projects as a bundle would be more cost effective, with an estimated construction cost savings of about $715,000.

Table 1. Expected Net Benefits (in millions of 2018 $) and B/C Ratio of the Proposed Northern Region Bridge Rehabilitation Projects

Northern Region Projects	Present Value of Estimated Benefits	Present Value of Estimated Costs	Net Present Value	B/C Ratio
Gulkana River (574)	$2,162.11	$2.15	$2,160.04	1,005
Rock Creek (684)	$76.32	$3.88	$72.44	20
Chokosna River (1193)	$2.19	$4.73	($2.55)	0.46
Total (*separate projects*)	$2,240.61	$10.77	$2,229.93	208
Total (*bundled*)	$2,240.61	$10.18	$2,230.52	220

Source: Northern Economics estimates based on the B/C model developed for this study.

Proposed Bridge Rehabilitation and Replacement Projects in the Northern Region

The proposed project will upgrade three structurally deficient rural bridges in the ADOT&PF Northern Region: Gulkana River Bridge No. 574 on the Richardson Highway, Rock Creek Bridge No. 684 on the Denali Highway, and Chokosna River Bridge No. 1193 on the McCarthy Road. All three bridges are located on historic roads.

The Richardson Highway connects Valdez, Alaska to communities along the highway and ultimately to Alaska's second largest city, Fairbanks, while providing direct maintenance and emergency response access to the Trans-Alaska Pipeline (TAPS). Load limitations on any

880 H Street, Suite 210 | Anchorage, AK 99501
1455 NW Leary Way, Suite 400 | Seattle, WA 98107
E-mail: mail@norecon.com | www.northerneconomics.com
Tel: 907 274.5600 | Fax: 907 274.5601

bridge along the Richardson stretch increase the cost of goods and services in the region. Rehabilitation of the Gulkana River Bridge will prolong the life of the structure, reducing risk of load posting or full bridge replacement on this commercial trucking route.

The Denali Highway is a seasonal road that connects the Parks and Richardson Highways and provides access to recreational and subsistence resources along its length. The Denali Highway connects the remote communities of Cantwell and Paxson on either end. The Rock Creek Bridge is remote and in the event of a structure failure, travelers could have to go several hundred miles out of the way to reach their destination. Replacement of this deficient structure will ensure continued access to recreational and subsistence resources along the Denali Highway.

The McCarthy Road is a seasonal road that winds through the Wrangell St. Elias National Park and connects the remote community of McCarthy to the main highway system in Alaska. The McCarthy Road provides access to recreational and subsistence resources along its length, including access to the Kennecott Mine which is a National Historic Landmark. The remote Chokosna River Bridge is a critical node along the McCarthy Road and in the event of structure failure residents of McCarthy would only have air access to get goods and supplies or access medical attention. Replacement of this deficient structure will ensure continued access to recreational and subsistence resources, as well as emergency road access to McCarthy, along the McCarthy Road.

Assumptions and Values of Key Input Parameters

All benefits and costs in the analysis are presented in 2018 dollars. The analysis uses 2018 as the base year and all future benefits and costs are discounted to 2018 dollars using a 7 percent real discount rate. The Alaska Consumer Price Index (CPI) is used as the cost deflator. [The Alaska CPI and the 2018 Deflator is shown in the *Alaska CPI* tab of the BC spreadsheet model].

General model assumptions used in the BCA are shown in Table 2 below.

Table 2. General Model Assumptions used in the Benefit Cost Analysis

B/C Model Parameters	Value
Year of dollar values in the model	2018
Discount Rate (Real), percent	7
Design Life of New Bridge, # of years	75
Design Life of Rehabilitated Bridge, # of years	50
Occupancy rate for personal vehicles, # of persons	1.7
Occupancy rate for buses, # of persons	10.7
Occupancy rate for commercial vehicles, # of persons	1.0
Replacement Year for Polyester Concrete Overlay	30
Operating Period for this Analysis, # of years	30

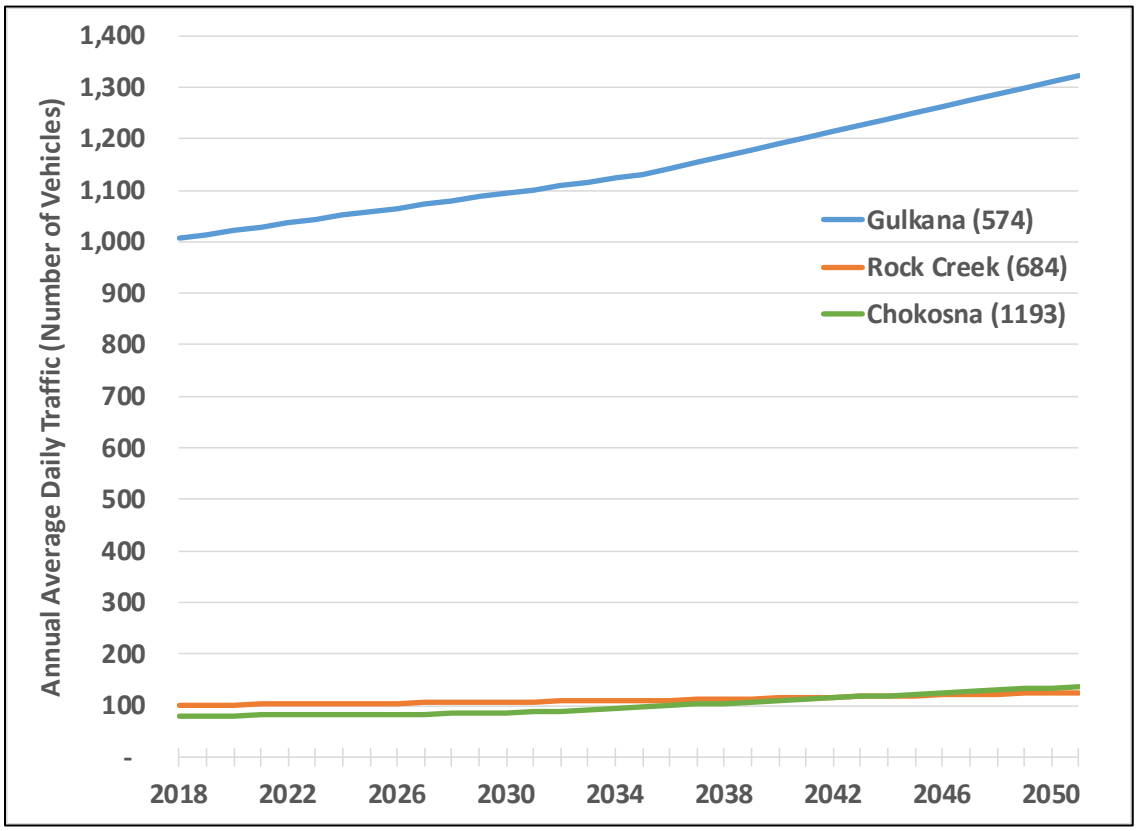
Sources:

1) Discount rate is based on the Office of Management and Budget Circular A-94.
2) Occupancy rates for personal vehicles and for buses are from "Average Vehicle Occupancy Factors for Computing Travel Time April 2018." https://www.fhwa.dot.gov/tpm/guidance/avo_factors.pdf. Accessed on Oct. 20, 2018.

3) Design life of a new/rehabilitated bridge is based on AASHTO Bridge code, provided by ADOT&PF.

The projected traffic volumes, measured as annual average daily traffic (AADT), used in this BCA analysis were provided by ADOT&PF. Traffic counts were measured on Milepost 127 of the Richardson Highway (Gulkana Bridge), Milepost 25 of the Denali Highway (Rock Creek Bridge), and Milepost 27 of the McCarthy Road (Chokosna Bridge).

Figure 1. Projected Annual Average Daily Traffic on the Gulkana, Rock Creek, and Chokosna Bridges



Source: Alaska Department of Transportation and Public Facilities.

The total projected AADT counts shown above were allocated to different types of vehicles according to the percentages shown in the table below.

Table 3. Allocation of Traffic Volume per Type of Vehicle, Percent of Annual Average Daily Traffic

Types of Vehicles	Gulkana Bridge	Rock Creek Bridge	Chokosna Bridge
Commercial vehicles			
Trucks (Classes 5-13)	22.4	14.0	10.8
Buses (Class 4)	0.6	0.5	0.2
Other Business Travel	4.6	7.0	10.4
Personal	72.4	78.5	78.6

Sources:

1) Commercial vehicle estimates are from the Alaska Department of Transportation and Public Facilities.
2) Other Business Travel vehicle estimates are based on 2016 estimate for local business travel.

Baseline (No Build) Description

The following describes the baseline conditions, which is the basis for determining or quantifying the effects of the no build case— load limits, single-lane operations, and eventual bridge closures.

The assumptions and calculations associated with the baseline conditions are shown in the 574 Baseline tab, 684 Baseline tab, and the 1193 Baseline tab.

Gulkana River Bridge 574

The bridge was originally constructed in 1974, with no significant alterations since original construction. Maintenance activities over the years have included scour repair, debris removal around piers, and deck repairs. The current bridge railing does not meet current standards for crashworthiness. The reinforced concrete deck has deteriorated over the years to a condition rating of 4, even with routine patching, with severe delamination and deck cracking present. The deck condition has been rated poor for over 10 years, despite maintenance activities to address the most severe deck deficiencies.

Given this current NBI rating, the following are assumed under the Baseline for this analysis:

- The bridge deck will have 2.6 years at NBI rating 3 before closure at NBI rating 2.
- The bridge deck will fall to rating 3 at the next inspection in 2019.
- Load limits are imposed the year after a rating 3 is reached (Year 2020).
- In the third year of the NBI rating 3 (year 2022), single lane operations will be put in place. Single lane operations will result in an average delay of 6 minutes per vehicle.
- The bridge will be closed at the end of year 2023.

Rock Creek Bridge 684

This bridge was built in 1955, with no significant alterations since its original construction. The bridge was load posted in 2011 to allow for single lane traffic only due to deterioration of the superstructure. The downstream bridge abutment and backwall have moved significantly, leading to cracks in the abutment piles.

The Rock Creek Bridge substructure has exceeded its expected service life. Its current NBI rating is a 4.

Given this current NBI rating, the following are assumed under the No Build Baseline:

- The substructure will have an expected 4 years at NBI rating 3 before closure at rating 2
- The substructure will drop to rating 3 at the next inspection in 2019
- At NBI rating 3, load limits are imposed in year 2020.
- In the third year of the NBI rating 3 (2022), single lane operations will be put in place.
- The bridge will be closed at the end of 2022.

Chokosna River Bridge 1193

This bridge was constructed in 1973, with no significant alterations done since it was built. The bridge was load posted in 2006 and has continued to deteriorate since then. The timber deck is damaged with holes in areas, the bearings are failing and there is surface rust throughout the structure. The timber abutments are decaying and sloughing and the sheet pile walls are leaning. The bridge floor beams are bowed and missing bolts in locations.

The bridge deck and the substructure have exceeded their service life; they currently have an NBI rating of 4. However, the bridge deck is estimated to have a shorter time at NBI rating 3 (2.6 years compared to 4 years) so the bridge deck is the controlling component for replacement.

Given this current NBI rating, the following are assumed under the No Build Baseline:

- The bridge deck will have 2 more years at rating 4 (years 2019-2020).
- The bridge deck will have 2.6 years at rating 3 before it closes at rating 2.
- At NBI rating 3, additional load limits are imposed (2021).
- In the third year of the NBI rating 3 (2023), single lane operations will be put in place. Single lane operations will result in an average delay of half a minute per vehicle.
- Bridge 1193 will be closed at the end of year 2024.

Project Benefits

The benefits of the project are evaluated based on the avoided costs associated with imposing the no build or baseline conditions described above.

1) **Avoided Costs of Load Limits**

Load limits imposed on the bridges will result in an increase in truck traffic by 4 percent, as some loads will have to be split between trucks to stay within the load limits. This increases operating costs and travel time of affected trucks.

The marginal costs of operating a truck per hour are based on the published report by the American Transportation Research Institute (ATRI)-- *An Analysis of the Operational Costs of Trucking* released in October 2018. The operating costs include fuel, repair and maintenance, insurance, permits/licenses, and tires. [Assumptions and calculations for vehicle operating costs are shown in *Vehicle Opg Cost* tab in the BC spreadsheet model].

The value of travel time for truck drivers are based on hourly compensation of heavy and tractor-trailer and light truck or delivery service drivers as published by the Bureau of Labor Statistics (BLS). [Wage and income data are shown in the *Wage & Income* tab in the BC spreadsheet model].

Load limits on the 574 and 684 bridges are in effect from 2020 through 2022 and load limits on the 1193 bridge are in effect in years 2021 through 2024.

Table 4. Estimated Net Effects of Load Limits Imposed on Bridge 574, in 2018 $

Category	Net Present Value	2019	2020	2021	2022
Increased Truck Operating Cost	$1,201,946	$0	$486,778	$490,219	$493,660
Increased Driver Travel Time	$855,078	$0	$346,299	$348,747	$351,195
Total	**$2,057,024**	**$0**	**$833,077**	**$838,966**	**$844,855**

Source: Northern Economics estimates based on the BC model developed for this study.

Table 5. Estimated Net Effects of Load Limits Imposed on Bridge 684, in 2018 $

Category	Net Present Value	2019	2020	2021	2022
Increased Truck Operating Cost	$66,169	$0	$26,839	$26,985	$27,132
Increased Driver Travel Time	$66,687	$0	$27,049	$27,197	$27,345
Total	**$132,856**	**$0**	**$53,888**	**$54,182**	**$54,477**

Source: Northern Economics estimates based on the BC model developed for this study.

Table 6. Estimated Net Effects of Load Limits Imposed on Bridge 1193, in 2018 $

Category	Net Present Value	2019 to 2020	2021	2022	2023	2024
Increased Truck Operating Cost	$48,172	$0	$16,174	$16,251	$16,327	$16,403
Increased Driver Travel Time	$48,108	$0	$16,153	$16,229	$16,305	$16,382
Net Effect of Load Limits	$96,280	$0	$32,327	$32,480	$32,632	$32,785

Source: Northern Economics estimates based on the BC model developed for this study.

2) Avoided Costs of Single Lane Operations

Single lane operations will take effect for the Bridges 574 and 684 in year 2022 and in years 2023 and 2024 for Bridge 1193.

Single lane operations will cause a 6-minute delay on Bridge 574, a 1-minute delay on Bridge 684, and half a minute delay on Bridge 1193. The time delay was quantified for each type of vehicle using the appropriate compensation or wage data for the type of travel [see *Wage & Income* tab in the BC spreadsheet model].

Table 7 presents the estimated effects of the single lane operations imposed on the various bridge projects.

Table 7. Net Present Value of the Estimated Effect of Single Lane Operations on Bridges 574, 684, and 1193, in 2018 $

Type of Travel	Gulkana (574)	Rock Creek (684)	Chokosna (1193)
Truck Drivers	$248,079	$2,556	$1,436
Bus Drivers	$5,647	$68	$22
Bus (Passengers)	$49,111	$588	$190
Other Business Travel Time	$55,003	$1,384	$1,492
Personal Travel Time	$1,005,087	$17,988	$13,089
Total	**$1,362,927**	**$22,584**	**$16,229**

Source: Northern Economics estimates based on the BC model developed for this study.

3) Avoided Costs of Bridge Closures

As noted in the baseline description above, Bridges 574 and 684 will be closed at the end of year 2022 and Bridge 1193 will be closed at the end of year 2024. These bridge closures will then prevent any road traffic passing through since there are no alternate bridge crossings that can be used. The following travel scenarios are therefore assumed following the bridge closures:

Bridge 574 Closure

The analysis assumes that vehicles are traveling a distance of 153 miles between Glenallen and Delta Junction on the Richardson Highway which takes about 2.7 hours. In the event of the bridge closure, vehicles will have to travel 557 miles to use the alternate route (detour) via Wasilla and Fairbanks. This detour is estimated to take 9 hours and 29 minutes.

Bridge 684 Closure

The analysis assumes that vehicles are traveling a distance of 136 miles between Cantwell and Paxson on the Denali Highway which takes about 3.4 hours. In the event of the bridge closure, vehicles will have to travel 324 miles to use the alternate route (detour) via Fairbanks. This detour is estimated to take 5 hours and 29 minutes.

Bridge 1193 Closure

There are no alternate routes that can be taken in the event of bridge closure. Hence, the bridge closure will result in people traveling by air.

The costs that motorists will have to incur after the bridge closure, using the alternate mode of travel (air), were quantified using current fares from Gulkana to McCarthy and the travel time delays (associated with the detours) and gain (via air travel) were also quantified. Note that the air fares used here are associated with a route that is supported by a U.S. Postal Service mail delivery contracts and are much less than other air taxi services. The fares are thought to approach the incremental cost of the service.

The avoided costs were determined based on the incremental costs associated with the project, hence only the net effects are quantified. For example, the incremental effect in terms of vehicle miles traveled on the 574 bridge route is 404 miles (which is the difference between the miles associated with the detour (557 miles) and the miles on the bridge route (153 miles)). The net effect in terms of travel time is 6.8 hours (which is 9 hours and 29 minutes on the detour route minus the 2.7 hours on the bridge route.

The net effects of the closure of Bridge 1193 include the benefits of using air travel instead of driving on the bridge route-- eliminated costs of operating the different types of vehicles and the travel time savings. These values are negative values since they represent a benefit (instead of a cost). The net effect of the bridge closure in present value terms is estimated to amount to $1.68 million (2018 $).

Table 8 and Table 9 show the net present values of the estimated costs of the bridge closures.

Table 8. Net Present Value of Estimated Effect of the 574 and 684 Bridge Closures, *in millions* of 2018 $

Category	Gulkana (574)	Rock Creek (684)
Increased Truck Operating Cost	$344.09	$9.86
Increased Truck Driver Travel Time	$232.91	$4.44
Increased Bus Operating Cost	$9.17	$0.31
Increased Bus Driver Travel Time	$5.10	$0.11
Increased Bus Passenger Travel Time	$44.33	$0.98
Increased Other Business Vehicle Operating Cost	$29.96	$2.10
Increased Other Business Travel Time	$49.65	$2.31
Increased Personal Vehicle Operating Cost	$471.48	$23.54
Increased Personal Travel Time	$907.32	$30.05
Total:	**$2,094.006**	**$73.712**

Source: Northern Economics estimates based on the BC model developed for this study.

Table 9. Net Present Value of Estimated Effect of the 1193 Bridge Closure, *in millions* of 2018 $

Category	Net Present Value
Increased Bus Passenger Travel Cost	$0.61
Eliminated Bus Operating and Driver Cost	($0.13)
Decreased Bus Passenger Travel Time	($0.33)
Increased Other Business Vehicle Travel Cost	$3.25
Eliminated Other Business Vehicle Operating Cost	($1.64)
Decreased Other Business Travel Time	($2.63)
Increased Personal Travel Cost	$41.79
Eliminated Personal Vehicle Operating Cost	($12.39)
Decreased Personal Travel Time	($23.07)
Eliminated Truck Driver Travel Time	($3.79)
Total:	**$1.683**

Source: Northern Economics estimates based on the BC model developed for this study.

The assumptions, data, and calculations for the various avoided costs (and benefit) associated with the bridge closures are provided in the *574 Baseline* tab, *684 Baseline* tab, and the *1193 Baseline tab* in the BC spreadsheet model.

4) Avoided Baseline Maintenance and Operating Costs

Table 10 shows the net present values and the future avoided maintenance and operating costs for the three bridges. The baseline costs are quantified only until the last year the bridges will be open to motorists. The data, assumptions, and calculations are shown in the *M&O* tab in the BC spreadsheet model.

Table 10. Net Present Value of the Estimated Baseline Maintenance and Operating Costs for Bridges 574, 684, and 1193, in 2018 $

Bridge/Cost Category	NPV	2019	2020	2021	2022	2023	2024
Gulkana (574)							
Pavement	$122	$0	$0	$0	$160	$0	$0
Bridge	$11,021	$0	$0	$3,725	$3,725	$3,725	$3,725
Total	$11,142	$0	$0	$3,725	$3,885	$3,725	$3,725
Rock Creek (684)							
Timber Deck	$15,326	$0	$0	$0	$0	$0	$23,000
Bridge	$753	$0	$0	$254	$254	$254	$254
Total	$16,079	$0	$0	$254	$254	$254	$23,254
Chokosna (1193)							
Timber Deck	$7,646	$0	$0	$5,000	$0	$5,000	$0
Bridge	$10,213	$0	$0	$3,452	$3,452	$3,452	$3,452
Total	$17,860	$0	$0	$8,452	$3,452	$8,452	$3,452

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study; ADOT&PF provided historical maintenance costs for the bridges.

5) Residual Value of Bridge

The residual values for the bridges were quantified and included in the BCA. For this calculation, it is assumed that the value (=capital cost) of the bridge depreciates in a linear manner over its service life. The design life for a rehabilitated bridge is 50 years and the design life of a new bridge is 75 years, while the operating period assumed for this analysis is 30 years. The discounted residual values for the three bridges are shown in the table below.

Table 11. Estimated Discounted Residual Values of Bridges 574, 684, and 1193, in 2018 $

Bridge	Present Value
Gulkana (574)	$71,917
Rock Creek (684)	$294,689
Chokosna (1193)	$372,202

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study; ADOT&PF provided capital costs of the bridge rehabilitation and replacement projects.

6) Avoided Emissions Costs

This analysis evaluated the net costs of emissions under the baseline conditions (without the bridge projects) and with the projects. This includes the differences in emissions associated with the detour route and the bridge route for the Bridges 574 and 684.

The costs of emissions are based on the recommended monetized values provided in the U.S. DOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The Guidance only

provided monetized costs for volatile organic compounds (VOCs), nitrogen oxides (NO_x), particulate matter (PM), and sulfur dioxide (SO_2). According to the document, DOT does not currently have a recommended value for the damage costs from CO_2 emissions; hence CO_2 emissions cost were not monetized). SO_2 emissions were also not monetized since there no data were found on SO_2 emissions from passenger vehicles and trucks. Aircraft emissions factors are also not available (small aircraft engines are not covered by current EPA regulations) thus emissions costs associated with the Chokosna Bridge project were not quantified.

The data, assumptions, and calculations for the costs of emissions are in provided in the *574 Emissions* tab and the *684 Emissions* tab of the BC spreadsheet model.

Table 12. Estimated Effects of Net Emissions, in 2018 $

Bridge	Net Present Value
Gulkana(574)	$65,452,362
Rock Creek (684)	$2,141,403
Chokosna (1193)	--

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study

Project Costs

Total project costs in this BCA include the estimated costs of upgrading and replacing the bridges, as well as the future maintenance and operations of the bridges.

1) Capital Costs

The undiscounted project capital costs for each bridge project are shown in Table 13. The table also compares the total costs for all the bridges if they were implemented separately versus the total costs for all the bridges if they were implemented together (or bundled).

Table 13. Estimated Project Costs of the Bridges 574, 684, and 1193, Undiscounted, in 2018 $

Bridge	Amount: Stand-Alone	Amount: Bundled
Gulkana (574)	$2,514,939	$2,334,013
Rock Creek (684)	$4,900,741	$4,817,515
Chokosna (1193)	$5,784,843	$5,333,954
Total	**$13,200,523**	**$12,485,482**

Source: Alaska Department of Transportation and Public Facilities (ADOT&PF).

The BC spreadsheet model provides a detailed break-down of the cost information in the *Construction Cost Estimate* tab.

2) Maintenance and Operations Costs

New bridges in Alaska are designed to be resilient structures with limited maintenance due to logistical challenges associated with short construction seasons and remote locations. Besides wearing surface replacement and minor upkeep, maintenance and operations work is assumed to be minimal. The table below shows the discounted estimated maintenance costs of the new and upgraded bridges.

Data, assumptions, and calculations are provided in the *M&O* tab in the BC spreadsheet model.

Table 14. Present Value of Maintenance & Operating Costs of the New 574, 684, and 1193 Bridges, in 2018 $

Bridge/Cost Category	Present Value
Gulkana (574)	
Pavement	$84,544
Bridge	$13,948
Total	**$98,492**
Rock Creek (684)	
Pavement	$8,832
Bridge	$1,937
Total	**$10,769**
Chokosna (1193)	
Pavement	$9,141
Bridge	$3,282
Total	**$12,423**

Source: Based on Alaska Department of Transportation and Public Facilities (ADOT&PF) Transportation Asset Management Plan and historical data on maintenance and operating costs, and Northern Economics assumptions about minor annual activities.

Summary Results: Benefit-Cost Analysis

The BCA results of the proposed bridge projects in the Northern Region are presented in Table 15. The Gulkana and Rock Creek bridge projects have a B/C ratio greater than 1 while the Chokosna Bridge project has a B/C ratio of 0.5 (which means the estimated costs are higher than the estimated project benefits. As a bundle, the estimated cost savings in present value terms amount to $580,000 (2018 $). The bundled projects have a B/C ratio of greater than 1.

Table 15. Net Present Values of Proposed Northern Region Bridge Projects' Benefits and Costs

Category	Net Present Value (millions)				
Project Benefits	Gulkana	Rock Creek	Chokosna	All Bridges (Separate)	All Bridges (Bundled)
Avoidance of Load Limit Costs	$1.20	$0.13	$0.10	$1.43	$1.43
Avoidance of Single Lane Operation	$1.36	$0.02	$0.02	$1.40	$1.40
Avoidance of Bridge Closure	$2,094.01	$73.71	$1.68	$2,169.40	$2,169.40
Avoidance of M&O Costs until Bridge Closure	$0.01	$0.02	$0.02	$0.05	$0.05
Residual Value of Bridge	$0.07	$0.29	$0.37	$0.74	$0.74
Avoided Emissions Costs	$65.45	$2.14	$0.00	$67.59	$67.59
Total Project Benefits	$2,162.11	$76.32	$2.19	$2,240.61	$2,240.61
Project Costs					
Capital Expenditures	$2.05	$3.87	$4.72	$10.64	$10.06
M&O Expenditures	$0.10	$0.01	$0.01	$0.12	$0.12
Total Project Costs	$2.15	$3.88	$4.73	$10.77	$10.18
Net Benefits	$2,159.95	$72.44	-$2.55	$2,229.84	$2,230.43
B/C Ratio	1,005	20	0.5	208	220

Source: Northern Economics estimates based on the BC spreadsheet model developed for this study.