Memorandum

To: Harold Frazier, Tribal Transportation Program Director
Standing Rock Sioux Tribe

From: Matt Flanagan, Engineer
Gina Blazanin, Engineer

Date: February 27, 2023

Subject: Bureau of Indian Affairs Route 6 (BIA 6) Reconstruction and Resurface Project – 2023 RAISE Grant Application Benefit-Cost Analysis Memorandum

Introduction

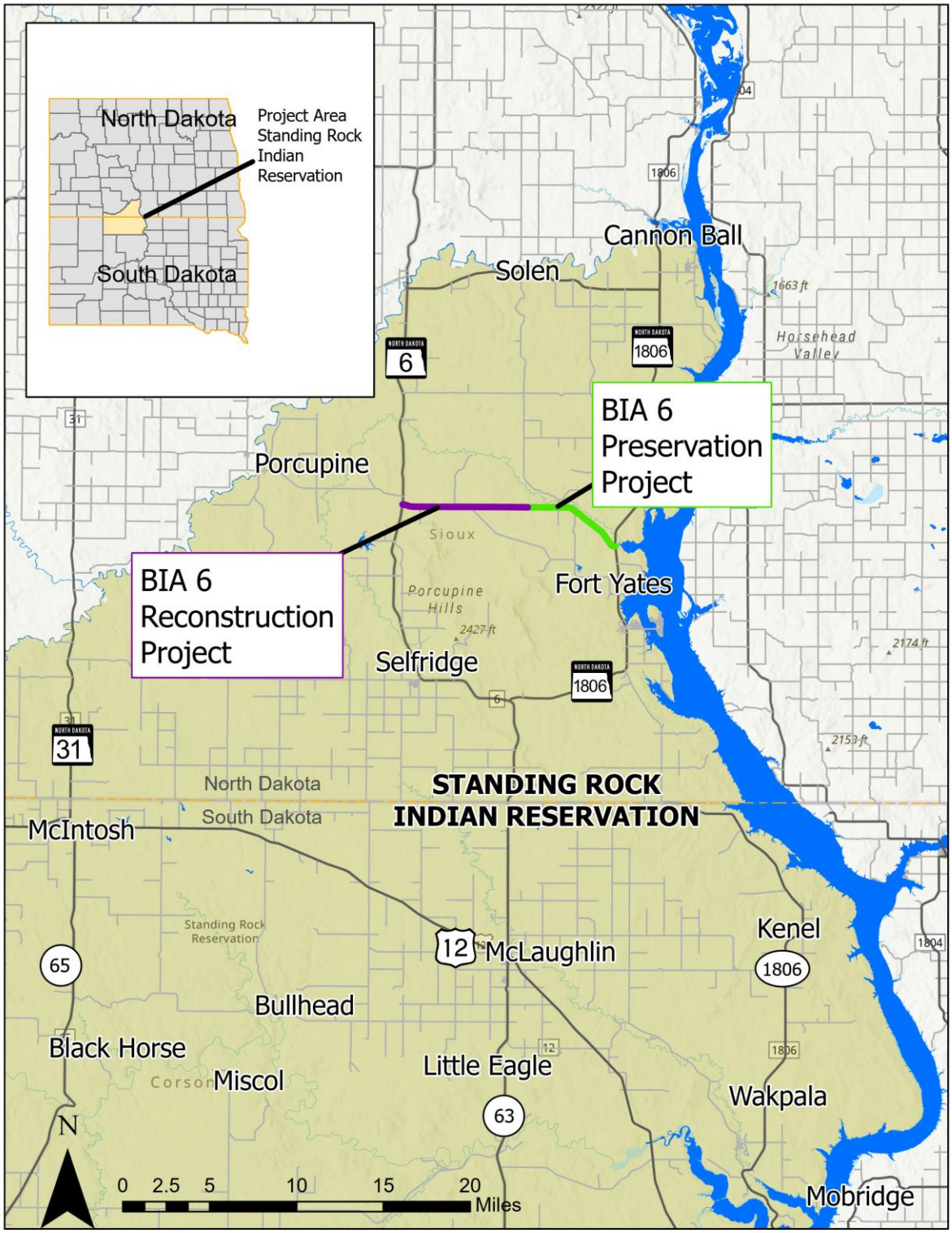
This memorandum summarizes the assumptions, methodology and results developed for the benefit-cost analysis of the No Build and Build Alternatives evaluated as part of the Bureau of Indian Affairs Route 6 (BIA 6) – 2023 RAISE Grant Application. The objective of a benefit-cost analysis (BCA) is to bring all the direct effects of a transportation investment into a common measure (dollars), and to account for the fact that benefits accrue over an extended period while costs are incurred primarily in the initial years. The primary elements that can be monetized are travel time, changes in vehicle operating costs, vehicle crashes, environmental impacts, capital costs and remaining capital value, and maintenance costs. The benefit-cost analysis can provide an indication of the economic desirability of an alternative, but decision-makers must weigh the results against other considerations, effects, and impacts of the project.

Project Overview

The Standing Rock Sioux Tribe (SRST) is requesting $18.57 million of 2023 Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant funding for Bureau of Indian Affairs Route 6 (BIA 6). The project limits are from North Dakota State Highway 6 to North Dakota State Highway 1806, approximately 13.1 miles. This project is of critical importance to the Standing Rock Sioux Tribe because it is the only east-west highway which connects remote communities of Porcupine and Shields, North Dakota, to Fort Yates, North Dakota. It is also a popular route which connects the Bismarck/Mandan area to the city of Fort Yates, which is a cultural hub within the Standing Rock Indian Reservation. The Tribe is located within the boundaries of the 2.3 million acres Standing Rock Indian Reservation located in North Dakota and South Dakota.

The project will consist of two phases reconstruction and resurfacing. Figure 1 shows the location of the two projects in Sioux County. The reconstruction project will occur in June 2024 – September 2024 beginning at the ND Highway 6 intersection and continuing east for 7.44 miles. The resurfacing project will occur in June 2025 – September 2025 covers the easternmost 5.71 mile segment of BIA 6. Both projects, when fully completed, will restore pavement to excellent condition, ensure a consistent 28-foot road width with 2-foot paved shoulders and rumble strips and improve deficient vertical curves along BIA 6.

Figure 1. Project Location Map



Description of Alternatives

For this analysis, a No Build and Build Alternative were under consideration.

No Build Alternative

Improving the pavement condition for BIA 6 is a primary objective of the Project. Historically the Standing Rock Sioux Tribe stretches their funding as far as they can to perform basic routine maintenance on the BIA and Tribal roadway networks. Given the existing condition of BIA 6, current SRST funding sources for basic routine maintenance are insufficient to bring the pavement into a state of good repair. Exacerbated by the extreme weather conditions of the Upper Great Plains, the pavement condition has deteriorated to the point where it is unsafe to travel at the posted speed limit (65 MPH) for a majority of BIA 6. Roadway reconstruction and pavement preservation (resurfacing) are needed to bring the roadway into a safe and operable condition. If the Tribe is unsuccessful in their 2023 RAISE pursuit, the pavement condition is expected to degrade to a level where the asphalt pavement can no longer be maintained responsibly and becomes a hazard to travel on. The Standing Rock Sioux Tribe anticipates that the pavement conditions will be in too poor of a condition to remedy by the year 2025 and will require conversion of the entire 13.1 mile segment of BIA 6 to a gravel roadway.

The pavement condition along BIA 6 was evaluated in the Tribe's 2017 Long-Range Transportation Plan (LRTP)[1] using the Pavement Surface Evaluation and Rating System (PASER). Roads were scored on a scale of 1 to 10, where 10 indicates perfect condition (new pavement) and 1 is a gravel road. At the time, most of BIA 6 was scored as 4-6. As of 2022, the Tribe estimates that the surface condition has fallen to 3-5. Pavement on the western portion of BIA 6 is in poor condition (PASER = 3-4), and eastern half of BIA 6 is in fairer condition (PASER = 5). In many areas, roadway shoulders have eroded to or past the edge lines of the travel lanes. Figure 2 shows existing pavement condition on BIA 6. The No Build Alternative assumes that the BIA 6 roadway is converted to a gravel roadway in 2025, with gravel road maintenance costs on an annual basis.

[1] https://projects.srfconsulting.com/raise/srst/Standing-Rock-Sioux-Tribe_LRTP.pdf

Figure 2. Existing Pavement Condition on BIA

The conversion of BIA 6 to a gravel roadway has significant impacts to the vehicles traveling through the region. This analysis identified and monetized the impacts of natural diversions associated with the conversion of BIA 6 to a gravel road. Natural diversion routes and travel times were determined using Google Maps[2] and assumed speed reductions on BIA 6 associated with converting BIA 6 to a gravel road.

Assumed traffic patterns are based on the existing AADT data obtained from the North Dakota Department of Transportation (NDDOT) Transportation Information Map: AADT[3]. Traffic along BIA 6 is assumed to be 65% traveling north/south (Fort Yates to Fallon, St Anthony, Breien, Lynwood, Lyons, Mandan and vice versa). The remaining 35% of traffic along BIA 6 is assumed to be traveling east/west (between Fort Yates and Porcupine/Rural Western reservation land and vice versa).

These natural diversion routes are dependent on the direction of travel to/from Fort Yates and the surrounding areas, and diversion routes are divided up as such. Detour routes and travel times were

[2] https://www.google.com/maps
[3] https://gis.dot.nd.gov/external/ge_html/?viewer=ext_transinfo

determined using Google Maps. These diversion routes are described below and are shown in Figures 3, 4, 5, and 6 display the different routes.

North/South BIA 6 Traffic - Natural Diversion (Fort Yates to Fallon, St Anthony, Breien, Lynwood, Lyons, Mandan and vice versa) - The natural diversion via ND 24 and ND 1806 begins in 2025, when BIA 6 is converted to gravel. The natural diversion in the No Build has the same travel time as the original route, even though it is roughly five miles longer. This is because the speed limit on the gravel BIA 6 roadway would be decreased which increases the travel time along that route. Additional travel time along BIA 6 was calculated assuming a posted speed limit of 65 mph along BIA 6 in the Build and 50 mph along BIA 6 in the No Build along with the assumed project length of 13.1 miles. All motorists are anticipated to take this natural diversion to reduce wear and tear on vehicles by traveling along the paved roadway. In the No Build, north/south users have two options[4]:

- **North/South No Build Via ND 6/BIA 6** is shown in Figure 3. This route is 33 miles and takes 37 minutes – Analysis assumes zero percent of users choose this route because of the gravel roadway. This is the existing route users take with additional travel time along BIA 6 due to conversion to gravel roadway.
- **North/South No Build Natural Diversion via ND 24/ND 1806** is shown in Figure 4. This route is 37.9 miles and takes 37 minutes – Analysis assumes 100 percent of users choose this route.

[4]The BCA Workbook allows reviewers to conduct sensitivity analysis using a different percentage of users on each of the two north/south traffic routes for both automobile and truck traffic.

Figure 3. North/South No Build Via ND 6 & BIA 6 (33 miles/37 minutes)

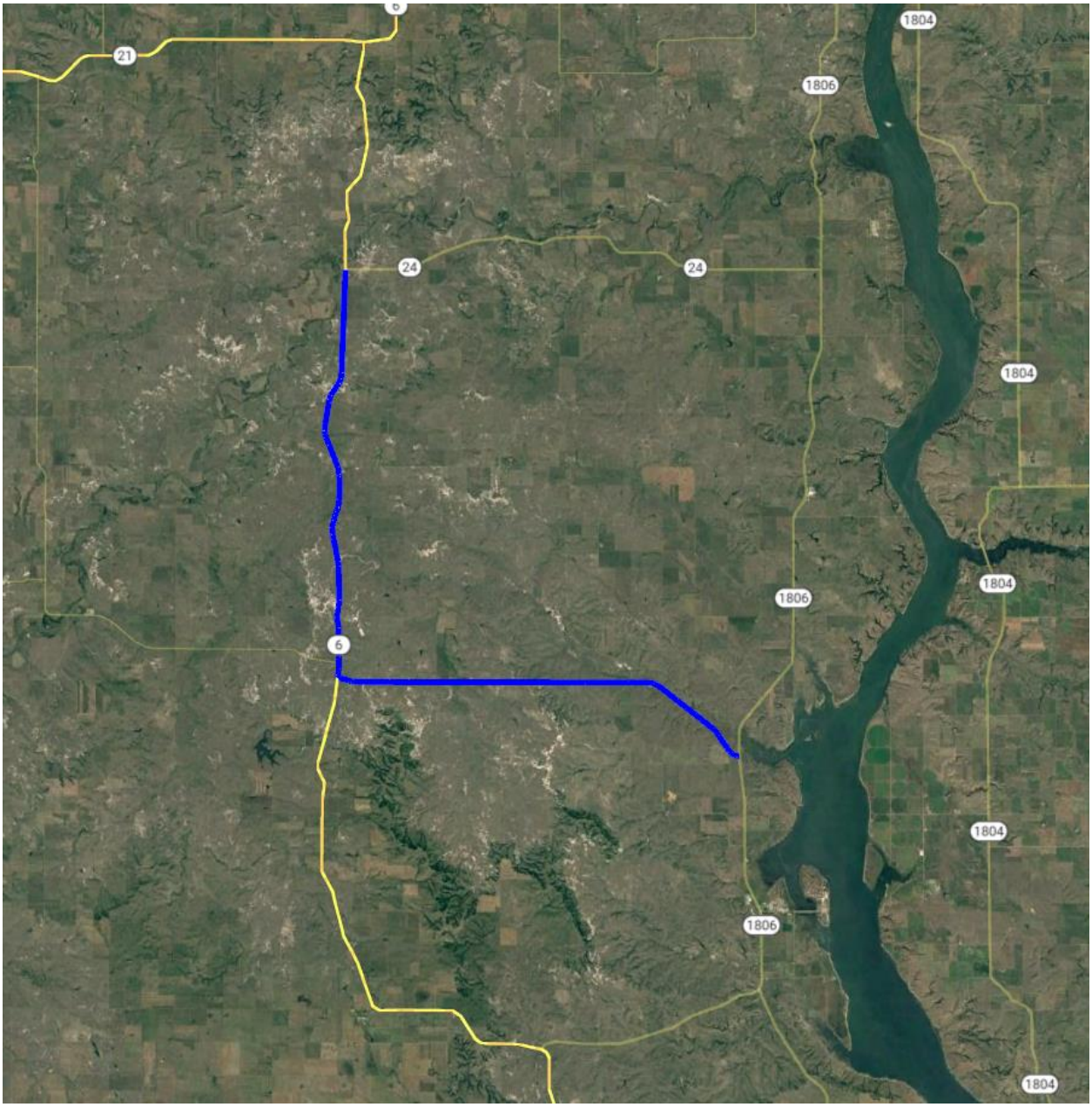
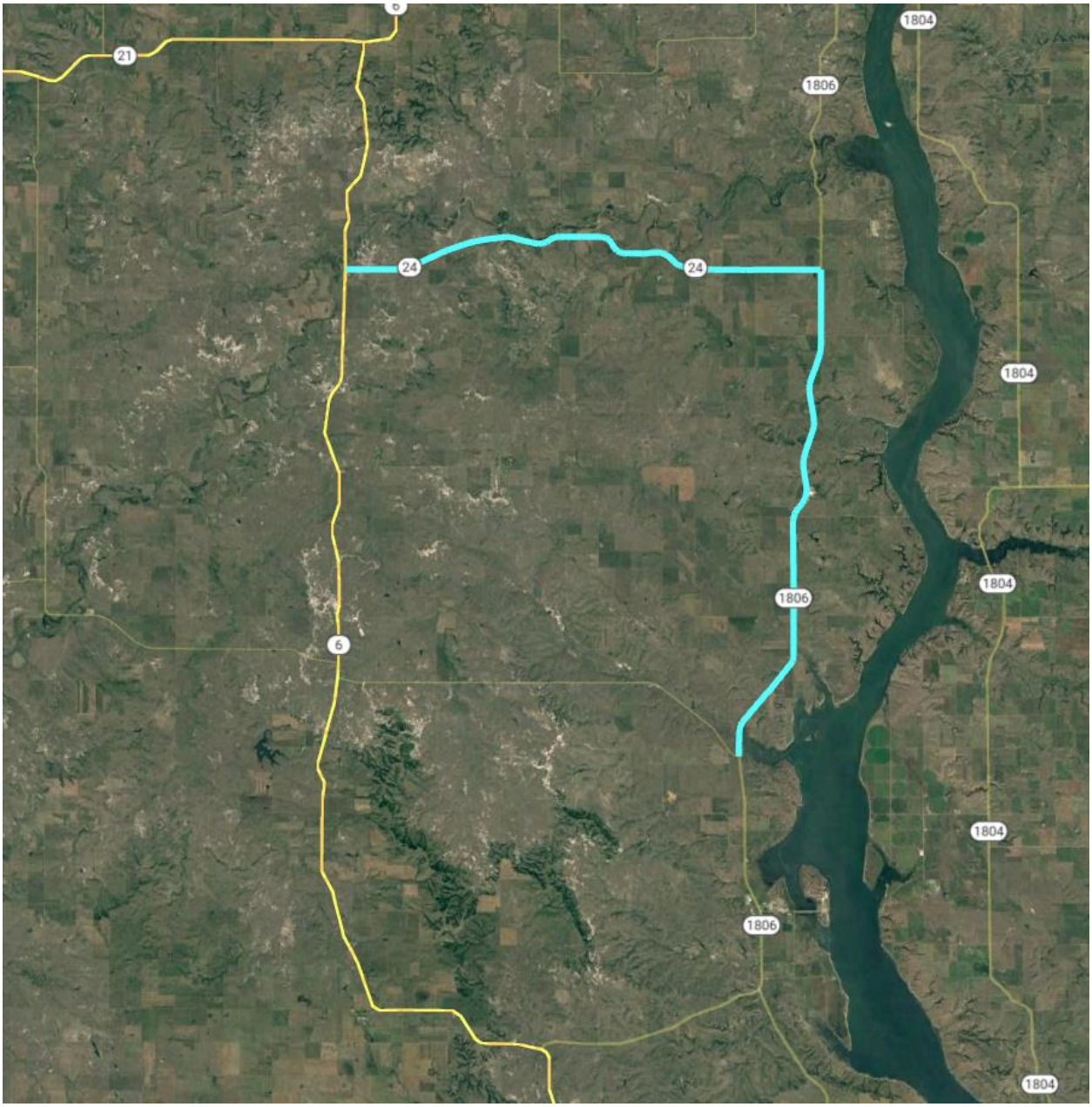


Figure 4. North/South No Build Natural Diversion via ND 24 & ND 1806 (37.9 miles/37 minutes)



East/West Vehicles (between Fort Yates and Porcupine/Rural Western reservation land) – This natural diversion via ND 6, and ND 1806 begins in 2025, when BIA 6 is converted to gravel. The natural diversion in the No Build is two minutes longer than the original route, however some drivers are assumed to take the natural diversion to reduce wear and tear on their vehicle. Additional travel time along BIA 6 was calculated assuming a posted speed limit of 65 mph along BIA 6 in the Build and 50 mph along BIA 6 in the No Build along with the assumed project length of 13.1 miles. This analysis assumed 100 percent of all east/west truck traffic[5] and zero percent of all east/west automobile traffic along BIA 6 is anticipated to take this natural diversion to reduce wear and tear on vehicles by traveling along the paved roadway. The remaining 100 percent of east/west automobile traffic is anticipated the BIA 6 route. In the No Build, east/west users have two options[6]:

- **East/West No Build Via BIA 6 & ND 1806** is shown in Figure 5. This route is 18.5 miles and takes 20 minutes – Analysis assumes zero percent of all automobiles and 100 percent of all trucks choose this route. This is the existing route users take with additional travel time along BIA 6 due to conversion to gravel roadway.
- **East/West No Build Natural Diversion Via ND 6 & ND 1806** is shown in Figure 6. This route is 26 miles and takes 26 minutes – Analysis assumes 50 percent of all automobiles and 100 percent of all trucks choose this route.

[5] The assumption of 100% of truck was made per SRST staff guidance.
[6] The BCA Workbook allows reviewers to conduct sensitivity analysis using a different percentage of users on each of the two east/west traffic routes for both automobile and truck traffic.

Figure 5. East/West No Build Via BIA 6 & ND 1806 (18.5 miles/24 minutes)

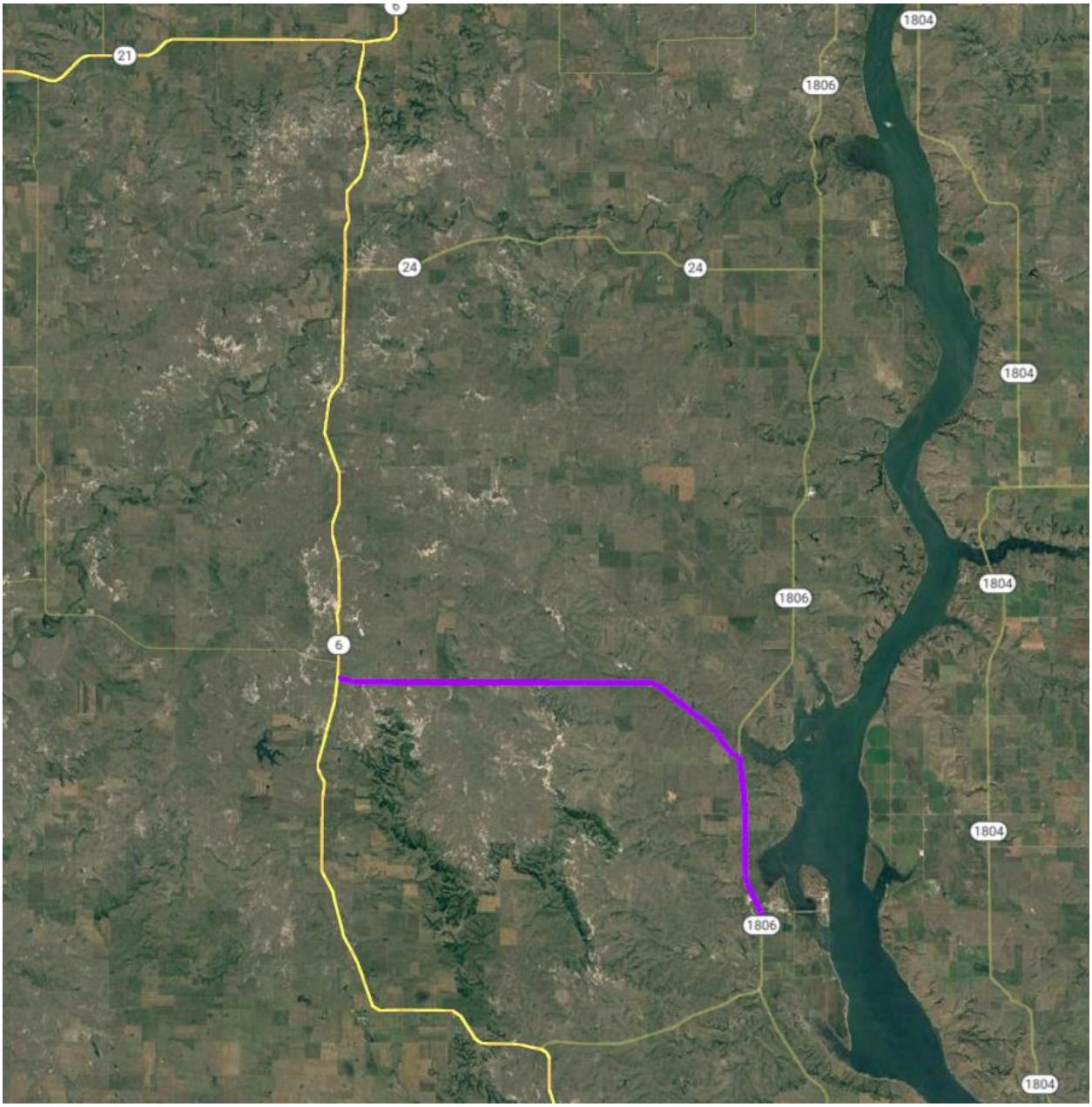
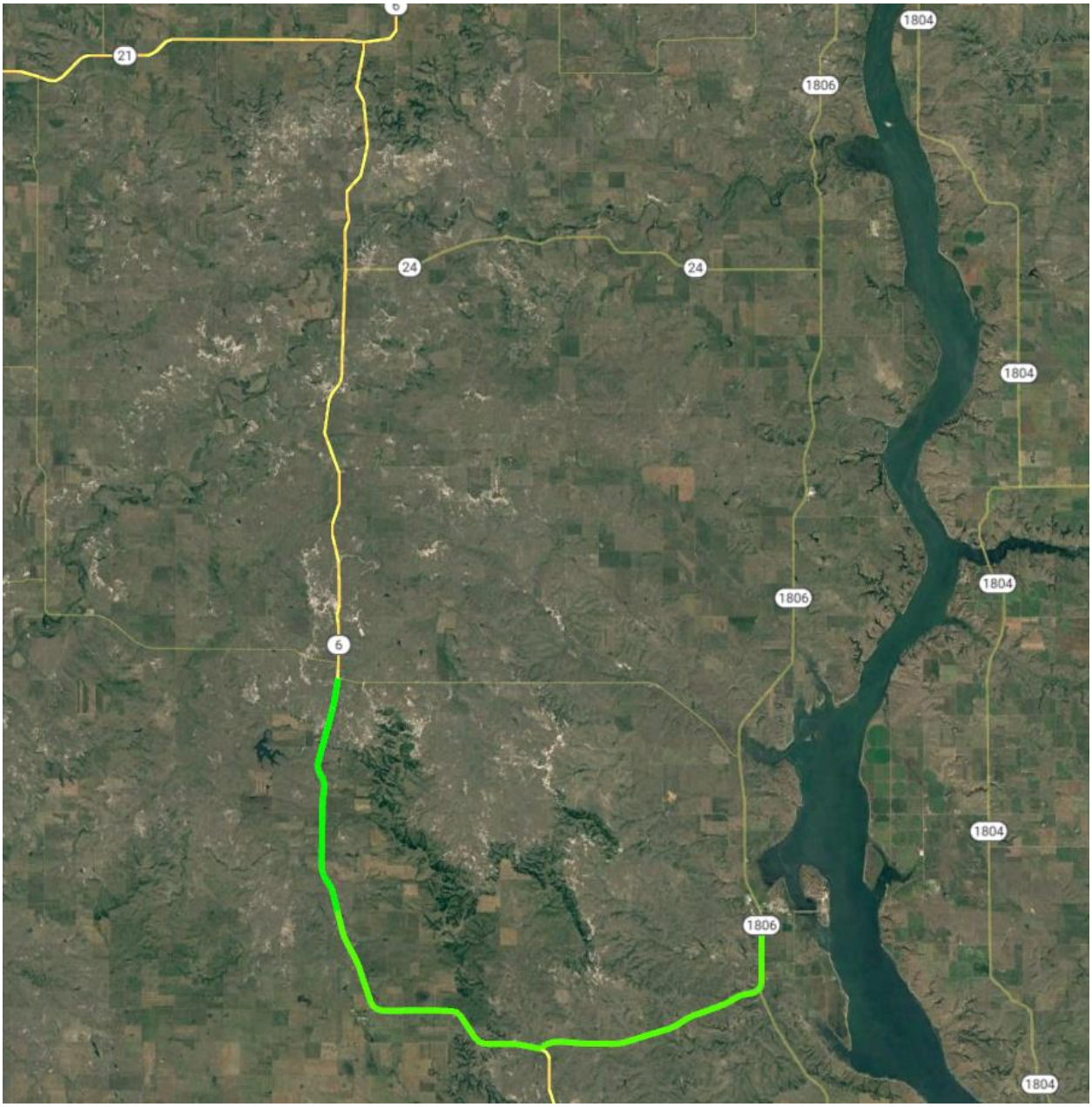


Figure 6. East/West No Build Natural Diversion Via ND 6 & ND 1806 (26 miles/26 minutes)



Build Alternative

The Build Alternative consists of reconstructing and resurfacing the BIA 6 roadway. Specific design elements considered in BCA are as follows:

- Reconstructs 7.44 miles of roadway to new condition.
- Resurfaces 5.71 miles of roadway.
- Installs edge-line rumble strips.

The project will be constructed in two phases:

- Phase 1 – BIA 6 Reconstruction (June 2024 to September 2024): This phase will consist of reconstructing the west portion of BIA 6, beginning from the ND Highway 6 intersection. This phase also includes the installation of centerline and shoulder rumble strips. During the 4 months of construction, vehicles are assumed to travel at the temporary construction speed zone of 25 mph for 24 hours a day.
- Phase 2 – BIA 6 Resurfacing (June 2025 to September 2025): This phase involves a complete resurfacing (mill and overlay) on the east portion of the BIA 6 corridor, beginning at the ND Highway 1806/ND Highway 24 intersection and installation of centerline and shoulder rumble strips. During the 4 months of construction, vehicles are assumed to travel at the posted speed of 25 mph for 24 hours a day.

The Build analysis relies on the same assumed traffic patterns based on the existing AADT used in the No Build analysis. In the Build analysis, all vehicles are assumed to use their existing routes.

- North/South Build Via ND 6/BIA 6 (33 miles, 33 minutes) – Assume 100 percent of users choose this route. This is the most efficient and the existing route users take.
- East/West Build Via BIA 6/ND 1806 (18.5 miles, 20 minutes) – Assume 100 percent of users choose this route. This is the most efficient and the existing route users take.

BCA Methodology

The following methodology and assumptions were used for the benefit-cost analysis:

1. **Main Components**: The main components analyzed included:
    - Travel time/delay.
    - Vehicle operating costs.
    - Crashes by severity.
    - Environmental and air quality impacts.
    - Initial capital costs: Capital costs were expected to be incurred in years 2024 and 2025.
    - Remaining Capital Value: The remaining capital value (value of improvement beyond the analysis period) was considered a benefit and was added to other user benefits.
    - Operating and maintenance costs.
2. **Analysis Years**: This analysis assumed that the Build Alternative would be constructed over a two-year period, starting in the year 2024, with completion in the year 2025. Construction was assumed to be staged such that Phase 1 would be constructed in June 2024 to September 2024 and Phase 2 would be constructed June 2025 to September 2025. Year 2026 was assumed to be the first full year that most benefits will be accrued from the entirety of the project. The

analysis primarily focused on annual benefits for the twenty-year period from 2026 to 2045[7], while some user costs were quantified during the construction phases. The present value of all benefits and costs was calculated using 2021 as the year of current dollars.

3. **Economic Assumptions**: The value of time, vehicle operating costs, emissions costs, and cost of crashes were obtained from the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023[8]. Per-mile operating costs associated with additional impacts of pavement roughness were derived using values from NCHRP Report 720 - "Estimating the Effects of Pavement Condition on Vehicle Operating Costs"; Table 7-5[9]. The analysis was completed using an assumed discount rate of seven percent.

4. **Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)**: Year 2022 VMT and VHT were along the BIA 6 corridor and the natural diversion routes. The total network VMT and VHT were developed using existing AADTs obtained from the NDDOT Transportation Information Map: AADT[10]. Travel time and route lengths were obtained using Google Maps and the assumed annual growth rate was obtained from the 2020 project plan set.

   BIA 6 was assumed to convert to gravel at the appropriate time in the year 2025 based on remaining service life under the No Build Alternative. This information was obtained through coordination with SRST Staff. Detailed descriptions of traffic impacts are described in the "No Build" and "Build" section of this memorandum. The BCA Workbook contains detailed information regarding pavement service life assumptions, detours during construction, natural diversions associated with conversion of BIA 6 to a gravel road in the No Build, and trip distances and times.

   Travel times and trip distances were applied to year 2022 and year 2039 daily traffic forecasts to determine VHT and VMT, respectively. Benefits for the years between 2026 and 2038 were interpolated using an annual growth rate, and benefits for years beyond 2039 were extrapolated using the same growth rate. Total user costs per alternative is the sum of all user costs for the period from 2024 to 2045 (i.e., includes construction years and 20 years after last project opening). Benefits due to change in VMT and VHT were calculated using costs per mile and per hour that account for vehicle occupancy and different vehicle types.

5. **Vehicle Occupancy and Vehicle Types**: Truck and auto travel time costs per hour and costs per vehicle mile traveled were used in addition to vehicle occupancy ratios, and the percent split of autos and trucks traveling on each route. Key assumptions for these areas included:

   - The corridor-wide truck percentage used in the analysis was 7.8 percent and was based on 2020 data from the project plan set.

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[7] This analysis assumed a 365-day year to account for benefits incurred on weekends and recreational peaks in the project area.

[8] 2023 USDOT Benefit-Cost Analysis Guidance for Discretionary Grant Programs: https://www.transportation.gov/sites/dot.gov/files/2023-01/Benefit%20Cost%20Analysis%20Guidance%202023%20Update.pdf

[9] Estimating the Effects of Pavement Condition on Vehicle Operating Costs: http://www.trb.org/Publications/Blurbs/166904.aspx

[10] NDDOT Transportation Information Map: AADT: https://gis.dot.nd.gov/external/ge_html/?viewer=ext_transinfo

- Vehicle occupancy that was used in the analysis is consistent with values provided by *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023. The analysis assumed occupancy of 1.67 people per automobile and 1.00 people per truck.

6. **Vehicle Operating Costs:** Improving pavement condition along BIA 6 is a primary objective of this project. As noted previously, the current pavement condition on BIA 6 is degraded such that further analysis is necessary to capture the additional user costs associated with vehicle operating costs compared to a facility with sufficient pavement quality. Methods for estimating these additional costs per mile associated with pavement roughness are described in the National Cooperative Highway Research Program (NCHRP) Report 720. These methods were applied along with an understanding of the current and projected pavement condition on the BIA 6 corridor to develop localized per-mile vehicle operating costs due to gravel road impacts. Additional vehicle operation costs associated with gravel roads were applied only to the No Build. Benefits were developed for the years 2026 through 2039 based on existing and forecast volumes along BIA 6.

   Note that pavement damage to natural diversion routes and associated additional vehicle operating costs were not quantified in the BCA but are expected to occur under a No Build Alternative, which signifies a conservative estimate in overall benefits for the Build Alternative.

7. **Safety Analysis:** The Build Alternative improves safety in the project area in two ways. First by adding roadway safety elements to BIA 6 as part of the project, and secondly by keeping traffic on this route and not encouraging traffic to divert to a less safe roadway. The Build Alternative directly improves safety by providing the following elements quantified in this Benefit-Cost Analysis:

   - Installation of edge-line rumble strips.
   - Restoring pavement condition along BIA 6 to excellent condition.

   SRST provided county wide crash data for years 2012, 2013, 2015, 2016, and 2017. Crash data reporting issues prevented use of crash data for the years 2014 and 2018-2021. Available five-year county wide crash data was used to determine the crash rates by severity along each reroute due to conversion of BIA 6 to a gravel roadway.

   The safety benefits associated with the installation of centerline and median rumble strips were monetized using reductions in crashes along the BIA 6 corridor using the crash modification factor for "Install Centerline and Median Rumble Strips" (CMF ID: 6942)[11]. This CMF predicts an annual reduction of 35 percent for all crash types and crash severities.

   Expected number of crashes in year 2039 were calculated by multiplying the base year crashes by the percent change in traffic volumes between the base year (this analysis assumed 2022 being the center of the crash analysis period due to available AADT data) and forecast year 2039. Forecast year crashes by severity and crash costs were calculated for the No Build and Build scenarios. Crash costs were obtained by applying the appropriate crash modification factor to the No Build crash data.

[11] CMF ID # 6942: https://www.cmfclearinghouse.org/detail.cfm?facid=6942

The crash cost savings associated with the natural diversions due to conversion of BIA 6 to a gravel roadway were monetized using existing crash rates by crash severity. Crashes along existing routes and diversion routes (excluding on the segment of BIA 6) were analyzed. Crash impacts along BIA 6 were analyzed separately. These cost savings and crashes by severity were calculated using the same 2012, 2013, 2015, 2016, and 2017 crash data noted above and AADT data obtained from the NDDOT Transportation Information Map: AADT (this analysis assumed 2022 being the center of the crash analysis period due to available AADT data).

Annual crashes by severity and crash costs for existing year 2022 and forecast year 2039 were calculated based on the change in VMT between the No Build Alternative and Build Alternative caused by the natural diversions described in the "No Build" and Section 4 of this methodology, "Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)." The shift of traffic to the natural diversion routes associated with conversion of BIA 6 to a gravel road is expected to result in increased crash costs for the No Build since severe crash rates are higher on natural diversion routes those along routes using BIA 6 in the Build.

All safety benefits were calculated for years 2022 and 2039 and interpolated (or extrapolated) based on an annual growth rate to determine total safety benefits over the analysis period from year 2026 to 2045. Crash data used in analysis is presented is presented in the BCA Workbook.

Crash cost assumptions for the KABCO scale are consistent with values and methodologies published in the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023.

8. **Environmental and Air Quality Impacts:** Annual VMT along BIA 6 and the natural diversion routes is expected to be impacted by the conversion of BIA 6 to gravel roadway in the year 2025. The change in VMT between the No Build Alternative and Build Alternative are described in Section 4 of this methodology "Development of Vehicle Miles Traveled (VMT) and Vehicle Hours Traveled (VHT)." Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3[12]. Emission rates per vehicle type are provided in the attached BCA Workbook. Total change in emissions was valued in accordance with the *Benefit Cost Analysis Guidance for Discretionary Grant Programs*, dated January 2023.

9. **Operating and Maintenance Costs**: Annual maintenance along BIA 6 was determined using existing average annual maintenance costs along BIA 6 (2018-2021) for years 2023 and 2024 and. Per-mile maintenance costs for gravel roadways, cost to convert a pavement to gravel roadway, costs and chip and seal costs in Stutsman County, North Dakota were obtained from the Transportation Research Synthesis, Minnesota Department of Transportation, Office of Policy Analysis, Research and Innovation: Decision Tree For Unpaving Roads (dated May 2010)[13].

   In the Build Condition, annual roadway maintenance costs were estimated by assuming 2.5 employees, 8 hours a day, 5 days a week, for 4 weeks total, plus an annual $2,500 in material

[12] Average emission rates per vehicle type were obtained from the Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) version 3
[13] Decision Tree For Unpaving Roads (dated May 2010) - https://www.dot.state.mn.us/research/TRS/2010/TRS1007.pdf. The assumed values are shown in Table 1

costs. The value of time was assumed to be at $21.59 per hour[14]. This is a conservative estimate as this approach is not able to capture the material costs associated with this work. The hourly cost of labor was obtained from Occupational Employment and Wages data for construction workers in North Dakota, published by the U.S. Bureau of Labor Statistics.

Additional details and assumptions on anticipated operations and maintenance costs are shown in the BCA Workbook.

10. **Calculation of Remaining Capital Value**: Components of the initial capital costs have service lives beyond the 20-year analysis period, therefore remaining capital value was calculated for the Build Alternative. This value was expressed in terms of 2021 dollars and was added to other project benefits in accordance with USDOT guidance. The assumed service life for the Build Alternative was 20 years (including periodical chip sealing).

    In determining the remaining capital value of the Build Alternative, project components were assumed to have a linear depreciation from the time each phase was completed to the end of the benefit-cost analysis period. The remaining capital value quantities were discounted and attributed to other project benefits for the Build Alternative.

11. **Factors Not Quantified**: Several factors were not quantified as part of the analysis that could potentially add to the benefits assumed in the BCA. These factors are noted below:
    - Increased travel time reliability in the study area due enhanced pavement condition and reduction in crashes associated with safety improvements.
    - Increased emergency response reliability between Fort Yates and surrounding area.
    - Increased connectivity between the cultural hub of Fort Yates and the surrounding rural townships and regions.
    - Safety Benefits (along BIA 6):
        - Mitigation of deficient vertical curves.
        - Widened shoulders along the roadway to reduce crashes due to running off the roadway.
        - Leveling off steep shoulder drop-offs to reduce potential severe crashes at such locations.
        - Correction of roadway side slopes to ensure proper roadway drainage
        - New pavement markings that are more visible and reflective during adverse driving conditions
    - Additional health benefits in this region are difficult to capture. This segment of BIA 6 is in an area of persistent and concentrated poverty, in a historically disadvantaged community, in one of the poorest areas in the nation with severely limited access to essentials, including groceries, fuel, and basic health care needs, and has a population with disproportionately high mortality rates. The monetary benefits associated with improved facilities along BIA 6 which provides direct access to groceries, general

[14] https://www.bls.gov/oes/current/oes472061.htm

stores, hospitals, and pharmacies improves user access to these essential services and their impact direct impact on community health are not captured in this analysis.

BCA Results

The benefit-cost analysis provides an indication of the economic desirability of a scenario, but results must be weighed by decision-makers along with the assessment of other effects and impacts. Projects are considered cost-effective if the benefit-cost ratio is at least 1.0. The larger the ratio number, the greater the benefits per unit cost. Results of the benefit-cost analysis are shown in Table 1. See Attachment A for the complete benefit-cost analysis workbook.

Table 1 – Total Project Results

	Initial Capital Cost (2021 Dollars)	Project Benefits (2021 Dollars)	Benefit-Cost Ratio (7% Discount Rate)	Net Present Value (2021 Dollars)
No Build vs. Build	$13.83 million	$23.40 million	1.69	$9.57 million

The Project is considered cost-effective however, the cost-effectiveness is likely underestimated, as numerous unquantifiable benefits will result from the reconstruction and preservation of BIA 6 in an area of persistent poverty and historically disadvantaged community. Unquantifiable benefits are outlined in the Merit Criteria Narrative and include but are not limited to:

- Equity and the Justice40 Initiative
- Quality of life for an underrepresented population
- Connection to employment, everyday goods, education and higher education, healthcare and emergency services, social services, cultural heritage, and historical sites.
- Economic competitiveness and opportunity of an underrepresented population

Attachment A

Benefit-Cost Analysis Worksheet